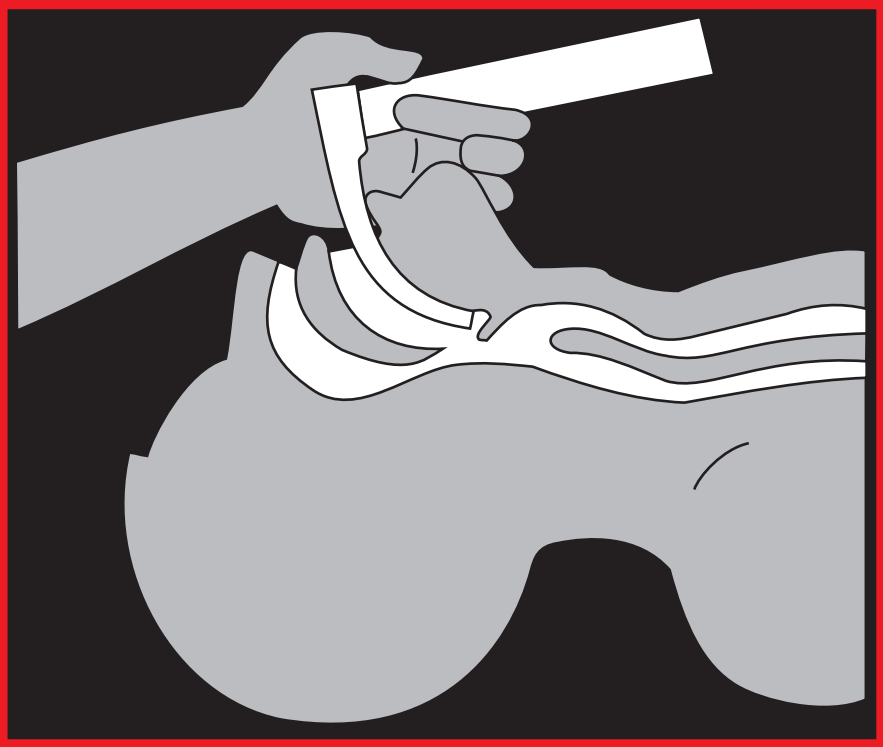
Basic Guide to Anesthesia for Developing Countries



Daniel D. Moos

Volume 1

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“Every prudent man acts out of knowledge.”
Proverbs 13:15

Soli Deo Gloria

Acknowledgements

This project would not have been possible without the help of many. The World Health Organization and Michael B. Dobson MD kindly gave permission to utilize illustrations from the publication Anaesthesia at the District Hospital, WHO, Geneva, 2000 for two earlier editions, published in Afghanistan and Cambodia. Permission to use material from the WHO publication is not an endorsement of this anesthesia manual over other manuals that may be available. The WHO does not endorse any specific company or product. Since the earlier editions, this manual has been configured to provide a copyright free edition to all who would desire it.

Professional illustrations were provided by Welti & Rose Advertising, Inc. Photographs provided by the author and William H. Hartland Jr. CRNA, PhD.

I am indebted to Dr. Mark Schanbacher who spent many hours with me going over this manual, word by word, and sentence by sentence. Several anesthesia providers/medical professionals gave their time to this worthy task. This group of academic and clinical experts provided valuable insights and thoughtful consideration to the content of this manual. Invaluable guidance was provided by Chuck Biddle CRNA, PhD; William Hartland Jr. CRNA, PhD; Richard A. Henker CRNA, PhD; John Nagelhout CRNA, PhD; Bob Halliburton CRNA, DNSc; Karen Zaglaniczny CRNA, FAAN, PhD; Donald M. Bell CRNA, DNSc, APN; Michael J. Kremer CRNA, FAAN, DNSc; John Aker CRNA, MS; Sandra M. Ouellette, CRNA, M.Ed., FAAN; Suzanne Brown, CRNA; Dennis L. Edwards MD; Deb Hansen Pharm.D; Ken Gross MD; Ken Foster MD; W.C. Petty MD; Asad Fayaz MD; Malte L. von Blumroder MD; Uffe Romer MD; Karen Mindling RN; and Carson F. Frazzini CRNA, MS. Editorial assistance was provided by Dan Fong , Leigh Berthoff, Jenera Turman, and Sandra Rosse. The cover was designed by Steve "Human" Pfauter. Initial layout by Janelle Meyers.

Thank you for your contributions!

Introduction

This manual is not complete. However, it is an excellent start. Anesthesia is essential for the practice of surgery. It is a great responsibility that we are given as anesthesia providers. Patients undergoing surgery put their lives in our hands. It is our duty to protect the patient, to give the patient our full attention, and to administer the safest anesthetic possible.

Vigilance means to be alert to danger or threats. Each of us must be vigilant when giving anesthesia to avoid unnecessary complications.

It is my prayer that this manual will help teach the anesthesia provider in training as well as serve as a review for those who are currently practicing the art and science of anesthesia.

Every effort was made to ensure that the material and information contained in this manual is correct and up-to-date. The publishers and author cannot accept liability from any potential errors contained in this manual or errors that may occur from the use of this material.

If this manual is published, translated, or used for the promotion of basic anesthesia knowledge, the author would appreciate an email. This project continues to evolve and your input is critical to making it useful in the developing world. Please feel free to contact me at moosd@charter.net with comments, questions, recommendations for future editions, and any concerns.

Daniel D. Moos

Resources

A number of resources are available for the anesthesia provider in developing countries.

Books

Anaesthesia at the District Hospital, 2nd Edition. Michael B. Dobson. Published by the World Health Organization in collaboration with the World Federation of Societies of Anesthesiologists. This manual was published to help guide medical officers in small hospitals. It contains a wealth of practical and useful information. This book is available in English.

Internet Resources

Manuals

Safe Anaesthesia. Lucille Bartholomeusz, 3rd edition updated and revised by Jean Lees**.** This manual is available at http://www.worldanaesthesia.org . This 700+ page manual contains comprehensive information concerning anesthesia. Individual chapters may be downloaded. This manual is available in English.

Basic Guide to Resuscitation for Developing Countries. Daniel D. Moos. This manual is available at http://www.worldanaesthesia.org and http://ifna-int.org . This manual can be freely downloaded, copied, and translated for the promotion of basic resuscitation techniques. Additional information concerning basic resuscitation may be obtained at http://erc.edu (European Resuscitation Council) and http://americanheart.org (American Heart Association).

Primary Trauma Care is an excellent resource for basic trauma care. It is available at **http://www.primarytraumacare.org .** This thirty-nine page manual is available in English, Chinese, Spanish, French, Indonesian, Mongolian, Farsi, and Vietnamese.

Education

World Anaesthesia Online can be accessed at http://www.nda.ox.ac.uk/wfsa/. This web site is dedicated to the promotion of anesthesia knowledge and skills in the developing

world. Update in Anaesthesia is "An educational journal aimed at providing practical advice for those working in isolated or difficult environments." The majority of the updates are available online in English. A small number of updates are available online in Russian and French. The print version is available in English, Russian, French, Mandarin, and Spanish.

World Anaesthesia can also be accessed at http://www.neda.ox.ac.uk/wfsa/ . World Anaesthesia is a newsletter of the World Federation of Societies of Anaesthesia. The newsletter allows "for the exchange of views & ideas on advancing the specialty of anaesthesia in the developing world." It is available in English.

International Organizations

International Federation of Nurse Anesthetists (IFNA) was founded in 1989 and currently has 34 country members. The IFNA is an international organization whose mission is in part dedicated to the advancement of educational standards and practices of anesthesia. The IFNA website is located at http://www.ifna-int.org .

Additional resources concerning the IFNA include:

Caulk R, Ouellette S M. The International Federation of Nurse Anesthetists A Professional Study and Resource Guide For The CRNA. AANA Publishing 2001; Chapter 19: 381-406.

McAuliffe M. Countries where anesthesia is administered by nurses. AANAJ 64 (5), 469-479.

Henry B, McAuliffe M. Practice and education of nurse anesthetists. Bulletin of the World Health Organization.The International Journal of Public Health. 77 (3), 267-270.

World Federation of Societies of Anesthesiologists (WFSA) was founded in 1955 and currently has 122 country members. The objectives of the WFSA is the improve/disseminate knowledge concerning the standards of anesthesia, pain treatment, trauma management and resuscitation to all countries of the world. The WFSA website can be located at http://anaesthesiologists.org .

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Medical Math

Chapter One

Medical Math

The purpose of this chapter is to review common terms, abbreviations, and formulas for calculating medication dosages, conversions, and intravenous fluid infusion rates.

Medical Math Abbreviations

TERM	ABBREVIATION
millimeter	mm
meter	m
gram	g
microgram	mcg
kilogram	kg
cubic centimeter	cc

TERM	ABBREVIATION
centimeter	cm
milligram	mg
milliliter	ml or mL
liter	L
drop or drops	gtt or gtts

Common Conversions

1 L	1000 ml
1 G	1000 mg
1 mg	1000 mcg
1 Kg	1000 g

The Formula Method

The formula method is useful in the calculation of medications that are administered orally, subcutaneously, intramuscularly, and intravenously. Oral medication calculations should be within the following guidelines:

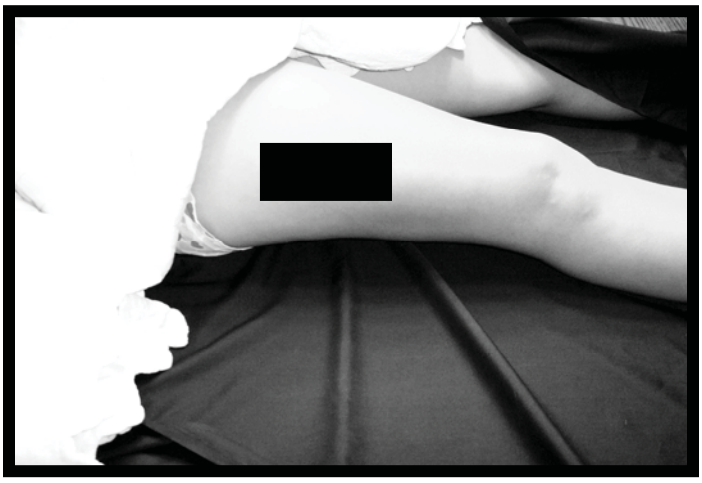
- In general, 3 tablets or capsules are the maximum number that should be needed to achieve the desired dose.
- No more than a 10% variation should exist between the dose ordered and the dose administered.
- If the dose calculated is larger or smaller than what is available, check the calculation, review the order and dosing guidelines to ensure that it is the correct dose.

Parenteral medication (subcutaneous, intramuscular, and/or intravenous route) calculations should be within the following guidelines:

- Subcutaneous volume should be 1.0 ml or less.
- Intramuscular volume depends on the size of the patient.

Healthy Adult	Up to 3.0 ml in large muscles
Elderly, thin adults, and older children	Up to 2.0 ml in large muscles
Toddler or infants	Up to 1.0 ml in large muscles

An intramuscular injection in the gluteus should be placed in the upper, outer quadrant. Trauma to the sciatic nerve will result in paralysis of muscle and absence of sensation below the knee.



An alternative site, that avoids major nerves, is the vastus lateralis on the outer (lateral) aspect of the leg. The shaded area indicates the area where the injection should be administered.

When mixing powdered medications read the label for the following:

- The correct sterile fluid to add (i.e. sterile water or sterile normal saline).
- The correct amount of fluid to add.
- The final concentration per ml (i.e. mg per ml of solution).
- How long the mixture may suitable for administration (there are time limitations for how long the solution will remain sterile and/or stable).
- How to store the medication once it is mixed.

The **formula method's** equation is $\frac{D}{H} = X$.

- D – dosage desired.
- H – concentration of the medication on hand (for example mg per ml).
- X – is the amount of medication that you will give.

Example: The patient is to receive 10 mg of succinylcholine. The concentration in the vial is 20 mg per ml. So how much should be administered?

The formula method's equation is D/H = X.

D = 10 mg H = 20 mg

$\frac{D}{H} = X$ Divide the ratio $\frac{10}{20} = 0.5$

X = 0.5 ml…would be prepared for administration.

Example: The patient is to receive 80 mg of succinylcholine intravenously. The concentration in the vial is 20 mg per ml. So how much should be administered?

The formula method's equation is $\frac{D}{H} = X$

D = 80 mg H = 20 mg

$\frac{80\ mg}{20\ mg} = X$ Divide the ratio $\frac{80}{20} = 4$

X= 4 ml…would be prepared for administration.

Conversion of Ratios and Percents

The ability to convert medications from ratios and/or percents to mg is a very important concept. Understanding how to make these common conversions will avoid potentially dangerous miscalculations.

Ratios

Medications may come in ratios. Example: Epinephrine sometimes is packaged as 1:1000. This ratio can be expressed as a fraction, $\frac{1}{1{,}000}$. The 1:1000 ratio means that 1 g of medication (in this instance epinephrine) is dissolved in 1000 ml of liquid. 1 g = 1000 mg. $\frac{1{,}000\ mg}{1{,}000\ ml} = \frac{1\ mg}{1\ ml}$. A 1:1000 epinephrine vial contains 1 mg per ml of epinephrine. Another example of ratios can be noted in solutions of local anesthetics that contain epinephrine. Often these solutions will contain a 1:100,000 or 1:200,000 ratio of epinephrine. A 1:100,000 ratio means that there is 1 g of medication diluted in 100,000 ml or 1000 mg in 100,000 ml.

$\frac{1000\ mg}{100{,}000\ ml}$ of solution =

$\frac{1\ mg}{100\ ml} =$

1 mg = $\frac{1{,}000\ mcg}{100\ ml} =$

10 mcg of epinephrine per ml

A final example would be a local anesthetic that contains a ratio of 1:200,000 epinephrine. A 1:200,000 ratio means that there is 1 g of medication diluted in 200,000 ml or 1000 mg in 200,000 ml.

$$\frac{1000\ mg}{200{,}000\ ml} \text{ of solution} =$$

$$\frac{1\ mg}{200\ ml} =$$

$$1 \text{ mg} = \frac{1{,}000\ mcg}{200\ ml} =$$

10 mcg/ 2ml

5 mcg per 1 ml

Converting % to mg

The ability to convert a % to mg is also important. Many anesthesia medications are packaged as a %. For example, thiopental is often reconstituted to a 2.5% mixture. Local anesthetics often come prepared in a % mixture. Converting a % to mg is very easy. All that is required is to move the decimal point one place to the right.

Example: A succinylcholine drip is reconstituted to a 0.2% solution. Move the decimal point one place to the right. 2 mg/ml is the result. This is the dose of succinylcholine in a 0.2% solution.

Example: Lidocaine may come as a 4% solution. Start with 4.0% and move the decimal point to the right one place. 4.0% = 40 mg per ml.

Converting mg to %

Converting mg to % is just the opposite of converting % to mg. When you convert mg to % simply move the decimal point one place to the left. Example: A vial of atropine contains 0.4 mg per ml. To convert mg to a % take 0.4 mg per ml and move the decimal point one place to the left. The solution contains a 0.04% concentration of atropine.

Example: Thiopental is often diluted to a concentration of 25 mg per ml. To convert it to a % take 25 mg per ml and move the decimal point one place to the left. The solution contains a 2.5% concentration of thiopental.

Intravenous Fluid Calculations

In the past, ml and cc have been used interchangeably. Due to safety concerns, and to avoid confusion, the use of ml has largely replaced the use of cc. Intravenous fluid tubing will indicate the **drop factor** on the package. The **drop factor** is the number of drops (gtts) per ml of intravenous

fluid. Regular intravenous tubing generally has a drop factor of 10, 15, or 20 gtts per ml. Microdrip tubing generally has a drop factor of 60 gtts per ml.
The formula used for calculating intravenous fluid flow rate is a two step process.

STEP 1: Calculate the amount of fluid to be administered by the number of hours that the infusion will be administered over.

$$\frac{Total\ amount\ of\ fluid\ to\ be\ infused}{Number\ of\ hours\ to\ be\ infused\ over} = ml\ per\ hour$$

Example: 450 ml of lactated ringers is to be infused over 3 hours.

$$\frac{450\ ml}{3\ hours} = 150 \text{ ml per hour}$$

STEP 2: Multiply the ml per hour by the drop factor on the package (number of drops per ml). Divide it by 60 minutes. In this example the drop factor is 20 gtts per ml. The calculated answer to the equation will determine the number of gtts per minute that should be infused.

$$\frac{ml\ per\ hour\ \ X\ gtts\ per\ ml\ (drop\ factor)}{60\ minutes} = \text{gtts per minute}$$

Example: Continuing the example in step 1…

$$\frac{150\ ml\ per\ hour\ \ X\ 20\ gtts\ per\ ml}{60\ minutes} = \frac{3000\ gtts}{60\ minutes} = 50 \text{ gtts per minute}$$

The answer to this equation is 50 gtts per minute.

If the answer to the calculation is not exact, round the results up or down to the nearest 10^{th}.

Example: If the answer to the calculation is 66 ml, then round the rate up to 70 ml.

Adjusting the IV drip rate until you get the correct gtt rate per minute may take a little effort. To adjust the drip rate count the number of gtts for 15 seconds and multiply the results by 4. Adjust the infusion up or down based on this. Periodically check the IV infusion rate to ensure that it is correct. As IV fluid infuses, the rate can change as the volume of the IV changes. If the height of the IV fluid is adjusted it is important to check the rate of the infusion. Raising the height of the IV will increase the rate of infusion. Lowering the height of the IV will decrease the rate of infusion.

Documentation on the Anesthesia Record

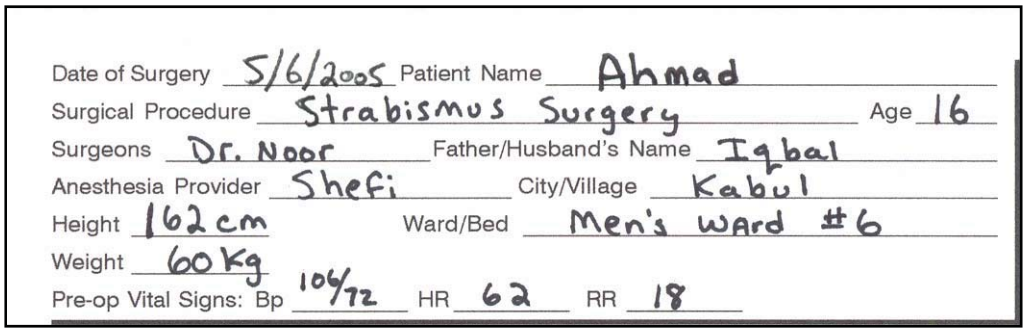
Chapter Two

Documentation on the Anesthesia Record

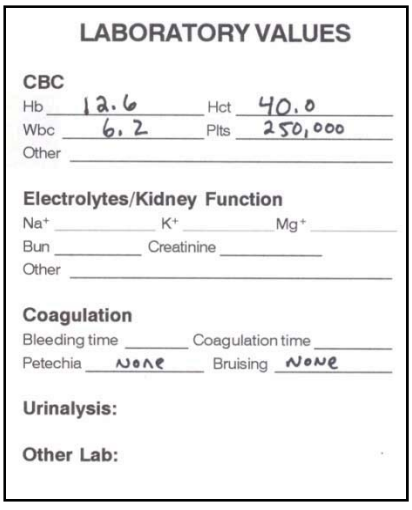
Recording information on the anesthesia record is important. The anesthesia provider is responsible for the patient from the time they enter the operating room through the recovery period. Maintaining a continuous record will help the anesthesia provider remain vigilant during the case. A well documented anesthesia record is useful for future anesthetics, guiding care of the patient. It serves to document anesthetic technique and complications that may have been encountered during the anesthetic. Documentation should be neat and legible. At the end of this chapter there is a full sized anesthesia record that may be copied and freely used. Anesthesia records differ from practice to practice. The purpose of this chapter is to provide an example of information that should be documented.

Pre-anesthesia Evaluation Documentation

The first item that is documented is identification of the patient. This will ensure that the pre-anesthesia workup does not get confused with another patient. The date of surgery, patient name, proposed surgical procedure, name of the surgeon, family contact, name of the anesthesia provider, city or village, ward or bed number, height, weight, and pre-operative vital signs should be documented.


Date of Surgery 5/6/2005 Patient Name Ahmad
Surgical Procedure Strabismus Surgery Age 16
Surgeons Dr. Noor Father/Husband's Name Iqbal
Anesthesia Provider Shefi City/Village Kabul
Height 162 cm Ward/Bed Men's Ward #6
Weight 60 Kg
Pre-op Vital Signs: Bp 104/72 HR 62 RR 18

Review the patient's laboratory values and document the results.


LABORATORY VALUES

CBC
Hb 12.6 Hct 40.0
Wbc 6.2 Plts 250,000
Other

Electrolytes/Kidney Function
Na+ K+ Mg+
Bun Creatinine
Other

Coagulation
Bleeding time Coagulation time
Petechia None Bruising None

Urinalysis:

Other Lab:

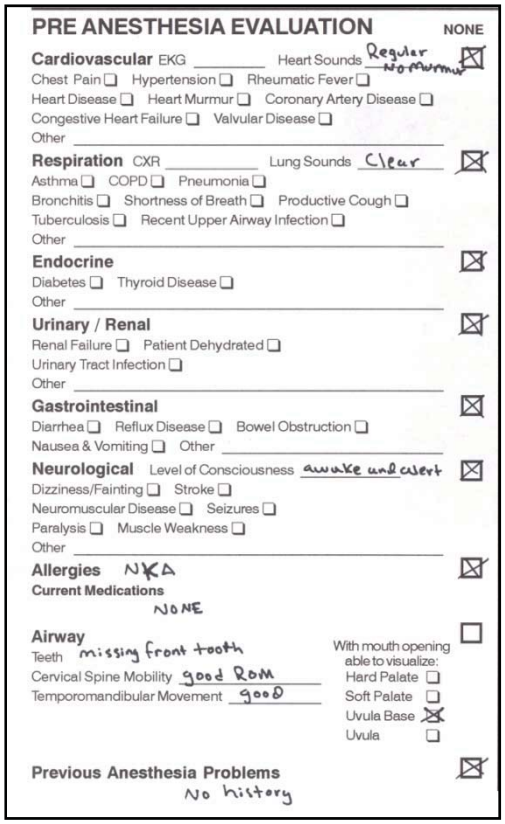
Review diagnostic studies including electrocardiograms (ECG) or chest x-rays (CXR) and document the results. The next step involves the patient interview and a physical exam. The interview consists of a systemic inquiry concerning the patient's health history including:

- Cardiovascular
- Respiratory
- Endocrine
- Urinary/Renal
- Gastrointestinal
- Neurological

The anesthesia record in this chapter is designed to help guide the anesthesia provider in asking about specific disease processes.
In addition ask about:

- Allergies
- Current medications
- Patient or family history of problems with anesthesia

The physical exam includes auscultation of the patient's heart and lungs. Determine if the patient's heart is regular or irregular. Can you auscultate murmurs? Auscultate the patient's lung sounds. Are they clear? Are there rhonchi, rales, or wheezing? Assess the patient's airway. Does the patient appear to be easy or difficult to intubate? Exam the patient's mouth. Are the teeth in good repair? Are there loose teeth? Are there missing teeth? Please refer to the Airway Management chapter for detailed airway assessment recommendations. Specific issues for the pediatric patient are discussed in the pediatric chapter.



PRE ANESTHESIA EVALUATION NONE

Cardiovascular EKG _____ Heart Sounds Regular No murmur ☒
Chest Pain ☐ Hypertension ☐ Rheumatic Fever ☐
Heart Disease ☐ Heart Murmur ☐ Coronary Artery Disease ☐
Congestive Heart Failure ☐ Valvular Disease ☐
Other _____

Respiration CXR _____ Lung Sounds Clear ☒
Asthma ☐ COPD ☐ Pneumonia ☐
Bronchitis ☐ Shortness of Breath ☐ Productive Cough ☐
Tuberculosis ☐ Recent Upper Airway Infection ☐
Other _____

Endocrine ☒
Diabetes ☐ Thyroid Disease ☐
Other _____

Urinary / Renal ☒
Renal Failure ☐ Patient Dehydrated ☐
Urinary Tract Infection ☐
Other _____

Gastrointestinal ☒
Diarrhea ☐ Reflux Disease ☐ Bowel Obstruction ☐
Nausea & Vomiting ☐ Other _____

Neurological Level of Consciousness awake and alert ☒
Dizziness/Fainting ☐ Stroke ☐
Neuromuscular Disease ☐ Seizures ☐
Paralysis ☐ Muscle Weakness ☐
Other _____

Allergies NKA ☒
Current Medications
NONE

Airway ☐
Teeth missing front tooth
Cervical Spine Mobility good ROM
Temporomandibular Movement good
With mouth opening able to visualize:
Hard Palate ☐
Soft Palate ☐
Uvula Base ☒
Uvula ☐

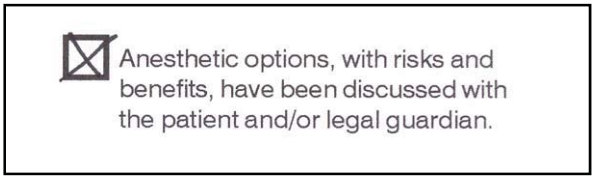
Previous Anesthesia Problems ☒
No history

Document the number of hours that the patient has fasted. For children, document a history of premature birth, prior surgical procedures, and type of anesthesia. Determine the general condition of the patient by assigning an ASA classification.

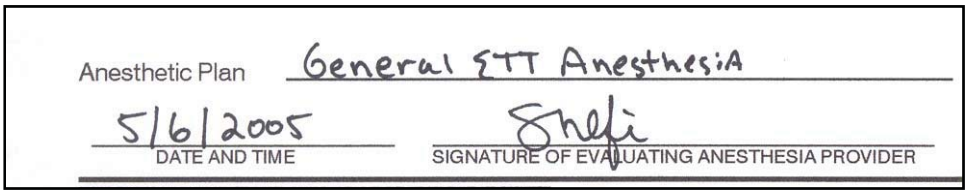
ASA Classification

- [x] ASA Class I: Normal Healthy Patient
- [ ] ASA Class II: Mild Systematic Disease
- [ ] ASA Class III: Moderate to Severe Disease
- [ ] ASA Class IV: Severe Systemic Disease
- [ ] ASA Class V: Moribund Patient Not Expected to Survive

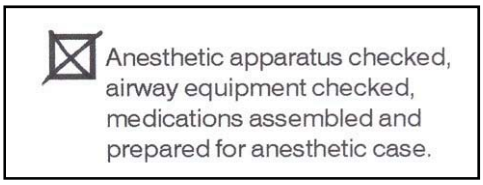
Discuss the anesthetic plan. Document that this has been completed.



Write out the anesthetic plan. Date and sign the anesthesia record.



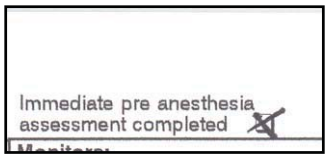
Preparations prior to the administration of an anesthetic are essential to good and safe care. Prior to administering an anesthetic, check the anesthesia apparatus, and airway equipment. Assemble and prepare medications for the anesthetic case. Document that this has been done.



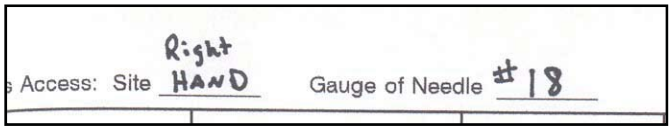
Anesthesia Care Documentation

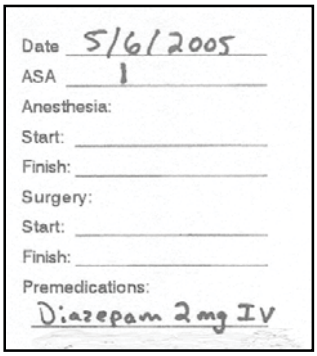
If the pre-anesthetic interview, physical exam, and evaluation were completed immediately prior to the surgical case, document that an immediate pre-anesthesia assessment has been done. If the initial pre-anesthesia evaluation was completed prior to the day of surgery, review the information,

and perform a physical exam, ensuring that there have been no changes in the patient's condition.

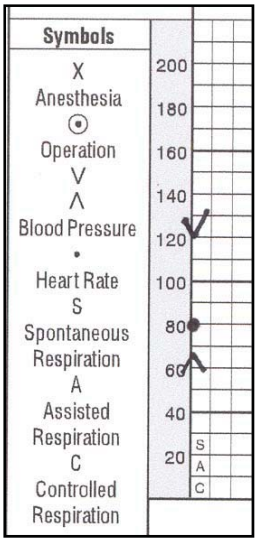


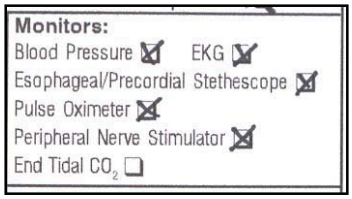
Document the date and ASA classification. Start the IV, documenting the site and size of the IV catheter. If the patient received premedication, document the medication, dose, and route.



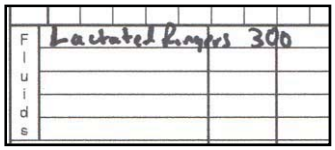


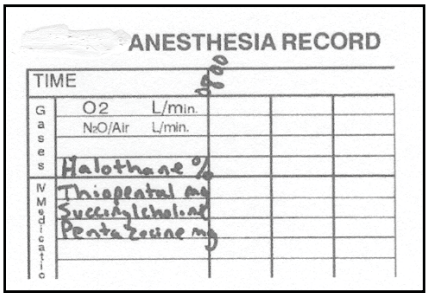
Apply monitors to the patient and record an initial set of vital signs. The patient's blood pressure should be noted by arrows. "v" is used for the systolic blood pressure. "^" is used for the diastolic pressure. The patient's heart rate can be indicated by a ".". Document the ECG rhythm, heart rate, blood pressure, and pulse oximetry reading. Document the monitors that will be used during the case.



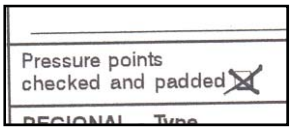


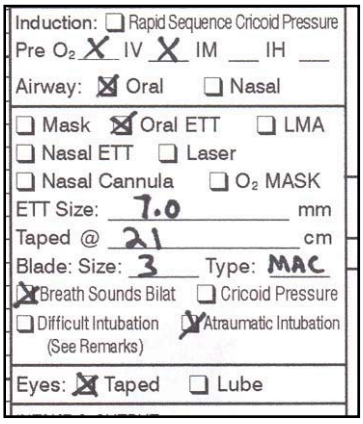
Document the intravenous fluid type and the amount infused. Document the medications that you will administer during the anesthetic.





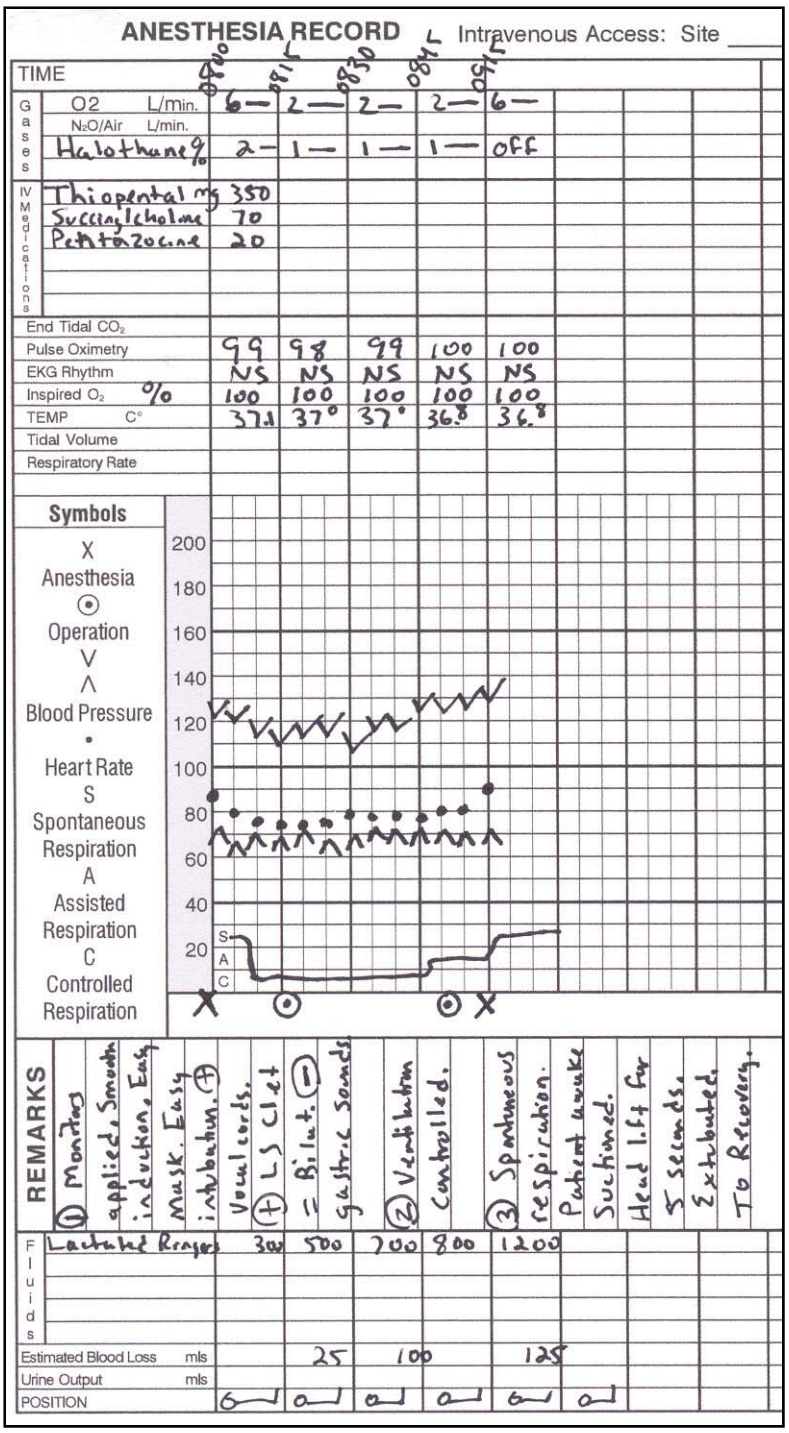
The section of the anesthesia record called "Remarks" is provided for documentation of the anesthesia provider's actions, unusual events, or problems encountered. If the patient is receiving a general anesthetic, document the type of circuit being used. Document that the patient has been pre-oxygenated; the type of induction (intravenous, inhaled, or intramuscular injection); use of mask ventilation, laryngeal mask airway, or endotracheal tube; cricoid pressure; type of intubation (nasal or oral); size of endotracheal tube; size of laryngoscope blade; type of laryngoscope blade; any difficulties encountered during intubation; and presence of equal, bilateral lung sounds. Document that the patient's eyes are protected. Document the positioning and ensure pressure points have been padded.



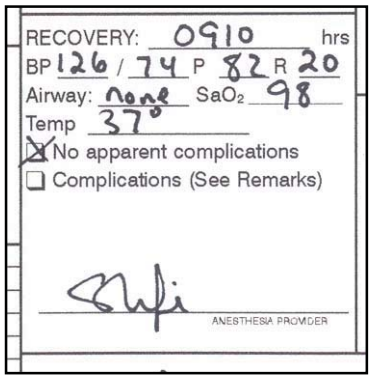


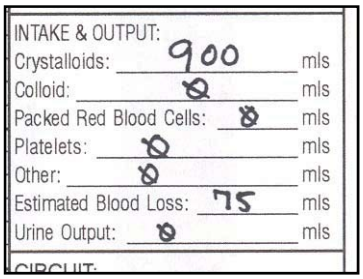
If the patient receives a regional anesthetic, document the type of regional block; position of the patient; interspace used for spinal or epidural anesthesia; needle type; needle size; the presence of paresthesia's (electrical shock type symptoms); the presence of cerebral spinal fluid for spinal anesthesia; type of local anesthetic used; dose; volume of local anesthetic; preparation solution; and the level attained. Document supplemental O2 administered by mask or nasal cannula.

All medications and dosages should be recorded. The type of ventilation should be documented as spontaneous, assisted, or controlled. This can be indicated by a "S" for spontaneous, "C" for controlled, and "A" for assisted. The patient's vital signs, pulse oximetry, and other monitors should be documented every five minutes. Your completed anesthesia record should be similar to the following example.



At the end of the anesthetic, document the total amount of medications administered, IV fluids, blood or blood products administered, blood loss, and urine output. Document the initial vital signs in the recovery area.


RECOVERY: 0910 hrs
BP 126 / 74 P 82 R 20
Airway: none SaO_2 98
Temp 37°
☒ No apparent complications
☐ Complications (See Remarks)
ANESTHESIA PROVIDER


INTAKE & OUTPUT:
Crystalloids: 900 mls
Colloid: 0 mls
Packed Red Blood Cells: 0 mls
Platelets: 0 mls
Other: 0 mls
Estimated Blood Loss: 75 mls
Urine Output: 0 mls
CIRCUIT:

Conclusion

Accurate documentation, on a time based anesthesia record, is important in helping the anesthesia provider maintain vigilance, as well as providing an accurate record to assist future anesthesia providers.

Date of Surgery _____ Patient Name _____
Surgical Procedure _____ Age _____
Surgeons _____ Father/Husband's Name _____
Anesthesia Provider _____ City/Village _____
Height _____ Ward/Bed _____
Weight _____
Pre-op Vital Signs: BP _____ HR _____ RR _____

ANESTHESIA RECORD

PRE ANESTHESIA EVALUATION

NONE

Cardiovascular ECG _____ Heart Sounds _____ ☐
Chest Pain ❑ Hypertension ❑ Rheumatic Fever ❑
Heart Disease ❑ Heart Murmur ❑ Coronary Artery Disease ❑
Congestive Heart Failure ❑ Valvular Disease ❑
Other _____

Respiration CXR _____ Lung Sounds _____ ☐
Asthma ❑ COPD ❑ Pneumonia ❑
Bronchitis ❑ Shortness of Breath ❑ Productive Cough ❑
Tuberculosis ❑ Recent Upper Airway Infection ❑
Other _____

Endocrine ☐
Diabetes ❑ Thyroid Disease ❑
Other _____

Urinary / Renal ☐
Renal Failure ❑ Patient Dehydrated ❑
Urinary Tract Infection ❑
Other _____

Gastrointestinal ☐
Diarrhea ❑ Reflux Disease ❑ Bowel Obstruction ❑
Nausea & Vomiting ❑ Hepatitis/Cirrhosis ❑
Other _____

Neurological Level of Consciousness _____ ☐
Dizziness/Fainting ❑ Stroke ❑
Neuromuscular Disease ❑ Seizures ❑
Paralysis ❑ Muscle Weakness ❑
Other _____

Allergies ☐

Current Medications

Airway ☐
Teeth
Cervical Spine Mobility _____
Temporomandibular Movement _____

With mouth opening able to visualize:
Hard Palate ❑
Soft Palate ❑
Uvula Base ❑
Uvula ❑

Previous Anesthesia Problems ☐

Anesthetic Plan _____

_____ DATE AND TIME

_____ SIGNATURE OF EVALUATING ANESTHESIA PROVIDER

LABORATORY VALUES

CBC
Hb _____ Hct _____
WBC _____ Plts _____
Other _____

Electrolytes/Kidney Function
Na^+ _____ K^+ _____ Mg^+ _____
BUN _____ Creatinine _____
Other _____

Coagulation
Bleeding time _____ Coagulation time _____
Petechia _____ Bruising _____

Urinalysis:

Other Lab:

ASA Classification

❑ ASA Class I: Normal Healthy Patient
❑ ASA Class II: Mild Systematic Disease
❑ ASA Class III: Moderate to Severe Disease
❑ ASA Class IV: Severe Systemic Disease
❑ ASA Class V: Moribund Patient Not Expected to Survive

Mallampati/Samsoon-Young Classification

❑ Class I: Uvula, faucial pillars, and soft palate
❑ Class II: Faucial pillars and soft palate
❑ Class III: Soft and hard palate
❑ Class IV: Hard palate

☐ Anesthetic options, with risks and benefits, have been discussed with the patient and/or legal guardian.

☐ Anesthetic apparatus checked, airway equipment checked, medications assembled and prepared for anesthetic case.

ANESTHESIA RECORD

Intravenous Access: Site _____ Gauge of Needle _____

TIME | TOTALS

Gases: O2 L/min. | N_2O/Air L/min.

IV Medications

End Tidal CO_2
Pulse Oximetry
ECG Rhythm
Inspired O_2
TEMP C°
Tidal Volume
Respiratory Rate

Symbols

X Anesthesia
⊙ Operation
V Blood Pressure
^
• Heart Rate
S Spontaneous Respiration
A Assisted Respiration
C Controlled Respiration

200 180 160 140 120 100 80 60 40 20 S A C

REMARKS

Fluids
Estimated Blood Loss mls
Urine Output mls
POSITION

Immediate pre anesthesia assessment completed ❑

Monitors:
Blood Pressure ❑ EKG ❑
Esophageal/Precordial Stethescope ❑
Pulse Oximeter ❑
Peripheral Nerve Stimulator ❑
End Tidal CO_2 ❑

❑ Blankets on Patient

Induction: ❑ Rapid Sequence Cricoid Pressure
Pre O_2 ____ IV ____ IM ___ IH ___
Airway: ❑ Oral ❑ Nasal

❑ Mask ❑ Oral ETT ❑ LMA
❑ Nasal ETT ❑ Laser
❑ Nasal Cannula ❑ O_2 MASK
ETT Size: _____ mm
Taped @ _____ cm
Blade: _____ Type: _____
❑ Breath Sounds Bilat ❑ Cricoid Pressure
❑ Difficult Intubation (See Remarks) ❑ Atraumatic Intubation

Eyes: ❑ Taped ❑ Lube

INTAKE & OUTPUT:
Crystalloids: _____ mls
Colloid: _____ mls
Packed Red Blood Cells: _____ mls
Platelets: _____ mls
Other: _____ mls
Estimated Blood Loss: _____ mls
Urine Output: _____ mls

CIRCUIT:
Circle ❑ Draw Over ❑
Semi-Open ❑ T-Piece ❑
Non Rebreathing ❑

RECOVERY: _____ hrs
BP ____ / ____ P ____ R ____
Airway: _____ SaO_2 _____
Temp _____
❑ No apparent complications
❑ Complications (See Remarks)

_____
ANESTHESIA PROVIDER

Date _____
ASA _____
Anesthesia:
Start: _____
Finish: _____
Surgery:
Start: _____
Finish: _____
Premedications:
_____
_____
_____

Pressure points checked and padded ❑

REGIONAL - Type
Position _____
Interspace _____
Needle _____
Paresthesia _____
CSF _____
Agent _____
_____
Dose _____
Diluent _____
Volume _____
_____
_____
Prep. Solution _____
Level _____

TOURNIQUET SITE
_____
Pressure: _____ mmHg
Times: _____ - _____
Times: _____ - _____

Surgeon: _____
Operation: _____

_____ _____
ANESTHESIA PROVIDER

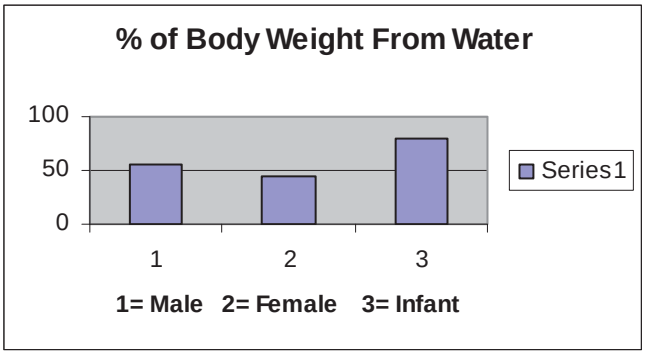
Documentation

Fluid Management and Replacement

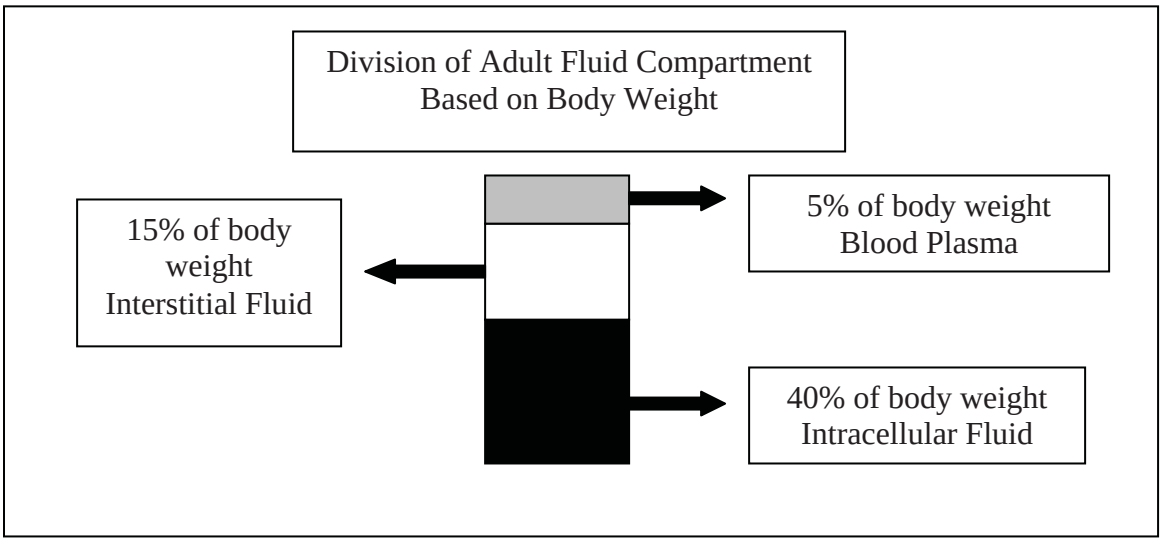
Chapter Three

Fluid Management and Replacement

Water makes up a large portion of the human body. It is vital to its function. 55% of the average man's body weight is water. 45% of a woman's body weight is water. 80% of an infant's body weight is water.



Bodily fluid can be divided into extracellular and intracellular. Extracellular fluid consists of intravascular fluid and interstitial fluid. Intravascular fluid includes blood and plasma. Interstitial fluid is located between cells. Intracellular fluid is located within the cell. The adult male's weight, by fluid compartment, is shown below.



Example: The division of an adult males fluid compartment, based on a 70 kg patient, would be as follows; 28 kg intracellular, 10.5 kg interstitial, and 3.5 kg blood/plasma.

A hot tropical environment and/or dry environment, combined with fasting prior to surgery, requires careful planning and replacement of the patient's fluid deficit. A fasting patient becomes dehydrated. The goal of replacing fluids is to restore the patient's intravascular volume. This will help prevent tachycardia and/or hypotension during anesthesia. Hydration improves the body's ability to carry oxygen and lowers the incidence of nausea and vomiting in the postoperative period.

Preoperative Evaluation

The patient should be evaluated for dehydration. The amount of time the patient has fasted should be determined. If the patient is experiencing acute and excessive nausea, vomiting, or diarrhea, it is not unreasonable to delay an elective surgical procedure and correct the patient's severe dehydration. The patient's fluids may be replaced with oral rehydration solution (ORS) or intravenous fluids. ORS is not effective for patients who have an ileus or bowel obstruction. The signs and symptoms of dehydration may include the following:

Signs & Symptoms of Dehydration

- Dry tongue
- Sunken eyes
- Loss of skin turgor
- Cool and cyanotic extremities
- Absence of veins by sight
- Hypotension (low blood pressure)
- Tachycardia (fast heart rate)
- Low urine output
- High specific gravity on urinalysis
- Sunken fontanel on infants

Calculating Fasting Fluid Deficit

It is important to determine the length of time your patient has been fasting. The patient should be weighed on the day of surgery. This is the first step in determining how much fluid to administer to the patient. The 4-2-1 formula is used to calculate the patient's fasting fluid deficit. The 4-2-1 formula is used for all age groups. The 1st 10 kg of the patient's weight is multiplied by 4ml per kg. The 2nd 10 kg of the patient's weight is multiplied by 2ml per kg. The remaining weight in kg is multiplied by 1 ml per kg. The total number of ml's are multiplied by the number of hours the patient has been fasting.

- 4 ml per kg per hour for 1-10 kg
- 2 ml per kg per hour for 11-20 kg
- 1 ml per kg per hour for 21 kg and up

Example: Calculate the **fasting fluid deficit** for a patient who weighs 60 kg. The patient has fasted for 8 hours. The first 10 kg is multiplied by 4 ml and equals 40 ml. For kg 11-20, multiply 10 kg by 2 ml per kg. This equals 20 ml. The remaining 40 kg is multiplied by 1 ml and equals 40 ml. 40 + 20 + 40 = 100 ml. Multiply 100 ml by the number of hours that the patient has fasted. 100 X 8 equals 800 ml. Example: Calculate the fasting fluid deficit for an 8 kg child. The child has fasted for 8 hours. 8 kg multiplied by 4 ml would equal 32 ml. 32 ml multiplied by 8 hours would equal 256 ml.

The fasting fluid deficit is generally administered over 3 hours. One half of the deficit is infused during the first hour. The 2nd half is administered over 2 hours. In the first example, approximately 400 ml would be infused during the first hour. 200 ml would be infused during the second hour. 200 ml would be infused during the third hour. In the second example, 128 ml would be administered during the first hour. 64 ml would be administered during the second hour. 64 ml would be infused during the third hour. Prior to induction of anesthesia an IV should be started and rehydration initiated. Pediatric patients receiving an inhaled anesthetic induction are an exception to this rule.

Intraoperative Fluid Requirements

Fluid Maintenance Requirements

Patients require fluid maintenance during surgery and in the immediate postoperative period. The patient should receive IV fluid maintenance replacement until they are able to take oral fluids. The amount of IV fluid the patient requires for maintenance is calculated by the 4-2-1 formula.

- 4 ml per kg per hour for 1-10 kg
- 2 ml per kg per hour for 11-20 kg
- 1 ml per kg per hour for 21 kg and up

Example: The fluid maintenance requirements for a patient who weighs 60 kg would be calculated as follows. The first 10 kg is multiplied by 4 ml and equals 40 ml. For kg 11-20, multiply 10 kg by 2 ml per kg. This equals 20 ml. The remaining 40 kg is multiplied by 1 ml and equals 40 ml. 40 + 20 + 40 = 100 ml. The patient should receive 100 ml per hour in maintenance fluid. Example: The fluid maintenance requirements for an 8 kg child would be calculated as follows. 8 kg multiplied by 4 ml would equal 32 ml. The patient should receive 32 ml per hour in maintenance fluid.

Insensible Fluid Loss

Patients experience **insensible fluid loss** during surgery. This fluid is lost by evaporation from the respiratory tract, sweating, and elimination. Insensible fluid loss is calculated by multiplying 2 ml per kg per hour of surgery.

Insensible Loss replace at 2 ml/kg/hour

Example: Insensible fluid loss for a patient whose weight is 60 kg would be calculated as follows. 60 x 2 would equal 120 ml. This is the amount of fluid that would be replaced during each hour of surgery. Example: Insensible fluid loss for a patient whose weight is 8 kg would be as follows. 8 x 2 = 16 ml. This is the amount of fluid that should be replaced for insensible fluid loss during surgery.

Fluid Replacement Based on Surgical Trauma

The extent of surgical trauma influences the amount of fluid that the patient will require during surgery. IV replacement of fluid is based on the amount of tissue exposed, evaporation, and movement of fluids during surgery (3rd spacing). Minor surgical procedures do not result in major tissue trauma, fluid shifts, or fluid loss. The amount is minimal. Moderate to severe surgical procedures result in a greater degree of tissue trauma, fluid shifts, and fluid loss. An example of a minor surgical procedure would be a procedure on the eye. An example of a surgical procedure involving severe surgical trauma would be an intra-abdominal procedure.

Minimal Trauma	3-4 ml/kg/hour
Moderate Trauma	5-6 ml/kg/hour
Severe Trauma	7-8 ml/kg/hour

Example: The amount of fluid required to replace losses in a patient weighing 60 kg, undergoing a minimally traumatic surgical procedure would be as follows. 60 kg multiplied by 3 ml would equal 180 ml per hour. Example: The amount of fluid required to replace losses in a patient weighing 8 kg, undergoing a minimally traumatic surgical procedure, would be as follows. 8 kg multiplied by 3 ml would equal 24 ml per hour.

Blood Loss

Blood loss is replaced with 3 ml of IV solution for every 1 ml of blood loss. Surgical procedures that result in minimal blood loss are not generally a big concern. Surgical cases resulting in larger blood losses should be carefully monitored. It is important to estimate how much blood has been lost and replace it.

IV Solutions

Practice setting may dictate the type of intravenous fluid that is available to the anesthesia provider. Each intravenous solution contains different components. Below is a table that compares the patient's extra cellular fluid (ECF) composition with the components found in common IV solutions.

	Dextrose $mg.dl^{-1}$	Na $mEq.L^{-1}$	Cl $mEq.L^{-1}$	K $mEq.L^{-1}$	Mg $mEq.L^{-1}$	Ca $mEq.L^{-1}$	Lactate $mEq.L^{-1}$	pH
ECF	90-110	140	108	4.5	2.0	5.0	5.0	7.4
5% Dextrose in water (D5W)	50							5.0
5% Dextrose in 0.45% NaCL (D5 and ½ NS)	50	77	77					4.2
5% Dextrose in 0.9% NaCL (D5 and NS)	50	154	154					4.2
0.9% NaCL		154	154					5.7
Lactated Ringers (LR)		130	109	4.0		3.0		6.7
5% Dextrose in lactated ringers (D5LR)	50	130	109	4.0		3.0		5.7

Lactated ringers or normal saline are preferred for fluid replacement during anesthesia and surgery. Lactated ringers are generally administered to an adult. Normal saline is generally administered to pediatric patients. Dextrose containing solutions should not be routinely used.

Putting It All Together

Determine the patient's weight in kg. Determine the number of hours that the patient has fasted. Calculate the patients IV fluid requirements. First, calculate the patient's **fasting fluid deficit**. Second, calculate the patient's **fluid maintenance requirement**. The fluid maintenance requirement is the amount of fluid administered during each hour of surgery. Fluid maintenance requirements should continued postoperatively until the patient is taking oral fluids. Third, calculate the patient's **insensible fluid loss**. Fourth, calculate the patient's fluid requirements based on the degree of **surgical trauma.** Calculating the patient's fluid requirements may seem complicated at first. With practice it will become easy and natural. Ideally, the calculations should be completed prior to surgery. It is helpful to write the calculations out.

Fasting Fluid Deficit	4 ml per kg per hour for 1-10 kg 2 ml per kg per hour for 11-20 kg 1 ml per kg per hour for 21 kg on up
Maintenance Fluids	4 ml per kg per hour for 1-10 kg 2 ml per kg per hour for 11-20 kg 1 ml per kg per hour for 21 kg on up
Insensible Fluid Loss	2 ml per kg per hour

Fluid Requirements Based on Surgical Trauma	minimal trauma = 3-4 ml per kg per hour moderate trauma= 5-6 ml per kg per hour severe trauma = 7-8 ml per kg per hour

Example: Calculate the **fasting fluid deficit** for a patient who weighs 60 kg. The patient has fasted for 8 hours. The first 10 kg is multiplied by 4 ml and equals 40 ml. For kg 11-20, multiply 10 kg by 2 ml. This equals 20 ml. The last 40 kg is multiplied by 1 ml and equals 40 ml. 40 + 20 + 40 = 100 ml. Multiply 100 ml by 8 hours. The **fasting fluid deficit** is 800 ml. Give ½ this amount the first hour, followed by ¼ the second hour, and ¼ the third hour. Calculate the **maintenance fluid replacement.** The first 10 kg is multiplied by 4 ml and equals 40 ml. For kg 11-20, multiply 10 kg by 2 ml. This equals 20 ml. The last 40 kg is multiplied by 1 ml and equals 40 ml. 40 + 20 + 40 = 100 ml. The patient should receive 100 ml per hour in **maintenance fluid**. This is the amount of fluid that the patient should continue to receive until they are able to take oral fluids. Calculate the **insensible fluid loss** by multiplying 2 ml by each kg of weight. 60 kg multiplied by 2 ml equals 120 ml. This is the amount of fluid to administer during each hour of surgery. Calculate the **surgical trauma fluid loss (minor)** by multiplying 3 ml by each kg of weight. 60 kg multiplied by 3 ml equals 180 ml. This is the amount of fluid that should be administered during each hour of the surgical procedure. Below is a summary of the calculations.

Fasting fluid deficit = 800 ml (400 ml 1st hour, 200 ml 2nd hour, 200 ml 3rd hour, 0 ml for the 4th hour, etc.)
Maintenance fluid = 100 ml per hour
Insensible loss = 120 ml per hour
Surgical Trauma fluid loss (minor) = 180 ml/hr

During the first hour the patient would receive 800 ml (400 + 100 + 120 + 180 = 800 ml); during the second hour of surgery the patient would receive 600 ml (200 + 100 + 120 + 180 = 600 ml); during the third hour of surgery the patient would receive 600 ml (200 + 100 + 120 + 180 = 600 ml). During the fourth hour of surgery the patient would receive the amount of fluid calculated for maintenance fluid requirements, insensible loss, and surgical trauma. Fluid replacement would not include the fasting fluid deficit. This deficit has already been replaced in the preceding three hours. Blood loss is replaced with 3 ml of IV fluid for every 1 ml of blood loss. Replacement occurs as blood is lost during the surgical procedure.

Example: Calculate the **fasting fluid deficit** for a patient who weighs 8 kg. The patient has fasted for 8 hours. 8 kg is multiplied by 4 ml and equals 32 ml. 32 ml multiplied by 8 hours equals 256 ml. This is your **fasting fluid deficit**. Give ½ this amount the first hour, followed by ¼ the second hour, and ¼ the third hour. Calculate the **maintenance fluid replacement.** 8 kg is multiplied by 4 ml and equals 32 ml. The patient should receive 32 ml per hour in maintenance fluid replacement.

Calculate the **insensible fluid loss** by multiplying 2 ml by each kg of body weight. 8 kg multiplied by 2 ml equals 16 ml. This is the amount of fluid to administer during each hour of surgery. Calculate the **surgical trauma fluid loss (minor)** by multiplying 3 ml by each kg of weight. 8 kg multiplied by 3 ml equals 24 ml. This is the amount of fluid that should be administered each hour of the surgical procedure. Below is a summary of the calculations.

Fasting fluid deficit = 256 ml (128 ml 1st hour, 64 ml 2nd hour, 64 ml 3rd hour, 0 ml for the 4th hour, etc.)
Maintenance fluid = 32 ml per hour
Insensible loss = 16 ml per hour
Surgical Trauma fluid loss (minor) = 24 ml/hr

During the first hour of surgery the patient would receive 200 ml of fluid (128 + 32 + 16 + 24 = 200 ml); during the second hour of surgery the patient would receive 136 ml (64 + 32 + 16 + 24 = 136 ml); during the third hour of surgery the patient would receive 136 ml (64 + 32 + 16 + 24 = 136 ml). During the fourth hour of surgery the patient would receive the amount of fluid calculated for maintenance fluid requirements, insensible loss, and surgical trauma. Fluid replacement would not include the fasting fluid deficit replacement. This has already been replaced in the preceding 3 hours. Blood loss is replaced with 3 ml of IV fluid for every 1 ml of blood loss. Replacement occurs as blood is lost during the procedure. Administer 3 ml of IV solution for every 1 ml of blood loss.

Drawing a simple grid can help keep track of fluid replacement.

	1st Hour	2nd Hour	3rd Hour	4th Hour
Fluid Deficit				
Maintenance Fluid				
Surgical Trauma				
Blood Loss				
Total				

Estimating Blood Volume

Patients undergoing a surgical procedure that may result in significant blood loss should have an estimated blood volume calculated. This is calculated with the patient's preoperative weight and preoperative hematocrit. The table below is the approximate blood volume based on age and weight.

Age	ml/kg of weight
Premature Infant	100-120 ml/kg
Full Term Infant	90 ml/kg
Infants 3-12 months	80 ml/kg
1 year old to Adult	70 ml/kg

To estimate the maximal allowable blood loss the anesthesia provider should have an idea, based on the patient's physical condition, at what level of hematocrit blood replacement should occur. A general rule is that at a blood loss greater than 25-30% of the patient's estimated blood volume a transfusion may become necessary. It may be less than this if the patient has significant disease processes such as cardiovascular disease. The ability to transfuse blood depends upon the capabilities of individual practice settings. To calculate the maximal allowable blood loss, first estimate the patient's blood volume. Example, a 65 kg adult would have an estimated blood volume of 70 ml per kg. 65 multiplied by 70 equals 4,550 ml of estimated blood. Next, the preoperative hematocrit should be known. In this example it was 36%. Since the patient is healthy, the anesthesia provider has decided to allow the hematocrit to decline to a level of 25%. The formula for calculating the maximal estimated blood loss is as follows:

$$\text{EBV (estimated blood volume)} \times \frac{Hct\ start - target\ Hct}{Hct\ start} = \text{Maximal Allowable Estimated Blood Loss}$$

Example:

Step 1: Subtract Hct start from target Hct.

$$4{,}550 \times \frac{36-25}{36} = \text{Maximal Allowable Estimated Blood Loss}$$

Step 2: 11 is divided by the preoperative hematocrit of 36.

$$4{,}550 \times \frac{11}{36} = \text{Maximal Allowable Estimated Blood Loss}$$

Step 3: Multiply 4,550 by 0.30

$$4{,}550 \times (0.30) = \text{Maximal Allowable Estimated Blood Loss}$$

$$4{,}550 \times (0.30) = 1{,}365 \text{ ml}$$

Surgeons and anesthesia providers usually underestimate blood loss. It is important to monitor the suction bottles, sponges, drapes, gowns, and the floor for blood loss.

Blood Products

One unit of packed red blood cells, with a volume of 250-300 ml, should increase adult hemoglobin by 1 gram and hematocrit by 3%. Generally, 0.5 ml of a unit of packed red blood cells should replace 1 ml of estimated blood loss. Packed red blood cells are concentrated and have a hematocrit of 70-80%. Whole blood will usually have a hematocrit of 40%. If whole blood is used to replace estimated blood loss, then infuse 1 ml of whole blood for each ml of blood loss.

Summary

Administering the appropriate amount of fluid is essential to the well being of the patient. A summary of fluid calculations can be found in the appendix.

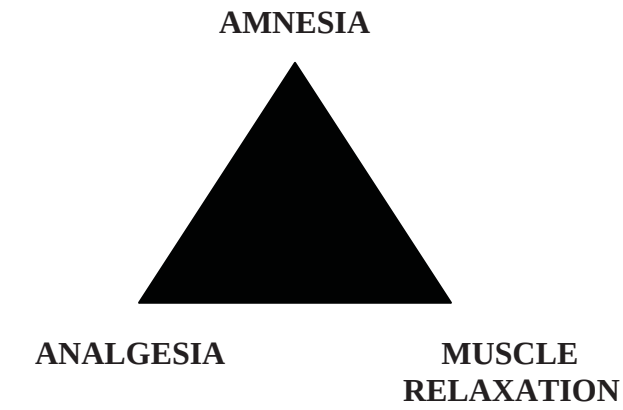
References:

1. Anaesthesia at the District Hospital. Michael B. Dobson. Principles of Fluid and Electrolyte Therapy (p. 36-43). World Health Organization 2000.
2. Basics of Anesthesia (5th edition). Robert K. Stoelting & Robert D. Miller editors. Alicia G. Kalamas. Fluid Management (p. 347-353). Churchill Livingstone/Elsevier. 2007.
3. Nurse Anesthesia (3rd edition). John J. Nagelhout & Karen L. Zaglaniczny editors. Elsevier/Sanders. 2005.

Medications Used in Anesthesia

Chapter Four
Medications Used in Anesthesia

There are three components that complete a general anesthetic: amnesia, analgesia, and muscle relaxation.



To accomplish this several medications must be administered. Inhalation anesthetics are used to induce general anesthesia in pediatric patients, as well as maintain an anesthetic during surgery for adult and pediatric patients. Induction agents (i.e. propofol, thiopental sodium, methohexital, and ketamine) are used to induce general anesthesia by the intravenous route. Propofol can be used as an infusion to maintain general anesthesia. Ketamine can be used by the intravenous route to maintain general anesthesia by administering additional boluses. Muscle relaxants can be divided into two groups. Depolarizing muscle relaxants include succinylcholine. Nondepolarizing muscle relaxants include pancuronium, gallamine, vecuronium, atracurium, and rocuronium. These medications aid in muscle relaxation for intubation and surgical relaxation. Muscle relaxant reversal agents terminate the effects of nondepolarizing muscle relaxants. Analgesics include opioid and non-opioid medications. These medications are important in providing analgesia for the patient during and after the anesthetic. Opioid agonist-antagonists are used to treat mild pain. An opioid antagonist (i.e. naloxone) is useful when an overdose of an opioid occurs. Anti-anxiety medications (i.e. midazolam or diazepam) are useful in the preoperative period to help calm the patient. They are also useful in providing amnesia so the patient will not have recall. Anti-nausea medications reduce nausea and vomiting in the postoperative period. Nausea and vomiting is a common complication of general anesthesia. Vasopressors (i.e. ephedrine and phenylephrine) are useful in the treatment hypotension. Resuscitation medications are used if the patient experiences a cardiac arrest or life threatening bradycardia.

This chapter contains basic information about medications that may be available in your anesthesia practice. The dosages have been checked but it is the responsibility of each anesthesia provider to

check dosages of medications that they are unfamiliar with before administration. The doses contained in this chapter are general guidelines. Each patient may respond differently. Some patients may require less, some more. It is important to know the patient's weight. This aids the anesthesia provider in the administration of the correct dose to the patient. This information should not replace the full prescribing information that can be found with medication inserts or comprehensive pharmacology textbooks.

Malignant Hyperthermia

Malignant hyperthermia is a genetic condition triggered by certain anesthetic medications. Certain populations may be more susceptible to this condition. The overall incidence has been estimated to be 1:40,000 to 50,000 adult anesthetics and 1:15,000 pediatric anesthetics. The main antidote, dantrolene sodium, may not be available in many developing countries. The survival rate for patients that develop malignant hyperthermia during an anesthetic, without treatment with dantrolene sodium, is only 20-30%. When treated with dantrolene sodium the survival rate increases to 70-80%. Malignant hyperthermia is diagnosed by a muscle biopsy. Specialized testing for this condition may not be available in many developing countries. A family history of high fever, muscle stiffness, unexplained cardiac arrest, or other signs and symptoms of malignant hyperthermia may be the only clues that a patient may have this disorder.

Anesthetic Medications that Trigger Malignant Hyperthermia

- Succinylcholine
- Sevoflurane
- Desflurane
- Isoflurane
- Halothane
- Enflurane
- Ether
- Cyclopropane
- Methoxyflurane

Safe Anesthetic Medications for Malignant Hyperthermia

- Local anesthetics
- Propofol
- Barbiturates
- Benzodiazepines
- Etomidate
- Nitrous oxide
- Opioids

Signs & Symptoms of Malignant Hyperthermia

Signs and symptoms of malignant hyperthermia may occur within a few minutes after being exposed to a "triggering" agent or several hours after the exposure. It is possible that the patient had been exposed to anesthetics in the past without a malignant hyperthermic reaction. The following are signs and symptoms of malignant hyperthermia.

- A rapid increase in heart rate
- Muscle stiffness of the jaw muscles as well as the trunk and limb muscles
- Rapid breathing
- Muscle breakdown that may result in a dark colored urine
- Increase in body temperature
- Internal bleeding
- Unexplained cardiac arrest
- A rapid increase in end tidal carbon dioxide

Treatment of Malignant Hyperthermia

The ability to treat a patient with malignant hyperthermia will depend on the resources available. Even if dantrolene sodium is not available the anesthetist should do everything possible to treat the patient. It is possible, with proper treatment, that 20-30% of these patients may survive. If this complication occurs, you will need additional help to carry out the following steps in treating the patient. Several of these steps should occur simultaneously.

1. Tell the surgeon and call for help.
2. Stop all volatile anesthetics/succinylcholine.
3. Hyperventilate the patient with 100% oxygen.
4. If available, mix 60 ml of preservative free water with 20 mg of dantrolene. Administer 2.5 mg/kg intravenous push. Repeat the administration of dantrolene until signs and symptoms of malignant hyperthermia stop. This may take up to 10-30 mg/kg.
5. Administer 1-2 mEq/kg of sodium bicarbonate.
6. Cool the patient if their temperature is greater than 39 degrees Celsius. This can be accomplished by removing drapes, cooling the room, applying ice to the surface of the skin, and the administration of cool normal saline by intravenous route. The goal is to reduce the temperature to less than 38 degrees Celsius.
7. Cardiac dysrhythmias are caused by acidosis and hyperkalemia. Treatment of malignant hyperthermia will usually correct the dysrhythmias. However, you may need to treat the patient with standard antidysrhythmics. Never use calcium channel blockers!
8. Hyperkalemia can be treated with hyperventilation, bicarbonate, glucose/insulin infusion, and calcium. As noted earlier, sodium bicarbonate should be administered in a dose of 1-2 mEq/kg. Calcium chloride may be administered in a dose of 10 mg/kg or 10-50 mg/kg of calcium gluconate. Insulin/glucose infusion may be administered in dose of 10 units of

regular insulin IV and 50 ml of 50% glucose for adult patients. In children, the dose should be 0.1 units of insulin per kg and 1 ml/kg of 50% glucose. Monitor blood glucose levels closely. The administration of albuterol may also decrease potassium levels.

9. Additional treatment is guided by end tidal carbon dioxide monitoring, arterial blood gases, creatinine phosphokinase, and urine output. If urine output declines to less than 0.5 ml/kg/hr, the patient may require diuretics to increase urine output to greater than 1 ml/kg/hr. This may help avoid renal failure. Dantrolene vials contain mannitol, which help with diuresis.
10. Follow up care includes an intensive care environment. Dantrolene in a dose of 1 mg/kg every 4-6 hours may be required. Additional monitoring of laboratory values such as arterial blood gases, electrolytes, glucose levels, and creatinine phosphokinase may be required.
11. The patient and family should be aware of this significant anesthetic related condition so they can inform other health care providers of this condition if future surgical intervention is required.

Inhalation Anesthetic Agents

Halothane

Description: Halothane is a halogenated hydrocarbon. It has a sweet, non irritating smell. It is a potent agent and a vaporizer is necessary for its administration. It is not flammable or explosive in clinical conditions. Inhalational induction is generally rapid and pleasant for the patient, making it suitable for inhaled inductions in children. In adults, halothane is usually started after an intravenous induction.

Dose:

- Concentrations used in anesthesia vary from 0.2-3%. The dose of halothane is often measured by MAC (minimum alveolar concentration). At 1 MAC 50% of patients will move with surgical stimulation.
- Adults: MAC in adults is 0.75%
- Children: MAC ranges from 0.75-1% and varies with age
- Without specialized monitors that measure anesthetic gas levels being inspired and expired, it is difficult to know what concentration of halothane the patient is receiving. When a monitor that measures the concentration of halothane is not available the anesthesia provider must rely on clinical signs of general anesthesia.

Effects:

- Some muscle relaxation, including relaxation of the uterus.
- Bronchodilation
- Depression of respiratory center (shallow breathing at an increased rate).

- Direct myocardial depression, resulting in a decreased blood pressure and heart rate. Ectopic heart beats may be noted in children, especially with procedures such as tonsillectomy and adenoidectomy.
- Vasodilatation
- Retention of carbon dioxide in spontaneously breathing patients may result in the release of catecholamines (i.e. epinephrine). This can cause dysrhythmias. Because of this effect, epinephrine should not be injected in doses greater than 0.1 mg (100 mcg) within a 10 minute period or 0.3 mg (300 mcg) per hour.

Side Effects and Complications:

- 12-25% of halothane is metabolized by the liver. Patients exposed to halothane may have a 1:3000 incidence of halothane induced hepatitis. Patients may exhibit liver dysfunction if they are exposed to several halothane anesthetics in a short period of time. Halothane should not be used in patients with hepatitis or liver disease.
- Halothane should not be used in patients with a family history of malignant hyperthermia.
- Halothane is poorly tolerated in patients that with aortic or mitral stenosis. The use of halothane in these patients may result in significant hypotension, increasing the risk of cardiac arrest.
- Halothane is not recommended for obstetric patients unless there is a surgical need for uterine relaxation (i.e. retained placenta) or for an emergency cesarean section. There are two reasons. The first, halothane causes uterine relaxation and may result in excessive blood loss. The second, halothane crosses the placental barrier and may depress the newborns' vital functions.
- If the surgeon is using cocaine, epinephrine, or other cardiac stimulant medications, carefully monitor the patient for heart rhythm changes. The surgeon should use these medications sparingly. If the heart rhythm changes, notify the surgeon, and stop the administration of the medication.

Isoflurane

Description: Isoflurane is a halogenated volatile anesthetic. Isoflurane is not suitable for inhaled inductions since it may cause breath holding, coughing, and laryngospasm. It is a potent agent that requires administration with a vaporizer. It is not explosive or flammable. Isoflurane is used for the maintenance of general anesthesia after an intravenous induction.

Dose:

- Concentrations for surgical anesthesia vary from 1%-2%. The dose of isoflurane is measured by MAC.
- Adults: MAC is 1.2% (may be less in the elderly).
- Children: MAC ranges from 1.5% to 1.8% and varies with age.

- Without specialized monitors that measure anesthetic gas levels being inspired and expired, it is difficult to know what concentration of isoflurane the patient is receiving. When a monitor that measures the concentration of isoflurane is not available the anesthesia provider must rely on clinical signs of general anesthesia.

Effects:

- Muscle relaxation occurs to a greater degree than with halothane. This will help increase the effects of nondepolarizing muscle relaxants.
- Dose dependent decrease in uterine contractility and tone.
- Bronchodilation
- Depression of respiratory center (shallow breathing at an increased rate).
- Reduces blood pressure through vasodilatation.
- Increases heart rate by 20%. More likely to occur in younger patients than in the elderly.
- Produces myocardial depression
- Isoflurane is minimally metabolized
- Does not sensitize the heart to epinephrine.
- Isoflurane can cause malignant hyperthermia.

Side Effects and Complications:

- Do not use in patients with a personal or family history of malignant hyperthermia.
- Patients with aortic or mitral valve stenosis may not tolerate hypotension and vasodilatation that is produced by isoflurane.
- Decreases in uterine tone may result in an increased blood loss in patients undergoing surgical procedures involving the uterus.
- Isoflurane will cross the placenta, resulting in neonatal depression during a cesarean section. The duration and dose administered will directly affect the amount of depression.

Sevoflurane

Description: Sevoflurane is a fluorinated volatile anesthetic. It is fast acting and has a sweet, non irritating smell. It is a potent anesthetic and a vaporizer is necessary for its administration. Inhalation induction in the pediatric population is rapid, making it a suitable alternative to halothane. In many countries sevoflurane has become the inhaled anesthetic of choice for inhalational inductions in children. Sevoflurane is not flammable or explosive in the clinical setting.

Dose:

- Concentrations for surgical anesthesia vary from 2-3.2%. The dose of sevoflurane is measured by MAC.
- Adults: MAC is 2.0% (may be less in the elderly)
- Children: MAC ranges from 2.5% to 3.2% and varies with age.
- Without specialized monitors that measure anesthetic gas levels being inspired and expired, it is difficult to know what concentration of sevoflurane the patient is receiving. When a

monitor that measures the concentration of sevoflurane is not available the anesthesia provider must rely on clinical signs of general anesthesia.

Effects:

- Rapid induction of anesthesia due to low solubility
- Rapid elimination and awakening due to low solubility
- Undergoes breakdown in soda lime. It should not be used in closed or low flow anesthesia systems.
- Muscle relaxation occurs with the administration of sevoflurane, increasing the effects of nondepolarizing muscle relaxants.
- Produces a dose dependent decrease in uterine contractility and tone.
- Bronchodilation
- Depression of respiratory center (shallow breathing at an increased rate)
- Reduces blood pressure through vasodilatation
- Has little effect on the heart rate.
- Produces depression of myocardial contractility to the same degree as isoflurane.
- Sevoflurane is metabolized by the liver and produces serum fluoride levels.
- Sevoflurane does not sensitize the heart to epinephrine.
- In pediatric patients there is an increased incidence of emergence delirium in the postoperative period. This generally does not last very long.
- Sevoflurane can cause malignant hyperthermia.

Side Effects and Complications:

- Do not use in patients with a personal or family history of malignant hyperthermia.
- Patients with aortic or mitral valve stenosis may not tolerate hypotension and vasodilatation that is produced by sevoflurane.
- Decreases in uterine tone may result in increased blood loss in patients undergoing surgical procedures involving the uterus.
- Sevoflurane will cross the placenta, resulting in neonatal depression during a cesarean section. The duration and dose administered will directly affect the amount of depression.

Desflurane

Description: Desflurane is a halogenated volatile anesthetic. Desflurane requires a specialized vaporizer. To administer the correct dose, the vaporizer must be electrically pressurized and heated. Desflurane is not suitable for inhaled inductions since it may cause breath holding, coughing, and laryngospasm. It is not explosive or flammable. Desflurane is used for the maintenance of general anesthesia after an intravenous induction.

Dose:

- Concentrations for surgical anesthesia vary from 6-9%. The dose of desflurane is measured by MAC.

- Adults: MAC is 6% (may be less in the elderly)
- Children: MAC ranges from 7% to 9% and varies with age.
- Without specialized monitors that measure anesthetic gas levels being inspired and expired, it is difficult to know what concentration of desflurane the patient is receiving. When a monitor that measures the concentration of desflurane is not available the anesthesia provider must rely on clinical signs of general anesthesia.

Effects:

- Muscle relaxation occurs to the same degree as with isoflurane, increasing the effects of nondepolarizing muscle relaxants.
- Produces a dose dependent decrease in uterine contractility and tone.
- Bronchodilation
- Depression of respiratory center (shallow breathing at an increased rate)
- Reduces blood pressure through vasodilatation
- At normal doses, heart rate does not differ much from preoperative levels. With deep anesthesia, heart rate and blood pressure may increase.
- Produces some myocardial depression but less than isoflurane.
- Desflurane is minimally metabolized and does not sensitize the heart to epinephrine.
- Desflurane can cause malignant hyperthermia.

Side Effects and Complications:

- Do not use in patients with a personal or family history of malignant hyperthermia.
- Patients with aortic or mitral valve stenosis may not tolerate hypotension and vasodilatation that is produced by desflurane.
- Decreases in uterine tone may result in increased blood loss in patients undergoing surgical procedures involving the uterus.
- Desflurane will cross the placenta, resulting in neonatal depression during a cesarean section. The duration and dose administered will directly affect the amount of depression.

MAC Dose of Inhaled Anesthetics by Age

Agent	Neonate	Infant	Small Children	Adults
Halothane	0.87%	1.1%	0.87%	0.75%
Isoflurane	1.6%	1.8%	1.5%	1.2%
Sevoflurane	3.2%	3.2%	2.5%	2%
Desflurane	8%	9%	7%	6%

Inhaled anesthetic agents differ in the speed of onset and elimination. This is due to several variables, including tissue solubility. If an inhaled anesthetic agent has a low solubility, it will have a faster onset and elimination. The patient will reach a level of general anesthesia faster. The patient will also emerge from a general anesthetic faster. The more soluble the inhaled anesthetic agent, the slower the onset and emergence from anesthesia. Soluble inhaled anesthetics must first be absorbed into the blood and tissue. Inhaled anesthetics that have a low solubility are not absorbed to the degree of highly soluble inhaled anesthetics, reaching anesthetic levels faster. The following inhaled anesthetic agents are listed in order of highest tissue solubility (slower onset and elimination) to the lowest tissue solubility (faster onset and elimination).

Halothane ➡ Isoflurane ➡ Sevoflurane ➡ Desflurane

Nitrous Oxide (N20)

Description: Nitrous oxide is a valuable and safe anesthetic. Nitrous oxide is a colorless liquid, turning into a gas as pressure is released. It is a good analgesic but poor anesthetic. It has a rapid onset because of its low solubility. It is used with other inhaled anesthetic agents. Nitrous oxide is carried in a physical solution in the blood and eliminated unchanged by the lungs.

Effects:

- Good analgesic, poor anesthetic
- Dizziness and euphoria
- Increased cerebral blood flow
- Nausea and vomiting
- May cause hypotension and arrhythmias
- When nitrous oxide is discontinued 100% oxygen should be used. This is because a large amount of nitrous oxide will be diffusing out of the blood, displacing oxygen in the lungs. This produces diffusion hypoxia.
- The minimum amount of oxygen that should be used is 30%. Nitrous oxide can cause hypoxia.
- Nitrous oxide is 34 times more soluble than nitrogen. This means that nitrous oxide can diffuse into air containing cavities, causing increased pressure. These areas include the middle ear, intestines, and endotracheal tube cuffs.

Dose:

- Adults and children: 0-70%

Contraindications:

- Do not use nitrous oxide in patients with a bowel obstruction or pneumothorax. Do not use nitrous oxide for surgical procedures on the eye or inner ear.
- Caution should be used in patients with mitral or aortic valve stenosis. Changes in blood pressure may be poorly tolerated.

- Avoid using nitrous oxide in or around pregnant patients or personal.

Induction Agents

Thiopental Sodium (Pentothal)

Description: Thiopental is a barbiturate prepared as a yellow powder. It is used as a 2.5% (25 mg per ml) solution for inducing anesthesia. It is strongly alkaline and may cause severe tissue reactions if injected outside a vein. Thiopental is administered by IV only. A normal induction dose will produce unconsciousness in one arm-brain circulation (about 15-25 seconds). The patient will remain unconscious for 5-15 minutes. Recovery occurs when the medication passes out of the brain. The liver is responsible for metabolizing thiopental sodium. Though the effects for anesthesia are short, it takes several hours for the body to eliminate it from the body. This is the reason that repeated doses should not be used.

Effects:

- Depression of the patient's cerebral function resulting in unconsciousness.
- Depression of respiration/apnea
- Causes a decrease in blood pressure. An overdose can result in a severe hypotension. Use decreased dosages in the elderly and patients who are dehydrated. Should be used in reduced dosages in patients with poor heart function.
- With severe blood loss/trauma the use of thiopental may result in severe hypotension or cardiac arrest, thus an alternative induction agent such as ketamine should be used.
- Poor analgesic. Stimulation, such as pain, may lead to laryngospasm, bronchospasm, or bradycardia.
- May increase patient's sensitivity to cold. Keep patient covered and not exposed in the operating room environment.

Dose:

- Adult: 3-5 mg/kg
- Children: 5-6 mg/kg

Contraindications:

- Should not be used in patients with severe blood loss associated with trauma. This could result in severe hypotension and cardiac arrest. An alternative, such as ketamine, should be used.
- Should not be used in patients with a poor functioning heart.
- Should not be used in patients that are experiencing acute asthma reactions.
- Should not be used in patients with porphyria. Porphyria is a genetic condition. The hepatic form of porphyria may result in abdominal pain, neurological abnormalities, seizures, and cardiovascular collapse when barbiturates such as sodium thiopental are administered.

Propofol

Description: Propofol is a short acting intravenous sedative-hypnotic. Propofol has several advantages over other anesthetic agents. The main advantages of propofol include a rapid induction of general anesthesia, rapid return of consciousness, minimal residual effect on the central nervous system, and a decreased incidence of nausea and vomiting. It can be used as an anesthetic induction agent, for the maintenance of general anesthesia, and for short term sedation in intensive care patients that are intubated and mechanically ventilated. Propofol is formulated in an emulsion as a 1% solution. The emulsion contains soybean oil, glycerol, and egg lecithin (derived from egg yolk). The emulsion may cause pain with injection. The emulsion supports bacterial growth and strict aseptic technique must be carried out. When a vial is opened the contents should be used within 6 hours. The rest of the contents should be discarded. Never share the same medication with other patients. The date and time, of when propofol was drawn up, should be recorded on the syringe to avoid administering it after 6 hours.

Effects:

- Propofol interacts with gamma-aminobutyric acid (GABA), the principle inhibitory neurotransmitter in the central nervous system.
- The high lipid solubility of propofol is responsible for its rapid onset. Propofol has a short distribution half life, allowing for rapid awakening.
- The liver is responsible for removing and metabolizing propofol. The kidneys are responsible for excreting the metabolites.
- Onset of action for propofol is 40 seconds. The peak effect is 1 minute. The duration of action is 5-10 minutes.
- The effects of propofol on the cardiovascular system include a decreased systemic vascular resistance (vasodilatation), decreased contractility of the heart, and decreased preload. These factors cause a decrease in blood pressure. Severe hypotension may be seen in patients who are dehydrated, actively bleeding, elderly, and/or those with poor heart function.
- The effects of propofol on the respiratory system include a dose dependant depression of ventilation and apnea. Propofol can easily and rapidly cause an airway obstruction. It also alters the normal respiratory responses to hypoxia and hypercarbia. When administering propofol airway equipment should be immediately available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.
- Propofol solutions that contain sulfites as a preservative should not be administered to asthmatic or actively wheezing patients. Sulfites can cause bronchoconstriction.
- Propofol may cause spontaneous movements and movements that look like tonic-clonic seizures.
- Pain is often associated with injection. A large vein should be used. Smaller veins, such as those on the dorsum of the hand, are often associated with pain. To reduce pain 2 -5

ml of 1% lidocaine can be administered immediately prior to the induction dose of propofol.

- Reduced doses should be used in the elderly and those that are dehydrated.

Dose:

- Adults: 2-2.5 mg/kg slowly over 30 seconds for induction of anesthesia. For maintenance of anesthesia a continuous infusion of 0.1-0.2 mg/kg/min or alternatively intermittent bolus of 20-50 mg.
- Children: 2.5-3.5 mg/kg slowly over 30 seconds for induction of anesthesia. For maintenance of anesthesia a continuous infusion of 0.125-0.3 mg/kg/min.

Contraindications:

- Do not use in hemorrhaging patients.
- Do not use in patients with poor heart function.
- Do not use in patients that are allergic to egg yolks and soy products.
- Administration of propofol for cesarean section may be associated with neonatal depression.
- Not recommended for patients with increased intracranial pressure.

Methohexital

Description: Methohexital is a short acting barbiturate. It can be used for sedation and as an anesthetic. It can be used as the sole anesthetic for pain free procedures. Its onset of action is 20-40 seconds. Methohexital's peak effect is at 45 seconds. The duration of action is 5-10 minutes. It can be used as an alternative to thiopental for anesthetic induction. Methohexital is eliminated by the liver. When the powder form is reconstituted only sterile water, D5W, or normal saline should be used. The powder form of methohexital is incompatible with lactated ringers. The solution will be stable for 24 hours when reconstituted with D5W or normal saline. If reconstituted with sterile water the solution will be stable for longer than 24 hours.

Effects:

- Does not produce analgesia or muscle relaxation.
- May produce excitement in the elderly and children.
- May cause involuntary muscle movements during induction of anesthesia.
- Decreases myocardial contractibility and causes vasodilatation.
- If given outside of a vein severe tissue damage may occur.
- Reduce dose in the elderly and in patients who are dehydrated or bleeding.
- When administering methohexital airway equipment should be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Sedation: For adults and children the dose is 0.25-1.0 mg/kg
- Induction: For adults and children the dose is 1.5-2.5 mg/kg

Contraindications:

- Do not use in patients with a history of porphyria.
- Do not use in patients with status asthmaticus.

Ketamine

Description: Ketamine is a unique medication. In anesthetic doses it leads to 'dissociative anesthesia'. This is a trance like state with profound analgesia and slightly impaired pharyngeal and laryngeal reflexes. Ketamine can be administered IV or IM. The IV dose ranges from 1-2 mg per kg. Induction of anesthesia occurs within 60 seconds. Duration of action is 5-15 minutes. The IM dose ranges from 5-10 mg per kg and takes 2 to 4 minutes to induce anesthesia. The duration of action for IM ketamine is 12-25 minutes.

Effects:

- Hallucinations are common in adults. Premedication with diazepam or midazolam may reduce hallucinations in adults.
- An increase in heart rate and blood pressure.
- Increased intra-ocular pressure and intra-cranial pressure.
- May cause salivation. Atropine or glycopyrrolate should be administered prior to ketamine or at the same time that ketamine is administered. The dose of atropine in adults is 0.4 mg. In children, the dose of atropine is 0.02 mg/kg. The dose of glycopyrrolate in adults is 0.1 – 0.2 mg. In children, the dose of glycopyrrolate is 4-6 mcg per kg. Glycopyrrolate has two distinct advantages over atropine when used to decrease secretions. Glycopyrrolate is two times more potent than atropine in decreasing secretions. Glycopyrrolate causes less tachycardia than atropine.
- Ketamine can cause uterine contractions and should not be used in pregnant patients unless it is used for caesarean section or term forceps delivery.
- There is no muscle relaxation. The patient may move or their arms and legs may assume an abnormal position.
- Ketamine generally supports respiration. The patient still may be at risk for aspiration. For patients at risk, for example a patient that just ate food, aspiration of gastric contents is a real possibility. The patient's airway should be protected with an endotracheal tube, aspiration of stomach contents can be fatal.
- When administering ketamine airway equipment should be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Sedation/analgesia: 0.5-1 mg/kg IV or 2.5-5 mg/kg IM
- Anesthesia induction: 1-2.5 mg/kg IV or 5-10 mg/kg IM
- Maintenance: $\frac{2}{3}^{rds}$ to $\frac{1}{2}$ of the initial dose as needed

Contraindications:

- Should be used cautiously in patients with ischemic heart disease (myocardial infarction, frequent chest pain) and in patients with hypertension.
- Should not be used if the surgeon is using cocaine. If the surgeon is using epinephrine containing solutions for injection, ketamine should be used with caution. The use of cocaine and epinephrine may result in severe hypertension, ischemia to the heart, and heart rhythm changes.
- Should not be used in patients with head injuries.

Muscle Relaxants/Paralytics

Muscle relaxants work at the neuromuscular junction. They block transmission of nerve impulses, resulting in muscular relaxation and paralysis. They do NOT affect the patient's consciousness or sensation. They should not be given to a conscious patient who is not under anesthesia. Muscle relaxants should not be given to any patient that you may not be able to ventilate or intubate. Muscle relaxation is used to allow for intubation and improve the surgeon's ability to operate.

During the course of normal muscle stimulation a wave of electrical impulses passes to a nerve ending in individual muscle fibers. At this junction the electrical impulse causes the release of acetylcholine. Acetylcholine crosses the junction to continue the movement of the electrical impulse, resulting in muscle contraction. Muscle relaxants resemble acetylcholine. This allows the muscle relaxant molecules to occupy the receptor site. By occupying the receptor site the muscle relaxant molecules prevent acetylcholine from attaching. This blocks the transmission of electrical impulses, producing muscle relaxation and paralysis of the muscles. The muscle relaxant is eventually metabolized and normal muscle function is regained.

Guidelines for Giving Muscle Relaxants/Reversal Agents

- Do not give to a patient whom you cannot ventilate or intubate.
- Allow succinylcholine to wear off before administering a nondepolarizing muscle relaxant.
- Do not reverse a nondepolarizing agent if there is no evidence of returning muscle tone or breathing in a patient. Attempted reversal when there is no evidence that the muscle relaxant is wearing off will result in prolonged paralysis.
- A muscle relaxant is not an anesthetic. Make sure the patient is anesthetized. Otherwise the patient may be paralyzed but awake and aware of the surgical procedure.
- Always reverse a nondepolarizing muscle relaxant, even if you think the relaxant has worn off. Patients given a muscle relaxant will frequently have residual muscle relaxation at the end of the surgical procedure.
- Before removal of the endotracheal tube ensure the patient has adequate strength exhibited by keeping the head lifted off the bed for 5 seconds, has the ability to squeeze your hand, and has the ability to follow verbal commands. If you have access to a peripheral nerve

stimulator, use it to determine the degree of neuromuscular blockade in conjunction with clinical signs. Review Positioning and Monitoring chapter for more information on the peripheral nerve stimulator.

Depolarizing Muscle Relaxants

Succinylcholine

Description: Succinylcholine is created by two acetylcholine molecules joined together. It is a depolarizing muscle relaxant. Muscle twitching (fasciculation) is noted when it is administered to a patient. The motor end plates remain depolarized and the muscles paralyzed. Paralysis occurs within 45 seconds. Succinylcholine is metabolized by plasma cholinesterase after 3-5 minutes. A genetic defect (pseudocholinesterase abnormalities) will affect a small percentage of the populations' ability to metabolize succinylcholine. This will result in prolonged paralysis. The patient may require artificial ventilation by an endotracheal tube for several hours. The effect will eventually wear off.

Dose:

- Adults: 0.6 -1.5 mg/kg by IV route
- Children: 1-1.5 mg/kg by IV route
- The usual dose is 1 mg/kg by IV route for both adults and pediatrics. The maximum dose should not exceed 150 mg.
- IM dose: 2.5-4 mg/kg. The maximum dose should not exceed 150 mg.

Side effects:

- Repeated administration may result in severe bradycardia and even cardiac arrest. Atropine may help prevent this. If possible, repeated doses should be minimized or avoided.
- When administering succinylcholine airway equipment should always be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.
- If there is a family history of malignant hyperthermia, succinylcholine and inhaled anesthetics should be avoided.
- Succinylcholine will increase the patients' potassium level in the blood by 0.3-0.5 meq/L. Higher levels of potassium are released in patients with recent burn injuries and a history of neurological diseases such as multiple sclerosis, muscular dystrophy, and paralysis. It can cause a large release of potassium, resulting in cardiac arrest.
- May result in muscle aches and pain after administration.
- The routine use of succinylcholine for pediatric patients is not recommended. This is due to the rare reports of cardiac arrest secondary to high potassium levels in pediatric patients with undiagnosed muscular dystrophy. Succinylcholine should be reserved for emergency intubation, rapid sequence induction, laryngospasm, and other emergent situations.

- Atropine may be administered prior to succinylcholine in children up to 8 years of age. This may prevent bradycardia. Some clinicians do not routinely use atropine for a one time dose but do use atropine if succinylcholine is repeated. Atropine should be drawn up and the patient should be monitored closely for bradycardia. The dose of atropine is 0.010-0.020 mg/kg. The minimum dose is 0.100 mg or 100 mcg in infants or toddlers.

Contraindications:

- Family or patient history of malignant hyperthermia.
- Family or patient history of prolonged paralysis after the administration of succinylcholine.
- Neurological diseases or injuries such as multiple sclerosis, muscular dystrophy, and paralysis.
- Open globe injuries in salvageable eyes.
- Recent, extensive burn injuries.
- Patients with hyperkalemia.

Nondepolarizing Muscle Relaxants

Pancuronium

Description: Pancuronium is a long acting nondepolarizing muscle relaxant. It is called 'nondepolarizing' since it does not depolarize the muscle like depolarizing muscle relaxants. Pancuronium does not cause fasciculation's. Onset of action is 3-5 minutes. Its duration of action is 60-90 minutes.

Effects:

- Blocks the neuromuscular junction and causes paralysis of the muscles.
- Pancuronium can cause an increase of 10-15% in a patient's heart rate and blood pressure. This is due to vagal blockade.
- Pancuronium will usually need to be reversed with neostigmine to terminate its paralytic effects. It is important to reverse this medication. If not reversed the patient may experience weakness due to residual neuromuscular blockade. Neostigmine must be administered with atropine or glycopyrrolate to avoid severe bradycardia or cardiac arrest.
- Always monitor the effects of pancuronium with a peripheral nerve stimulator, if available.
- When administering pancuronium airway equipment should be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Adults/children: 0.04-0.08 mg/kg IV
- Maintenance dose is 0.01 mg/kg IV every 60 minutes as needed

Gallamine

Description: Gallamine is a long acting nondepolarizing muscle relaxant. It is slow in onset, occurring at 1-2 minutes. Peak effect occurs at 3-5 minutes. Duration of action is 25-90 minutes.

Effects:

- Blocks the neuromuscular junction and causes paralysis of the muscles.
- Increases heart rate, blood pressure, and cardiac output by vagal blockade, activation of the sympathetic nervous system, and inhibition of catecholamine reuptake.
- Eliminated by the kidneys.
- Resistance to neostigmine and other anticholinergics if the patient is taking theophylline, has burn injuries, or paresis.
- Always reverse gallamine with neostigmine or pyridostigmine mixed with atropine or glycopyrrolate.
- Always monitor the effects of gallamine with a peripheral nerve stimulator, if available.
- When administering gallamine airway equipment should always be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Intubation dose in adults and children: 1-1.5 mg/kg
- Maintenance of blockade in adults and children is: 0.1-0.75 mg/kg

Contraindications:

- Do not use in patients with myasthenia gravis.
- Do not use in patients with poor renal function.

Vecuronium

Description: Vecuronium is a medium acting nondepolarizing muscle relaxant. Its onset of action is less than 3 minutes. Its peak effect occurs at 3-5 minutes. Duration of action is 25-30 minutes. Vecuronium is generally supplied as a powder that will need to be reconstituted with sterile water or normal saline. Once mixed it retains its potency for 24 hours.

Effects:

- Blocks the neuromuscular junction and causes paralysis of the muscles.
- May cause bradycardia when administered with fentanyl due to its vagotonic effects.
- Hypothermia, antibiotics, local anesthetics, loop diuretics, magnesium, lithium, and aminoglycosides may result in a prolonged neuromuscular blockade.
- If administered after succinylcholine has worn off, dosage requirements may be decreased by 30-40%.
- May result in enhanced neuromuscular blockade in patients with myasthenia gravis.
- Always reverse vecuronium with neostigmine, or pyridostigmine mixed with atropine or glycopyrrolate.
- Always monitor the effects of vecuronium with a peripheral nerve stimulator, if available.

- When administering vecuronium airway equipment should be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Intubation dose in adults and children: 0.08-0.1 mg/kg
- Maintenance of blockade: 0.01-0.05 mg/kg

Rocuronium

Description: Rocuronium is a medium acting nondepolarizing muscle relaxant. Its duration is similar to vecuronium. Its onset is much faster than vecuronium. Onset of action occurs between 45-90 seconds. The peak effect occurs at 1-3 minutes. The duration of action is dose dependant and can last 15 minutes with small doses and up to 150 minutes with larger doses.

Effects:

- Blocks the neuromuscular junction and causes paralysis of the muscles.
- Rocuronium may slightly increase heart rate.
- Hypothermia, antibiotics, local anesthetics, loop diuretics, magnesium, lithium, and aminoglycosides may result in a prolonged neuromuscular blockade.
- If administered after succinylcholine has worn off, dosage requirements may be decreased by 30-40%.
- May result in enhanced neuromuscular blockade in patients with myasthenia gravis.
- Always reverse rocuronium with neostigmine or pyridostigmine mixed with atropine or glycopyrrolate.
- Always monitor the effects of rocuronium with a peripheral nerve stimulator, if available.
- When administering rocuronium airway equipment should be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Intubation dose in adults: 0.6-1.2 mg/kg
- Intubation dose in children: 0.4-1 mg/kg
- Maintenance of blockade in adults and children: 0.06-0.6 mg/kg

Atracurium

Description: Atracurium is a nondepolarizing muscle relaxant with a moderate duration of action. The onset of action is approximately 3 minutes. The peak effect occurs at 3-5 minutes. Its duration of action ranges between 20-35 minutes.

Effects:

- Blocks the neuromuscular junction and causes paralysis of the muscles.

- The metabolism of atracurium is unique. Atracurium is metabolized by Hoffman elimination and ester hydrolysis. Hoffman elimination is temperature and pH dependent, metabolizing 1/3rd of the dose of atracurium. Ester hydrolysis occurs with non-specific plasma esterase's, metabolizing 2/3^{rds} of the dose of atracurium.
- Laudanosine is the major metabolite of Hoffman elimination and ester hydrolysis. In high concentrations laudanosine may cause central nervous system excitement. This generally occurs only with long term continuous infusions.
- The main advantage of atracurium over other nondepolarizing muscle relaxants is its metabolism. Metabolism is independent of kidney, liver, and plasma cholinesterase function. It is an excellent choice in patients with abnormal liver function, renal failure, and pseudocholinesterase abnormalities.
- Histamine release may be associated with an increase in heart rate and a decrease in blood pressure when higher than recommended doses or rapid injection occurs. It does not usually occur with recommended doses when given slowly.
- Increased resistance to neuromuscular blockade in patients taking theophylline and/or patients that have burn injuries or paresis.
- Always monitor the effects of atracurium with a peripheral nerve stimulator.
- Effects may be reversed with neostigmine, edrophonium, or pyridostigmine mixed with atropine or glycopyrrolate.
- When administering atracurium airway equipment should be available including a bag-mask-valve device or anesthesia circuit, oral airways, oxygen, and intubating equipment.

Dose:

- Intubation in adults and children: 0.3-0.5 mg/kg
- Maintenance of blockade in adults and children: 0.1-0.2 mg/kg

Contraindications:

- Use with caution in patients with asthma. If possible use a muscle relaxant that does not release histamine.

Muscle Relaxant Reversal Agents

Neostigmine, pyridostigmine, and edrophonium are used to reverse the effects of nondepolarizing muscle relaxants. They are acetylcholinesterase inhibitors. They increase the concentration of acetylcholine at the nerve endings by inhibiting the breakdown of acetylcholine. Extra acetylcholine will compete with the muscle relaxant for receptors, terminating the action of the muscle relaxant. Careful consideration must be given to dosing these medications. If an overdose is given, the patient may develop a cholinergic crisis. The maximum dose of neostigmine is 5 mg, pyridostigmine 50 mg, and edrophonium 40mg. Symptoms of cholinergic crisis include bradycardia, sweating, nausea, vomiting, bronchospasm, muscle weakness, and even paralysis. Treatment of this condition

includes discontinuing the use of the reversal agents and administering atropine in a dose of 10 mcg/kg IV, every 3-5 minutes, until the symptoms stop.

Neostigmine

Description: Neostigmine is used to reverse the effects of nondepolarizing muscle relaxants. Onset of action is 3 minutes. Duration of action is 40-60 minutes.

Effects:

- Neostigmine must be administered with atropine or severe bradycardia/cardiac arrest may occur. Atropine may be combined in the same syringe as neostigmine. Alternatively, you can administer atropine first. Glycopyrrolate may be used instead of atropine.
- Neostigmine should be used cautiously in patients with a history of seizures, asthma, bradycardia, and abnormal heart rhythms.

Dose:

- Adults/children: 0.05 mg/kg of neostigmine (maximum dose is 5 mg) mixed with 0.015 mg/kg of atropine or glycopyrrolate 0.01 mg/kg.

Contraindications:

- Should not be used in patients with an active case of peritonitis, bowel obstruction, or urinary tract obstruction.

Pyridostigmine

Description: Pyridostigmine is closely related to neostigmine. Pyridostigmine has a slower onset and longer duration of action when compared to neostigmine. Onset of action is 2-5 minutes. Duration of action is 90 minutes.

Effects:

- Pyridostigmine must be administered with atropine or glycopyrrolate to prevent severe bradycardia or cardiac arrest. Atropine or glycopyrrolate may be combined in the same syringe as pyridostigmine. Alternatively, you can administer atropine or glycopyrrolate first.
- Pyridostigmine should be used cautiously in patients with a history of seizures, asthma, bradycardia, and abnormal heart rhythms.

Dose:

- Adults/children: 0.25 mg/kg of pyridostigmine (maximum dose is 30 mg) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate.

Contraindications:

- Should not be used in patients with an active case of peritonitis, bowel obstruction, or urinary tract obstruction.

Edrophonium

Description: Edrophonium is a short acting muscle relaxant reversal. Because it has a short duration of action most anesthesia providers use neostigmine or pyridostigmine to reverse nondepolarizing muscle relaxants. There is a potential risk that edrophonium could wear off and the patient could become paralyzed or weak, since most nondepolarizing medications have a medium to long duration. Onset of action is 30-60 seconds. Duration of action is 5-20 minutes.

Effects:

- Edrophonium must be administered with atropine or glycopyrrolate to prevent severe bradycardia or cardiac arrest. Atropine or glycopyrrolate may be combined in the same syringe as edrophonium. Alternatively, you can administer atropine or glycopyrrolate first.
- Edrophonium should be used cautiously in patients with a history of seizures, asthma, bradycardia, and abnormal heart rhythms.

Dose:

- Adults/children: 0.5-1 mg/kg of edrophonium (maximum dose is 40 mg) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate.

Contraindications:

- Should not be used in patients with an active case of peritonitis, bowel obstruction, or urinary tract obstruction.

Anticholinergic Medications

Anticholinergic medications are administered to prevent the side effects of neostigmine, glycopyrrolate, or pyridostigmine. They also can be administered to decrease secretions and to increase heart rate.

Atropine

Description: The onset is 45-60 seconds. Duration of action is up to 1-2 hours. When used to decrease secretions its duration of action is up to 4 hours.

Effects:

- Tachycardia and rhythm changes may occur.
- Flushing of the skin may occur.
- Decreased sweating

Dose:

- Adults/children: 0.015 mg/kg of atropine given before or with neostigmine, pyridostigmine, or edrophonium IV.
- When used to decrease secretions, the adult dose is 0.4 – 1 mg IV. In children, the dose is 10-20 mcg IV (the minimum dose is 100 mcg).

Glycopyrrolate

Description: The onset of glycopyrrolate is less than 1 minute. The duration of action is up to 2-3 hours. When used to decrease secretions, the duration of action may be up to 7 hours. Glycopyrrolate has two distinct advantages over atropine when used to decrease secretions. Glycopyrrolate is two times more potent than atropine in decreasing secretions. Glycopyrrolate causes less tachycardia than atropine.

Effects:

- Tachycardia and rhythm changes may occur
- Flushing of the skin may occur
- Decreased sweating

Dose:

- Adults/children: 0.01 mg/kg of glycopyrrolate given before or with neostigmine, pyridostigmine, or edrophonium IV.
- When used to decrease secretions, the adult dose is 0.1-0.2 mg IV. In children, the dose is 4-6 mcg/kg IV.

Analgesics

Opioid Analgesics

Opioid analgesics bind to several receptors to produce analgesia. The mu receptors are the primary receptors responsible for analgesia. Stimulation of the mu receptors result in analgesia, hypoventilation, bradycardia, euphoria, and physical dependence. Opioids vary in their potency.

Morphine 10 mg = Fentanyl 100 mcg = Demerol 75 mg

It is important to monitor the patient for respiratory depression. The reversal agent for an opioid overdose is naloxone. Adult dose is 0.1-0.4 mg IV. This can be repeated every 3-5 minutes, if the patient is not responding. The patient's respirations should be supported. A jaw thrust may be needed for patients who have an airway obstruction. Patients who are not breathing should be assisted by mask ventilation or endotracheal tube placement. In children, the dose of naloxone is 10-100 mcg/kg IV. This can be repeated every 3-5 minutes, if the patient is not responding. The patient should be monitored closely since the opioid may have a longer duration of action than the initial dose of naloxone. It is likely that the patient will need to have repeated doses of naloxone.

Morphine

Description: Morphine is an opioid agonist that is an alkaloid derivative of opium. Morphine binds with opiate receptors, decreasing pain. Morphine will start to work in 1 minute when given by the IV route and 1-5 minutes by the IM route. Morphine's peak effect will be at 5-20 minutes by the

IV route and 30-60 minutes by the IM route. The duration of action for morphine is 2-7 hours when administered by the IV or IM route.

Effects:

- Sedation, euphoria, and the inability to concentrate.
- Nausea, vomiting, itching, dry mouth, constipation, and urinary retention.
- Respiratory depression
- If morphine is administered with promethazine, decrease the dose of morphine by half.

Dose:

- Adults: 2.5 mg to 10 mg IV or IM every 2-6 hours. Morphine should be slowly titrated by IV route.
- A smaller dose should be administered to the elderly, adults that weigh less than 60 kg.
- Children: 6 months to 12 years the dosing is 0.03 mg to 0.05 mg/kg by IM or IV route every 3 to 8 hours.

Meperidine/Pethidine

Description: Meperidine and pethidine are the same medication. Meperidine/pethidine is a synthetic opioid that is $1/10^{th}$ as potent as morphine. Meperidine/pethidine will start to work in 1 minute when administered by the IV route and 1-5 minutes by the IM route. The peak effect will be at 5-20 minutes by the IV route and 30-50 minutes by the IM route. The duration of action is 2-4 hours when given by the IV or IM route.

Effects:

- Sedation, euphoria, and the inability to concentrate.
- Nausea, vomiting, itching, dry mouth, constipation, and urinary retention.
- Respiratory depression
- If meperidine/pethidine is administered with promethazine, decrease the dose of meperidine by half.
- Should be avoided in patients with a history of seizures. Meperidine is broken down into metabolites that can contribute to seizures.
- Meperidine is an excellent medication to administer for shivering. Shivering is a natural response of the body to increase temperature. However, shivering can increase the body's oxygen consumption by up to 300%. Shivering should be treated with warm blankets. In adults, a dose of 12.5 mg of meperidine intravenously will help reduce shivering. This dose may be repeated one time.

Dose:

- Adults: 50-150mg IM. The IV dose is 50-100 mg. If given by the IV route it should be titrated in smaller, frequent doses until the desired effect is obtained. For shivering, a dose of 12.5 mg may be administered. This may be repeated once.
- Children: 1- 1.5 mg/kg every 3-4 hours. The preferred route in pediatrics is IM.

Contraindications:

- Avoid in patients with a history of seizures.
- Should not be used in patients who are on MAO inhibitors (i.e. isocarboxazid, phenelzine, tranylcypromine).

Fentanyl

Description: Fentanyl is a potent opioid analgesic. It is 75-100 times more potent than morphine. It has a rapid onset and short duration. When administered by the IV route it will start to work within 30 seconds. Its action will peak at 5-15 minutes. Duration of action is up to 60 minutes.

Effects:

- Sedation, euphoria and the inability to concentrate.
- Nausea, vomiting, itching, dry mouth, constipation, and urinary retention.
- Respiratory depression
- May cause an increase in muscle tone and muscle rigidity.

Dose:

- Adults: 2-10 mcg/kg IV
- Children: 1-5 mcg/kg IV

Codeine

Description: Codeine is an opioid that has some unique features.

Effects:

- Decreases the incidence of coughing
- Treatment of mild to moderate pain
- Codeine produces mild sedation
- May cause mild to moderate nausea and vomiting, especially in children.
- Dizziness

Dose:

- It can be administered orally or IM. If codeine is administered in the preoperative period, the oral dose should be administered in syrup form, 60 minutes prior to the induction of anesthesia.
- Adults: 15-60 mg orally or IM
- Children: 0.5-1.0 mg/kg in patients greater than 1 year of age. The maximum dose in children is 60 mg.

Opioid Agonist-Antagonists

Butorphanol

Description: Butorphanol is an opioid agonist-antagonist. Butorphanol does not work on all of the same receptors as opioid agonists (i.e. morphine, fentanyl, and meperidine). Butorphanol has the ability to produce analgesia with limited depression of respiration and a lower risk of physical dependence. The administration of butorphanol may decrease the effectiveness of pure opioid agonists. The onset of action is 1-5 minutes IVP, with a peak effect in 5-10 minutes. Duration of action is 2-4 hours. Butorphanol may be administered by IM injection. The onset of action is 10 minutes, with a peak effect in 30-60 minutes. Duration of action is 3-4 hours.

Effects:

- Common side effects include sedation, respiratory depression, itching, nausea, vomiting, and urinary retention.
- Respiratory depression can be reversed with naloxone.
- May cause an increase in blood pressure and cardiac output. Should be used with caution in patients with coronary artery disease.
- Analgesia is limited and not as potent as pure opioid agonists.
- Should not be used in patients with a history of opioid dependence. This may cause withdrawal symptoms.

Dose:

- Adults: 0.5-2 mg IV or 1-4 mg IM every 3-4 hours
- Children: not recommended

Nalbuphine

Description: Nalbuphine is an opioid agonist-antagonist. Nalbuphine has the ability to produce analgesia with limited depression of respiration and a lower risk of physical dependence. It is equal to morphine in potency. It is a useful agent to administer to reverse respiratory depression due to the administration of opioids, without reversing analgesia. Nalbuphine can be administered intravenously, intramuscularly, or subcutaneously. The onset of action when administered intravenously is 2-3 minutes, with a peak effect at 5-15 minutes. Duration of action is 3-6 hours. When administered by the intramuscular or subcutaneous route, the onset is less than 15 minutes. Duration of action is 3-6 hours.

Effects:

- Interaction of nalbuphine with general anesthesia can result in respiratory depression.
- Limited analgesia. Administering more than the recommended dose of nalbuphine will not produce additional pain relief, but will increase the side effects.
- Common side effects include sedation, respiratory depression, and itching.
- Respiratory depression can be reversed with naloxone.

- Should not be used in patients with a history of opioid dependence. This may cause withdrawal symptoms.

Dose:

- Adults: 5-10 mg IV, IM, subcutaneously
- Children: not recommended

Pentazocine

Description: Pentazocine is an opioid agonist-antagonist. Pentazocine has the ability to produce analgesia with limited depression of respiration and a lower risk of physical dependence.

Effects:

- Interaction of pentazocine with general anesthesia can result in respiratory depression.
- Limited analgesia. Giving more than the recommended doses of pentazocine will not produce additional pain relief, but will increase the side effects.
- Common side effects are sedation, diaphoresis, and dizziness.
- 20 mg of pentazocine will produce the same amount of sedation, analgesia, and respiratory depression as 10 mg of morphine does.

Dose:

- Adults: 10-20 mg IV or 30 mg IM
- Children: not recommended

Opioid Antagonists

Naloxone

Description: Naloxone is an opioid reversal agent. Naloxone will reverse respiratory depression associated with opioid overdose. Naloxone will have a peak effect at 5-15 minutes and will last between 1-4 hours. The duration of action may be less than the opioid.

Effects:

- Inhibits the effects of opioids at the opiate receptors.
- Naloxone will reverse analgesia, respiratory depression, sedation, and hypotension associated with an opiate overdose.
- Side effects may include sweating, nausea, vomiting, pulmonary edema, arrhythmias, hypertension, or hypotension.

Dose:

- Adults: 0.1-1.0 mg intravenously, subcutaneously, or intramuscularly. Repeat and titrate until it reverses the effects of the opiate.
- Children: 10-100 mcg/kg. Titrate to effect.

- Monitor the patient closely. The duration of action of naloxone may be shorter than the duration of action of the opiate.
- Start with lower doses at first. If an overdose of naloxone is administered side effects such as hypertension, pain, pulmonary edema, agitation, and cardiac arrhythmias may occur.
- Use with caution in patients who may be addicted to opioids. Sudden reversal may cause withdrawal symptoms.

Non-Opioid Analgesics

Ibuprofen

Description: Ibuprofen is a non-steroidal anti-inflammatory medication. It works on different receptors than opioids and opioid agonist/antagonists. Ibuprofen is useful in the management of pain but produces limited analgesia.

Effects:

- Ibuprofen can impair platelet function leading to bleeding. It can cause renal failure in patients with poor kidney function. It should be avoided in patients with kidney disease.
- It should be avoided in patients with impaired cardiovascular function, the elderly, and patients in shock.
- May inhibit bone healing.

Dose:

- It can be administered in an oral suspension preoperatively.
- Adults: 400 mg for adults
- Children: 5-10 mg/kg
- Since the volume of the oral suspension is small, it can be administered 60 minutes prior to anesthesia with little risk of aspiration.
- Ibuprofen, in the form of a rectal suppository, may be administered to children in a dose of 5-10 mg/kg.

Acetaminophen

Description: Acetaminophen is a mild non-opioid analgesic. Acetaminophen also reduces fever by direct action on the hypothalamus heat-regulating center. It can be administered orally in liquid form or as a rectal suppository.

Effects:

- Can be toxic to the liver
- Can cause anemia and reduce the number of platelets. This can lead to an increase in bleeding.
- Acetaminophen should be avoided in patients with a history of impaired liver and/or renal function.

Dose:

- May be given 60 minutes before induction of anesthesia in an oral suspension/syrup.
- Adults: 325-1000 mg every 4-6 hours. Maximum dose in a 24 hour period is 4 grams (4,000 mg).
- Children: 10-15 mg/kg every 4-6 hours. May be given as a rectal suppository after the induction of anesthesia.

Anti-Anxiety Medications

Benzodiazepines are used for sedation, relief of anxiety, muscle relaxation, and amnesia. Benzodiazepines work on GABA receptors in the central nervous system to produce these effects.

Midazolam

Description: Midazolam has several advantages over diazepam. Its onset is more rapid. When administered IV, its effects will be noted in 30 seconds to 1 minute with a peak effect of 3-5 minutes. When administered by the oral route its effects are generally seen in 10 minutes with a peak effect of 30 minutes. The duration of action is less than diazepam. Duration of action for midazolam is 15 minutes to 1.5 hours IV and 2-6 hours with oral administration. Additional advantages of midazolam over diazepam include a decreased incidence of burning with injection and greater amnesic effect (3-4 times more potent than diazepam). The administration of IV midazolam should be titrated with great care. It produces a rapid onset of sedation and may result in loss of airway control, respiratory depression, and hypotension.

Effects:

- Sedation, relief of anxiety, amnesia
- Muscle relaxation
- Respiratory depression
- Hypotension, reduce dose in patients that are hypovolemic
- When midazolam is administered with opioids the patient should be monitored for hypotension and respiratory depression. Consideration should be given to using smaller doses.
- Patients with chronic obstructive pulmonary disease are sensitive to the effects of midazolam.

Dose:

- Adults: For sedation 1 mg IV every 2-3 minutes, titrated to effect.
- Children: For sedation in children 6 months to 5 years of age a dose of 0.05-0.1 mg/kg IVP may be administered to effect. The total dose should not exceed 6 mg. For children aged 6-12 years a dose of 0.025-0.05 mg/kg IVP may be titrated to effect. The total dose should not exceed 10 mg. The oral route may also be used for children 6 months and older. The

dose is 0.25-0.5 mg/kg with a maximum dose of 15-20 mg. The onset for oral midazolam is 10-30 minutes.

- When administering midazolam by the oral route it should be mixed with a small amount (3-5 ml) of a sweet clear juice or analgesic syrup to cover up the bitter taste.
- The dose of midazolam in the elderly should be reduced and titrated to effect.
- Overdose of midazolam is treated with support of respiratory function, treatment of hypotension, and flumazenil.

Contraindications:

- Should not be administered in patients who have untreated open angle or narrow angle glaucoma.

Diazepam

Description: Diazepam is metabolized to other substances that are sedative. This may result in prolonged sedation. The administration of IV diazepam should be titrated with great care. It produces a rapid onset of sedation and may result in loss of airway control, respiratory depression, and hypotension. Diazepam's onset is less than 2 minutes by the IV route. It has its peak effect at 3-4 minutes and will last up to 3 hours. The IV dose can be irritating to veins, resulting in pain and thrombophlebitis.

Effects:

- Sedation, relief of anxiety, amnesia
- Muscle relaxation
- Respiratory depression
- Hypotension

Dose:

- Adults: 2-10 mg IV
- The dose of diazepam in the elderly should be slowly titrated to effect.
- Children from 6 months of age to 11 years: 0.12-0.15 mg/kg.
- Diazepam should be given slowly in the IV. Large veins should be used since diazepam is irritating resulting in thrombophlebitis.
- The IM route is not recommended since diazepam is painful when administered by this route and absorption is unpredictable.

Contraindications:

- Should not be administered in patients who have untreated open angle or narrow angle glaucoma.

Benzodiazepine Antagonist

Flumazenil

Description: Flumazenil is a benzodiazepine antagonist used to reverse respiratory depression, hypotension, or oversedation due to a benzodiazepine overdose. It blocks the effect of benzodiazepines at the GABA receptor in the central nervous system. Onset is1-2 minutes IV. Duration of action is 45-90 minutes.

Effects:

- Reverses the effects of a benzodiazepine overdose.
- May cause withdrawal symptoms in patients that are on long term benzodiazepine therapy or benzodiazepine dependent. Symptoms may include seizures, panic attacks, anxiety, and arrhythmias.
- Should be used cautiously in patients with a history of a seizure disorder.
- Patients may be initially confused and may attempt to pull at the IV or endotracheal tube.
- Monitor the patient for hypertension and arrhythmias.
- Patients should be monitored for up to 2 hours after the administration of flumazenil. There is the potential that the benzodiazepine could resedate the patient since flumazenil may have a shorter duration of action.
- Flumazenil may be irritating to small veins and cause tissue reactions at the injection site. Use large veins when administering this medication.

Dose:

- Adults: 0.2 – 1 mg. 1 mg is the maximum dose. Titrate slowly at a rate of 0.2 mg per minute until the desired effect is noted.

Anti-Nausea Medications

Metoclopramide

Description: Metoclopramide exerts its anti-emetic effect on dopamine2 receptors and increases gastric emptying. Onset of action is 1-3 minutes. Peak effect is 1 hour. Duration of action is 1-2 hours.

Effects:

- Sedation, dry mouth, and hypotension
- Dysphoria or a feeling of uneasiness, agitation, or fear. Dysphoria has been estimated to occur in 1 out of 500 patients. For this reason you may elect to administer metoclopramide after induction of anesthesia.
- Metoclopramide should be used sparingly in children due to increased reactions of agitation, restlessness, and abnormal muscle movements.
- Hypotension may occur if metoclopramide is given rapidly. Metoclopramide should be administered by slow IV push.

Dose:

- Adults: 5-10 mg IV
- Children less than 6 years of age: 0.1 mg/kg
- Children aged 6-14 years: 2.5-5 mg

Contraindications:

- Metoclopramide should not be administered to patients with gastrointestinal obstruction, hemorrhage, or perforation.
- Metoclopramide is contraindicated in patients with epilepsy and pheochromocytoma.

Promethazine

Description: Promethazine is an anti-emetic that blocks histamine receptors. Onset of action is 2-5 minutes IV. Duration of action is 2-8 hours. If administered by the IM route, its onset of action is 15-30 minutes and duration of action is 2-8 hours.

Effects:

- Sedation
- May interact with anesthetics resulting in prolonged sedation.
- Dry mouth, an increase in heart rate and may decrease blood pressure.
- Care must be taken if administered to children.
- Overdoses may result in central nervous system excitement and seizures. Fixed and dilated pupils, flushing of the face, and fever can occur in children if an overdose of promethazine is administered.

Dose:

- Adult: 12.5 mg-25 mg IV or IM
- Children: If given in pediatric patients, the child must be older than 2 years of age, and the dose is 0.25-0.5 mg/kg with a maximum dose of 25 mg.
- Promethazine should be used sparingly in children due to increased reactions of agitation, restlessness, and abnormal muscle movements.

Odansetron

Description: Odansetron is an anti-nausea medication that blocks the 5-HT3 receptor. It works within 30 minutes and may last 12-24 hours.

Effects:

- Should be administered slowly over 1-5 minutes.
- May cause hypotension, changes in heart rate, bronchospasm, or rarely seizures.
- May cause discomfort or irritation at the IV site.

Dose:

- Adults: 4 mg intravenously

- Children: 0.15 mg/kg intravenously

Diphenhydramine

Description: Diphenhydramine will block the H-1 histamine receptor, reducing nausea and vomiting. It also can be used in the treatment of allergic reactions. It has a slight sedative effect. It will start to work within a few minutes, lasting up to seven hours.

Effects:

- Blocks H-1 histamine receptors
- Children are at increased risk for restlessness, agitation, and seizures.
- Should be used with great caution in patients with a history of a seizure disorder, narrow-angle glaucoma, bowel obstruction, and urinary bladder neck obstruction.
- May cause arrhythmias, audible wheezing, sedation, confusion, and blurry vision.
- It should never be used in premature infants or newborns. It should be used with caution in children.

Dose:

- Adults: 10-50 mg or 0.3-0.5 mg/kg intravenously
- Children: 0.5 mg/kg with a maximum dose of 6.25 mg in children aged 2-6 yrs; a maximum dose of 12.5-25 mg in children aged 6-12 years.

Droperidol

Description: A butyrophenone that is used as an antiemetic. Droperidol may cause sedation. It exerts its antiemetic effects at the chemoreceptor trigger zone in the brain. Onset is 3-10 minutes. Duration of action is 2-4 hours.

Effects:

- May lower blood pressure
- May cause abnormal movements and feelings of impending doom if administered in the preoperative period. This may be treated with 25 mg of diphenhydramine.
- May cause an abnormal heart rhythm by prolonging the QT interval. This is a rare complication.

Dose:

- Adults: 0.625 mg IVP
- Children: not recommended

Contraindications

- Do not use in patients with Parkinson's disease.

Common Vasopressors

Ephedrine

Description: Ephedrine is a medication that increases heart rate and blood pressure. It also can cause bronchodilation. The onset is immediate when administered by the intravenous route. It will have a peak effect at 2-5 minutes and last 10-60 minutes. When administered IM, it will have a peak effect in less than 10 minutes, with a duration of action of 10-60 minutes. Ephedrine is a temporary measure to improve heart rate and hypotension. Never use it as a substitute for volume replacement, only as a temporary measure while other actions are taken to increase the heart rate and blood pressure.

Effects:

- An increase in heart rate and blood pressure
- May cause hypertension, tachycardia, and an increase in blood sugar. In patients who are awake it may cause anxiety and tremors.

Dose:

- Adults: 5-20 mg IV. Titrate to effect. Ephedrine may be given IM in a dose of 25-50 mg.

Phenylephrine

Description: Phenylephrine is a medication used to treat hypotension. It is a direct vasoconstrictor, increasing blood pressure. Caution should be used in patients who are bradycardic, since vasoconstriction can cause a further slowing of the heart rate. Phenylephrine is a temporary measure to improve hypotension. Never use it as a substitute for volume replacement, only as a temporary measure while other actions are taken to increase the blood pressure. Phenylephrine works rapidly in less than 1 minute. It will last 15-20 minutes. Phenylephrine often will come in a very concentrated 1% solution or 10 mg/ml. It must be diluted prior to administration. The most common method is to remove 0.01 ml or 1 mg and dilute it in 10 ml of normal saline. This will result in a 0.01% solution or 100 mcg/ml.

Effects:

- Increases blood pressure through vasoconstriction.
- May cause bradycardia. Use with extreme caution in patients with a low heart rate.
- If injected into tissue it may cause tissue damage since it will constrict the vessels. Make sure the IV is working well before injecting.
- Use phenylephrine cautiously in patients with bradycardia, severe coronary artery disease, and elderly patients.

Dose:

- Adults: 50-100 mcg

Resuscitation Medications

Atropine

Description: Atropine is an anticholinergic medication that blocks vagal impulses to the heart. Vagal impulses can slow the heart rate to the point of cardiac arrest. Atropine can be used in both adults and children to treat bradycardia. It is important to treat slow heart rates quickly, so the patient does not go into cardiac arrest.

Effects:

- Dry mouth, dizziness, dilated pupils, tachycardia, and hypertension.

Dose:

- Adults: initial dose of 0.5 mg IV. May be repeated in increments, up to a total dose of 3 mg.
- Children: 0.01-0.02 mg/kg IV (the minimum dose is 100 mcg)
- If an IV route is not available you can mix the atropine with sterile normal saline. The volume of normal saline should be the same as the volume of atropine. This mixture can be administered through the endotracheal tube. This route is not as effective as the IV route.

Epinephrine

Description: Epinephrine is an important medication to administer during a cardiac arrest. During a cardiac arrest it is important to shut off the gas anesthetic, open up the IV fluids, begin CPR, and administer epinephrine.

Effects:

- Epinephrine works on the heart by increasing cardiac output and heart rate.
- It also constricts the patient's vascular system, increasing blood pressure.

Dose:

- Adults: 0.5 to 1 mg should be given IV
- Children: 0.01 mg/kg IV
- If an IV route is not available mix epinephrine with sterile normal saline in equal volumes and administer it through the endotracheal tube. This route is not as effective as the IV route.

Basic Considerations for the Administration of Medications

- Sink with running water available to wash hands. Hand hygiene includes washing both hands for 10-15 seconds. Dry hands with a clean towel.
- Anesthesia areas should be clean with an absence of vomit, dust, and insects. This will help prevent contamination.
- Antiseptic solution concentration and percentage should be labeled.
- Gauze or cotton wool should be stored in dry containers.

- Area of injection or intravenous catheter site should be cleansed with cotton swab dipped in alcohol and dried with a cleaning agent.
- Use a new syringe for each medication. Do not reuse syringes.
- Label the syringe with the name of the medication to prevent confusion.
- Shake the vials of medications well before withdrawing medications.
- Syringes should be disposed of in a puncture resistant container.

Anesthesia Medication Dosages

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Acetaminophen (non-opioid analgesic)	325-1000 mg every 4-6 hours. Maximum dose is 4,000 mg in a 24 hour period.	10-15 mg/kg every 4-6 hours	Can be toxic to the liver. Avoid in patients with impaired liver function or renal function.
Atracurium (nondepolarizing muscle relaxant)	Intubation: 0.3-0.5 mg/kg Maintenance: 0.1-0.2 mg/kg	Intubation: 0.3-0.5 mg/kg Maintenance: 0.1-0.2 mg/kg	Use with caution in patients with asthma.
Atropine (to decrease secretions)	0.4 mg	0.02 mg/kg	Minimum dose for child is 100 mcg. Max dose for teen aged child is 1 mg.
Atropine (for low heart rate)	0.5 -1 mg max dose 3 mg	0.02 mg/kg max dose child is 0.5 mg	Minimum dose for child is 100 mcg. Max dose for teen aged child is 1 mg.
Atropine (combined with neostigmine pyridostigmine or edrophonium)	0.015 mg/kg of atropine given before or with neostigmine, pyridostigmine or edrophonium IV.	Same	
Butorphanol (non-opioid agonist/antagonist)	0.5-2 mg IV or 1-4 mg IM every 3-4 hours	Not recommended	Do not use in patients with coronary artery disease. Do not use in patients with opioid dependence.
Codeine (opioid analgesic)	15-60 mg orally	0.5 – 1 mg/kg for patients > 1 year old (max dose is 60 mg)	Can be given every 4-6 hours
Diazepam (sedation/anti-anxiety)	2-10 mg	0.12-0.15 mg/kg for a child aged 6 months to 11 years of age.	Decrease the dose for the elderly.
Diphenhydramine (anti-emetic)	25-50 mg or 0.3-0.5 mg/kg intravenously	0.5 mg/kg with a maximum dose of 6.25 mg in children 2-6 years; maximum dose of 12.5-25 mg in children 6-12 years.	Use cautiously in children. Never use in premature infants or newborns.

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Droperidol (anti-emetic)	0.625 mg IVP	Not recommended	May cause abnormal movements or feelings of impending doom. Treat with 25 mg diphenhydramine. Do not use in patients with Parkinson's disease. May cause a serious abnormal heart rhythm.
Edrophonium (reversal of nondepolarizing muscle relaxants)	0.5-1 mg/kg of edrophonium (maximum dose is 40 mg of edrophonium) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate	Same	Maximum dose is 40 mg. Must be mixed with atropine or glycopyrrolate. Short duration of action may allow the non depolarizing muscle relaxant re-paralyze the patient.
Ephedrine (vasopressor)	5-20 mg intravenously. Titrate to effect. Ephedrine may be given intramuscularly in a dose of 25-50 mg.	Not recommended	Never use as a replacement for volume resuscitation.
Epinephrine (cardiac arrest)	0.5-1 mg	0.01 mg/kg	
Fentanyl (opioid analgesic)	2-10 mcg/kg IV	1-5 mcg/kg IV	
Flumazenil (reversal/antagonist for benzodiazepines)	0.2 – 1 mg. 1 mg is the maximum dose. Titrate slowly at a rate of 0.2 mg per minute until the desired effect is noted	Not recommended	Use with great caution in patients that have a history of seizures or dependent on benzodiazepines.
Gallamine (muscle relaxant)	Intubation 1-1.5 mg/kg Maintenance: 0.1-0.75 mg/kg	Same as adults	Do not use in patients with decreased renal function.
Glycopyrrolate (to decrease secretions)	0.1-0.2 mg	4-6 mcg/kg	
Glycopyrrolate (reversal of nondepolarizing muscle relaxants)	0.01 mg/kg of glycopyrrolate given before or with muscle relaxant reversal.	0.01 mg/kg of glycopyrrolate given before or with muscle relaxant reversal.	

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Ibuprofen (non-opioid analgesic)	400 mg orally	5-10 mg/kg orally	Can be given every 6 hours
Ketamine (anesthetic)	2 mg/kg	0.5-2 mg/kg	Use atropine to decrease secretions
Meperidine/Pethidine (opioid analgesic)	50-100 mg IV 50-150 mg IM every 3 to 4 hours	1 – 1.5 mg/kg IM or IV every 3-4 hours	Decrease dose by half if patient has been given promethazine. Decrease dose in elderly and those that weigh less than 60 kg.
Methohexital (anesthetic induction)	Sedation: 0.25-1 mg/kg IV Induction: 1-1.5 mg/kg IV	Same	
Metoclopramide (anti-emetic)	5-10 mg	0.1 mg/kg less than 6 years old. 2.5-5 mg 6 years to 14 years.	Given every 6-8 hours as needed.
Midazolam (sedation/ to reduce anxiety/ amnesia)	Sedation: 1 mg IV every 2-3 minutes, titrated to effect	IV route: 6 months to 5 years a dose of 0.05-0.1 mg/kg titrated to effect. (Max 6 mg) 6-12 years a dose of 0.05-0.1 mg/kg (Max 10 mg) Oral Route: 6 months and older 0.25- 0.5 mg/kg with max dose of 15-20 mg.	Oral dose should be mixed with a small amount (3-5 ml) of sweet clear juice or analgesic syrup to cover up bitter taste. Oral dose takes up to 30 minutes to be fully effective. Potent sedative, monitor patients for respiratory depression and hypotension.
Morphine (opioid analgesic)	2.5-10 mg IM or IV every 2-6 hours	0.03-0.05 mg/kg IM or IV every 3-8 hours. For children 6 months to 12 years.	Decrease dose by half if patient has been given promethazine. Decrease dose in elderly and those that weigh less than 60 kg.
Nalbuphine (opioid agonist-antagonist)	5-10 mg IV, IM, or subcutaneously.	10-100 mcg/kg IV, IM, or subcutaneously.	Do not use in patients with a history of opioid dependence.

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Naloxone (opioid antidote)	0.1-.04 mg IV, IM, or SC	10-100 mcg/kg IV, IM, or SC	Antidote for opioids. May be given by IV, IM, or SC (subcutaneous) routes. Repeat every 3-5 minutes until the patient is responding and breathing.
Neostigmine (reversal for nondepolarizing muscle relaxants)	0.05 mg/kg neostigmine (maximum of 5 mg) must be given with atropine or glycopyrrolate	Same dose as adult	Reversal for nondepolarizing muscle relaxants. Mix or give the atropine or glycopyrrolate first. Neostigmine can cause severe bradycardia if given alone.
Odansetron (anti-emetic)	4 mg intravenously	0.15 mg/kg	
Pancuronium (muscle relaxant)	Intubation: 0.04-0.08 mg/kg Maintenance: 0.01 mg/kg every 60 minutes	Same dose as adult	If you need to repeat the dose give 0.01 mg/kg in adults and children.
Pentazocine (opioid agonist-antagoinist)	20 mg IM or IV	Not used in children	Give every 2-4 hours as needed.
Phenylephrine (vasopressor)	50-100 mcg IV	Not routinely used in children	Never use as a replacement for volume replacement. May cause bradycardia in patients who are hypovolemic.
Promethazine (anti-emetic)	12.5-25 mg	0.25-0.50 mg/kg. Must be greater than 2 years. Max dose is 25 mg.	If given IV, give slowly over 5 minutes. Same dose can be given IM. Should be given every 4-6 hours as needed.

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Propofol (anesthetic induction)	2-2.5 mg/kg slowly over 30 seconds for induction of anesthesia. For maintenance of anesthesia a continuous infusion of 0.1-0.2 mg/kg/min or alternatively intermittent bolus of 20-50 mg.	2.5-3.5 mg/kg slowly over 30 seconds for induction of anesthesia. For maintenance of anesthesia a continuous infusion of0.125-0.3 mg/kg/min.	Give slowly over 30 seconds. May cause pain with injection.
Pyridostigmine (nondepolarizing muscle relaxant reversal)	0.25 mg/kg of pyridostigmine (maximum dose is 30 mg of pyridostigmine) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate.	0.25 mg/kg of pyridostigmine (maximum dose is 30 mg of pyridostigmine) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate.	Antidote for nondepolarizing muscle relaxants. Mix or give the atropine or glycopyrrolate first. Pyridostigmine can cause severe bradycardia if given alone.
Rocuronium (muscle relaxant)	Intubation dose in adults: 0.6-1.2 mg/kg. Maintenance of blockade in adults and children: 0.06-0.6 mg/kg.	Intubation dose in children: 0.4-1 mg/kg. Maintenance of blockade children: 0.06-0.6 mg/kg.	
Succinylcholine (depolarizing muscle relaxant)	Intubation dose: 0.6-1.2 mg/kg IV 2.5-4 mg IM dose.	Intubation dose: 1-1.5 mg/kg IV 2.5-4 mg IM dose.	Should not use more than 150 mg. Many contraindications…review carefully. Repeated doses close together may cause bradycardia or cardiac arrest.
Thiopental Sodium (anesthetic induction)	3-5 mg/kg	Children: 5-6 mg/kg Infants: 7-8 mg/kg	Use with caution in the elderly and dehydrated or bleeding patients.
Vecuronium (muscle relaxant)	Intubation: 0.08-0.1 mg/kg Maintenance: 0.01-0.05 mg/kg	Same as adult dose	

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Preparing for Anesthesia

Chapter Five
Preparing for Anesthesia

The preparations that an anesthesia provider performs prior to an anesthetic are essential steps to safe care. Take time to ensure that equipment is prepared and in good working order before the patient enters the operating room. There are three areas to be concerned about: general equipment check, patient related equipment check, and information about the patient.

General Equipment Check

Specific recommendations on equipment will not be given since it may vary from practice to practice. There are some general guidelines that will prove useful, ensuring the safety of the patient.

- Ensure the oxygen cylinders have an adequate supply of oxygen. Additional sources of oxygen should be available in case the primary source fails. It takes only minutes for a patient to develop hypoxia and suffer harm.
- Turn on the oxygen supply, check the pressure, and for the flow of oxygen.
- Ensure that connections to the oxygen cylinder are tight and without leaks. Check the inlet filter for dust. Clean it if necessary.
- Check for leaks or breaks in the oxygen supply lines.
- Calibrate the oxygen sensor. The alarm should be on to alert the anesthesia provider of a low oxygen reading.
- If oxygen sensors are not available in your practice setting, the only means of ensuring that cylinders contain oxygen may be your sense of smell. It is possible that cylinders may contain a gas other than oxygen. Always smell the gas before administering it to the patient.
- Oxygen reservoir check. Check for proper assembly of T-piece, ensuring that the air inlet is unobstructed.
- Check spare oxygen cylinders. Ensure there is an adequate amount of oxygen.
- Test the adequacy of oxygen flow through the anesthesia circuit. Ensure the anesthesia circuit has no leaks. This can be tested by placing a finger over the end of the circuit and allowing the anesthesia bag to fill up. If the anesthesia circuit retains the oxygen, then there are no leaks. An intact anesthesia circuit, with no leaks, is essential to safe anesthesia.
- Vaporizer check. Check if the vaporizer is filled and its connectors fit.
- Check carbon dioxide canisters for color changes, indicating the absorbent needs to be replaced.
- Self inflating bags/bellows. Check connection.
- Breathing valve. Check by breathing through it yourself.
- Check the mechanical ventilator to ensure that it is functioning properly. Ensure the settings are correct for the patient prior to use.
- Ensure safety alarms are on and not shut off.

- If nitrous oxide is available, ensure the flow meters work correctly, preventing a hypoxic dose.
- Test the suction set up. Ensure that it is working properly.
- Test pulse oximetry and other equipment that will be used to monitor the patient's vital functions.
- Test the capnography by exhaling carbon dioxide into the tubing.
- Test the bag mask device to ensure its proper function. Make sure that it is the proper size for the patient.

Patient Related Equipment Check

It is important to have all the equipment necessary for anesthesia care immediately available. For each patient assemble the following supplies and equipment:

- A mask that fits the patient's face.
- Endotracheal tubes appropriate for the age and size of the patient. For pediatric cases, assemble the size calculated and one size larger and one size smaller. For adult patients, ensure that the endotracheal tube cuff is intact and holds air. Have a back up endotracheal tube available.
- An assortment of oral and nasopharyngeal airways that are the correct size for the patient.
- Tape to secure the endotracheal tube and to tape the eyes shut. Taping the eyes shut during a general anesthetic will avoid corneal abrasions. Corneal abrasions are painful scratches on the eye caused by trauma or drying.
- Check the laryngoscope handle and blade, ensuring they work. Assemble the correct types of laryngoscope blades for the patient's age and size.
- Ensure that intravenous fluids are immediately available. Calculate the patient's fluid requirements.
- Assemble medications. Calculate the appropriate dosages based on patient weight. It is helpful to write the correct doses at the top of the anesthesia worksheet.
- Assemble syringes and needles.
- Have emergency medications out and immediately available. These would include medications such as epinephrine, atropine, and succinylcholine. Ensure you calculate the appropriate dosages for each patient. Write them down. This will make it easier to draw up and administer if an emergency arises.

Preoperative Assessment of the Patient

It is your responsibility to provide the safest possible anesthetic care to each patient. This begins with a thorough and accurate preoperative assessment. If the patient presents with medical conditions that may adversely impact the ability to provide a safe anesthetic, question whether or not

an elective procedure should be postponed, allowing for improving the patient's condition. Examples of conditions that may warrant postponing an elective procedure include, but are not limited to the following:

- An active upper respiratory tract infection
- Active nausea and vomiting leading to significant dehydration
- Diarrhea leading to significant dehydration
- Other acute conditions that may place the patient at risk for complications.

Should the patient require a consultant to treat their medical conditions before surgery, notify the surgeon of your concern and request a consultation. Examples of situations that may warrant a consultation would include:

- Undiagnosed or untreated hypertension
- Acute chest pain
- Shortness of breath
- Active wheezing
- Abnormal laboratory values
- Poorly controlled diabetes

Once a preoperative assessment has been completed, an individualized anesthetic technique should be selected that is suitable for the patient. For example, a patient with severe cardiac disease may better tolerate a local or regional anesthetic, with or without sedation, rather than a general anesthetic. Regardless of the technique, it is your responsibility to consider which medications may be appropriate or inappropriate based on the patient's condition and co-existing diseases.

Medical History, Interview and Physical Exam

Review the patient's history and interview them. There should be an accurate weight recorded to help calculate appropriate dosages of anesthetic medications. Review the patient's vital signs. This can be a guide in what may be normal for that particular patient.

Age	Normal Heart Rate Range	Bradycardia	Tachycardia
Adult	60-100 beats per minute	Less than 60	Greater than 100
Children 1-8 years	80-100 beats per minute	Less than 80	Greater than 100
Infants 1-12 months	100-120 beats per minute	Less than 100	Greater than 120
Neonates 1-28 days	120-160 beats per minute	Less than 120	Greater than 160

Age	Normal Systolic Blood Pressure	Normal Diastolic Blood Pressure
Adult	90-140 mmHg	60-90 mmHg
Child 1-8 years	80-110 mmHg	
Infant 1-12 months	70-95 mmHg	
Neonate 1-28 days	Greater than 60 mmHg	

Age	Normal Respiratory Rate
Adult	12-20 breaths per minute
Children 1-8 years	15-30 breaths per minute
Infant 1-12 months	25-50 breaths per minute
Neonate 1-28 days	40-60 breaths per minute

Note allergies, sensitivities, or adverse reactions to medications. Note allergies, sensitivities, or adverse reactions to tape or foods. Review current medications that the patient is taking, both prescription and over the-counter. Medications the patient is currently taking may interact with anesthetic medications or impact the patient during the anesthetic.

Medication	Potential Effects During Anesthesia
Alcohol abuse, chronic opioid or benzodiazepine use	May lead to a tolerance to anesthetic medications. The patient may require more than what is anticipated.
Beta blockers	May lead to bradycardia, bronchospasm, reduced responsiveness to vasopressors that target the sympathetic nervous system, and may depress the heart leading to hypotension.
Antibiotics (aminoglycosides)	May prolong the effect of nondepolarizing muscle relaxants.

Aspirin, coumadin, ticlopidine, clopidogrel, warfarin, heparin, low molecular weight heparin, and other blood thinners/anticoagulants	May increase the risk for bleeding/hemorrhage. Neuraxial blockade is contraindicated in patients who are anticoagulated.
Calcium Channel Blockers	May cause hypotension.
Digitalis	May cause changes in the heart rhythm.
Diuretics	May cause changes in electrolytes such as potassium and sodium which may result in changes in the heart rhythm.
Monoamine Oxidase Inhibitors and Tricyclic antidepressants	May cause an exaggerated response to vasopressors such as ephedrine/epinephrine.
Insulin and oral hypoglycemics	May result in a very low blood glucose level

Ask the patient about herbal remedies. Some herbal remedies may place the patient at increased risk for bleeding.

Herbal Remedy	**Potential Effect for Increased Bleeding**
Garlic, Ginger, Ginseng, Ginko, Feverfew, & Vitamin E.	May decrease the platelet's ability to form the primary clot.
Alfalfa, Chamomile, Horse Chestnut	May contain a coumadin like substance.

Review the patient's previous surgical history. Inquire about a patient and/or family history of complications related to anesthesia. If the patient has a history of being paralyzed and/or unable to breathe without assistance after an anesthetic, then you may want to avoid succinylcholine. The patient may be unable to metabolize this medication. If the patient has never had surgery but a blood relative died due to a high fever during anesthesia, then you may want to avoid a general anesthetic. The patient may have malignant hyperthermia. This potentially fatal condition occurs when a patient with a malignant hyperthermia susceptibility trait is exposed to triggering agents, which include inhaled anesthetics, succinylcholine, and rarely stress. Has the patient ever experienced jaundice after an anesthetic? This may indicate halothane hepatitis or liver dysfunction related to anesthetic medications. Ask the patient about the last time they ate or drank. This will ensure that the patient has followed the preoperative instructions regarding the intake of food and fluids. It will also assist the anesthesia provider in calculating fluid replacement.

Fasting Elective Cases

- Adults: no solid food for 8 hours; clear liquids up to 2 hours preoperatively.
- Children and Infants: no solid food for 8 hours; non-human milk up to 6 hours; breast milk up to 4 hours; water up to 2 hours preoperatively.

Emergency Cases

- If the surgery can be safely delayed, wait 6 hours since the last solid food intake. If the surgery cannot be delayed for 6 hours, then proceed with a rapid sequence induction with cricoid pressure. (Please refer to airway management chapter.)

Review of Systems

The patient should have a systematic review of the systems. The anesthesia record in this manual can guide the anesthesia provider in assessing the patient preoperatively.

Cardiovascular- Review the electrocardiogram if there is one available. Ask the patient about a history of chest pain, hypertension, rheumatic fever, valvular disorders, congestive heart failure, or other problems. Ask the patient if they get short of breath or have chest pain with activity. This may be a sign of coronary artery disease.

Respiratory- Review the chest x-ray if there is one available. Ask the patient about a history of asthma, smoke exposure, smoking history, recent upper airway infections, tuberculosis, chronic lung disease, a productive cough, shortness of breath with activity, or other problems related to their lungs.

Endocrine- Does the patient have a history of diabetes or thyroid disorders? Do they take insulin or other medications that affect their blood sugar? Has a blood glucose level been measured immediately prior to surgery?

Urinary/Renal- Review any electrolyte levels if they were drawn prior to surgery. Does the patient have a history of renal failure? Has the patient experienced dehydration related to illness? Does the patient take diuretics that could affect their potassium? Does the patient have a urinary tract infection?

Gastrointestional- Does the patient have diarrhea, gastric reflux disease, bowel obstruction, nausea & vomiting, or other conditions?

Neurological- Does the patient have a change in their level of consciousness, history of passing out, stroke, paralysis, seizures, stroke, muscle weakness, or other conditions?

Child Bearing Age Females- Anesthetic medications can affect the pregnant patient. It is important to ask the patient if they could be pregnant.

Laboratory Values

Routine Laboratory Values

For patients who are healthy and have no medical problems, the absence of laboratory tests is not a reason to delay the case. Often young and healthy patients do not require routine laboratory values prior to an elective procedure. Patients may require laboratory values based on their medical conditions. Patients who have medical conditions such as diabetes, kidney, liver, and thyroid disease should have appropriate laboratory tests prior to undergoing surgery and anesthesia.

Complete Blood Count- A complete blood count usually contains a hemoglobin, hematocrit, white blood cell count, platelets, and may contain a differential. A differential breaks down the various components of the white blood cell count. A complete blood count should be ordered based on the type of surgery being performed and the amount of blood loss that is expected. Surgical cases that may involve moderate to severe bleeding should have a hemoglobin and hematocrit obtained. Minor surgical cases, in young healthy patients, a hemoglobin and hematocrit may not be needed. If possible, a complete blood count should be ordered for patients with a history of malnutrition, menstruating women, sickle cell anemia, anemia, bleeding, infection, and conditions that impact the complete blood count. A platelet count may be required for patients with a history of abnormal bleeding, abnormal bruising, history of thrombocytopenia, and disorders of the spleen.

Urinalysis- A urinalysis is helpful if diabetes, kidney disease, or a urinary tract infection is suspected.

Metabolic Profile (electrolytes, blood glucose, renal function)- Patients with known kidney disease should have a metabolic profile drawn to measure potassium, sodium, blood urea nitrogen, and creatnine. Patients that are taking diuretics should have electrolytes drawn.

Coagulation Studies- Patients that have a history of abnormal bleeding or bruising, currently taking anticoagulant/antiplatelet medications, severe malnutrition, and/or a history of liver disease should have coagulation studies drawn.

Liver Function Tests- Patients with a history of hepatitis, alcohol or drug abuse, and other conditions that may affect the liver should have liver function tests prior to surgery.

Pregnancy Tests- If of child bearing age, the patient should be carefully questioned about possible pregnancy. If the patient is not menstruating and/or not sure if they are pregnant, a pregnancy test should be considered.

Physical Exam

A physical exam is conducted during the interview. Look at the general condition of the patient. Is the patient jaundiced, pale, cyanotic, short of breath, wheezing, in pain, or edematous?

Neurological- Does the patient appear alert and appropriate? Are there changes in their level of consciousness? Does the patient exhibit changes in their ability to move or sensation?

Cardiovascular- Look for signs of edema in the lower extremities. When auscultating the heart sounds document the rhythm:

- Regular or
- Irregular

Listen for any additional sounds such as:

- Murmurs
- Clicks
- Rubs

Document if the patients pulse is:

- Strong or
- Weak

If the patient has valvular heart disease, antibiotics may be required preoperatively depending on the type of valvular lesion and surgical procedure.

Lungs- Is the patient struggling to breathe? Are they able to talk without stopping to catch their breath? When listening to lung sounds note if the patient exhibits the following:

- Normal respirations
- Labored respirations
- Shallow respirations
- Noisy respirations
- Crackles or rales- crackling or rattling sounds
- Wheezing- high pitched whistling expirations
- Stridor- harsh, high pitched inspirations
- Rhonchi- coarse, gravelly sounds

Bleeding- Does the patient have areas of abnormal bruising?

Abdomen- Is the patient's abdomen distended? This may be due to intestinal gas, ascites, tumor, or other conditions.

Airway Exam- Evaluate the patient's airway. (Refer to the section on airway assessment in the airway management chapter).

During this time explain to the patient what to expect. Make sure to answer the questions of the patient and their family.

Premedication

A premedication may be ordered prior to surgery. Routine premedication is not required for all patients. Identify patients that may benefit from medications in the preoperative period. Premedication may be administered for a number of reasons.

- To provide sedation and relieve anxiety (for example, a benzodiazepine).
- To provide pain relief (for example, an opioid).
- To decrease secretions (for example, atropine or glycopyrrolate).
- To reduce the risk of aspiration of gastric contents (for example, H-2 blocker, metoclopramide, and a non-particulate antacid).

(Please refer to the section on anesthetic and adjunctive medications for dosing.)

ASA Classification

A risk classification is assigned to the patient after a detailed preoperative evaluation. The ASA (American Society of Anesthesiologist's) class system is designed to assign a general risk classification to patients undergoing anesthesia. It is a rough guide that takes into account the patients overall health. The patient that has several serious medical problems is a higher risk than the young healthy patient. A numerical value between 1-6 is assigned. A '6' is reserved for patients that are brain dead and donating their organs. An "E" is added after the number for emergent surgical procedures. The following is a basic guide to the ASA classification system:

ASA Class	Patients Overall Health and Specific Conditions
I	Normal healthy patient.
II	Mild systematic disease such as controlled diabetes, obesity, and controlled hypertension.
III	Severe systematic disease that limits the patients activity such as chest pain, respiratory diseases that limits activity, and a history of a heart attack.
IV	Severe disease that not only limits the patients' activity but is also a constant threat to their life such as renal failure and congestive heart failure.
V	A patient that is not expected to survive 24 hours.

Conclusion

The administration of anesthesia begins with a thorough preparation of anesthetic equipment, patient related equipment, medications, and a thorough preoperative evaluation. These activities should be completed prior to an anesthetic induction. Adhering to proper preparation provides for an environment that promotes safe anesthesia care.

References:

1. Anaesthesia at the District Hospital. Michael B. Dobson. Drugs used in general anesthesia. World Health Organization 2000.
2. Handbook of Anesthesiology. MR Ezekiel. Current Clinical Strategies Publishing. 2002.
3. Basics of Anesthesia. RK Stoelting, RD Miller. Churchill Livingstone/Elsevier. 2007.
4. Nurse Anesthesia (3rd edition). John J. Nagelhout & Karen L. Zaglaniczny editors. Elsevier/Sanders. 2005.

Positioning and Monitoring

Chapter Six
Positioning and Monitoring

The patient under general anesthesia is at risk for injury if improperly positioned. Patients can be placed in uncomfortable and even dangerous positions under general anesthesia that would not be tolerated if awake. Care must be taken to check the patient for areas at risk for injury. All pressure points should be padded and secure. Improper positioning can cause injuries such as pressure sores and nerve damage. The incidence of injury increases if the patient experiences hypotension and hypothermia. It is the responsibility of the anesthesia provider to take an active role in the positioning and prevention of unnecessary injuries.

Preventing Injury to the Patient

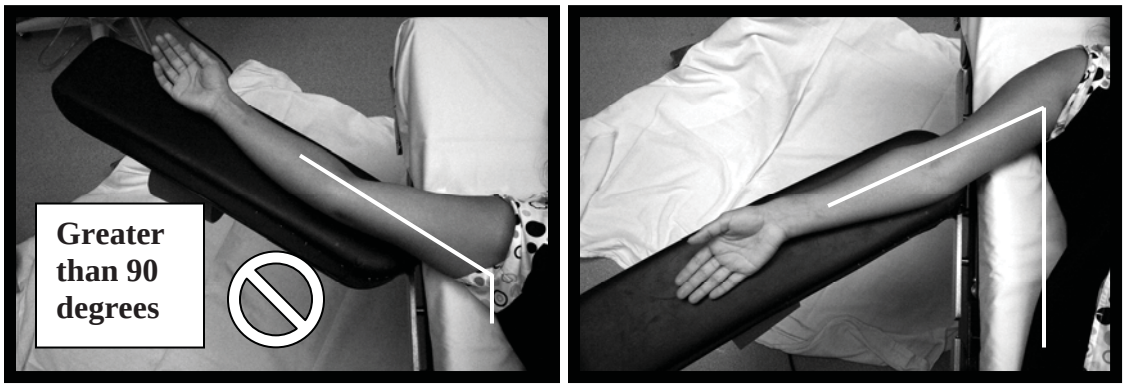
Eyes- Should be closed and taped shut to prevent drying. Taping the eyes shut will also prevent the eye from being scratched when performing routine anesthesia care around the face. When working around the eye with an anesthesia mask or during intubation, care must be taken to avoid contact with the patient's eyes. Scratches to the eye or drying can lead corneal abrasions. A corneal abrasion is a very uncomfortable and avoidable complication. Avoid placing pressure on the eye. Prolonged pressure can lead to the catastrophic complication of blindness. Pressure to the eyes must be avoided when the patient is positioned prone.

Face- The facial nerves are close to the surface of the skin and can be easily damaged by pressure from hands, anesthesia mask, and straps. This may result in damage or paralysis to a portion of the face.

Skin- Ensure that there is not excessive pressure on any one area of the body. Ensure that pressure points are padded. Too much pressure will lead to a decrease in blood flow and may cause pressure sores. This is especially important over bony areas and areas with cartilage. Bony areas that deserve special attention include heels, ankles, elbows, hips, lower back (sacrum), and knees. Cartilageous areas that deserve attention include the nose and ears. If the patient is positioned in a lateral decubitus position check the down ear.

Lips, Teeth, and Tongue- Are vulnerable to injury when performing laryngoscopy and during the insertion of an oral airway. When performing a preoperative assessment, check for loose teeth. This will help avoid the accidental removal of a loose tooth when performing laryngoscopy, intubation, and/or placement of an oral airway. Laryngoscopy and insertion of an oral airway must be gentle and not forced. Ensure that the tongue is not caught between the oral airway and/or the endotracheal tube.

Arms- Should be positioned at the patient's side. The patient's arms should be less than 90 degrees, if positioned on an arm board. If greater than 90 degrees, trauma to the **brachial plexus may occur** due to stretching.

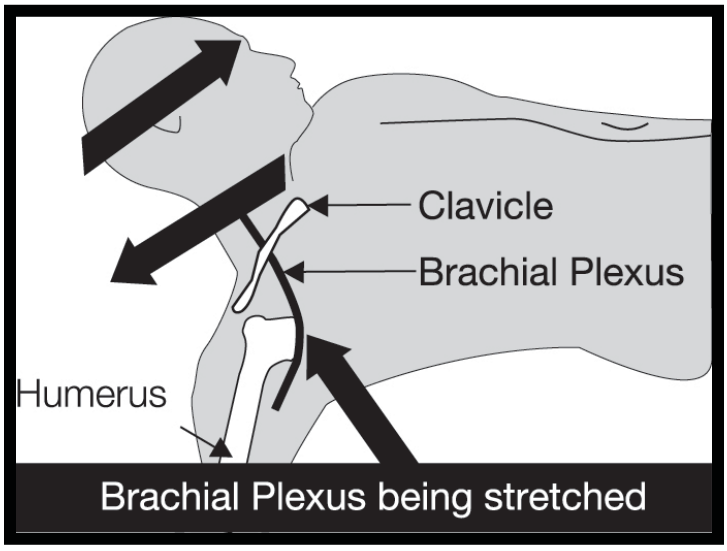


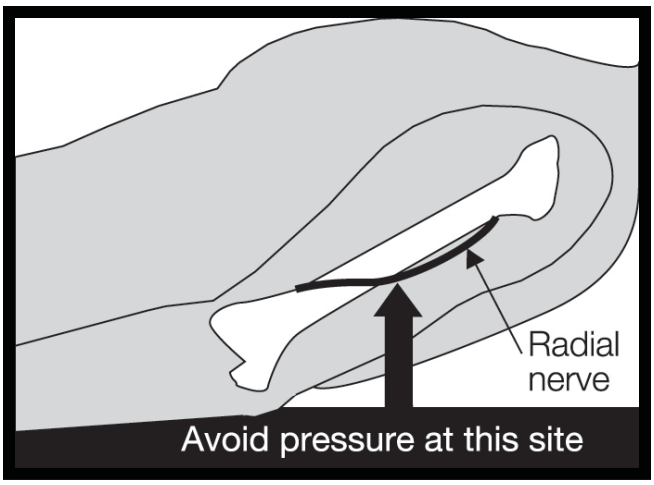
Incorrect Positioning
Arm is greater than 90 degrees

Correct Positioning
Arm is at 90 degrees or less

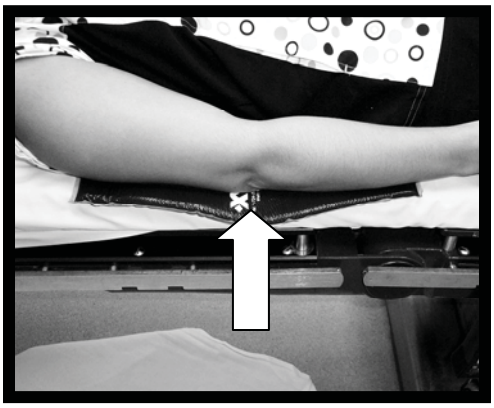
If a single arm or both arms are positioned above the head of the patient, damage may occur to the brachial plexus and **axillary nerve**. The damage caused may result in the patient not being able to raise their arm, as well as decreased skin sensation over the outer aspect of the upper arm.

If the patient's head must be turned to one side for surgical reasons, it is important not to position the opposite arm out to the side. This will cause stretching of the **brachial plexus**. The opposite arm should be placed at the side of the patient, padded at the elbow, and secured so it does not fall off the edge of the operating room table.

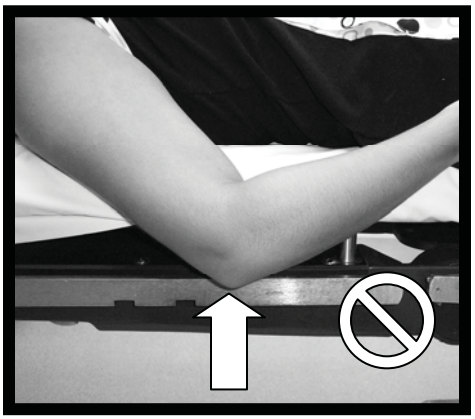




The **radial nerve** should be protected. The radial nerve can be compressed against the outer aspect of the humerus. Avoid pressure at this site, as noted in the illustration. Damage to the radial nerve will result in wrist drop.



The elbow should be well padded. Pressure may damage the **ulnar nerve**. This may result in hand weakness, numbness and tingling, and pain.



It is important to ensure that the elbow is not hanging off the side of the bed. Pressure to the ulnar nerve can result in nerve damage.

When the arms are at the side or positioned out to the side, the hands should be palm up (supinated) to decrease the risk of ulnar nerve compression.

Legs- The **sciatic nerve** can be damaged by a tourniquet or by an improperly placed intramuscular injection. Trauma to the sciatic nerve will result in paralysis of muscle and absence of sensation below the knee. The legs should be positioned at the same time with external rotation and the knees

slightly flexed. The **common peroneal nerve** can be damaged in the lithotomy position (legs up) if the outside of the knee is against a firm object, such as a brace or leg holder. This area should be padded. The proximal portion of the knee contains the **saphenous nerve** and should be padded if against a brace.

Tourniquets- If used for a surgical procedure, a tourniquet should **not** be inflated for more than 120 minutes (2 hours). Ischemic nerve damage can occur when a tourniquet is left elevated for more than 2 hours. The anesthesia provider should notify the surgeon every 30 minutes concerning the amount of time that has passed since the tourniquet was inflated. Tourniquets should be applied with a thin layer of padding. The tourniquet pressure should be set at two times the systolic blood pressure for lower limbs and 70-90 mmHg greater than the patients' systolic blood pressure for upper limbs. If excessive pressure is applied, trauma can occur to skin and nerves. If you do not have an air tourniquet and need to use a bandage for a tourniquet, it is important to use as wide a tourniquet as possible. The bandage should not have much elasticity. Elastic, rubber type bandages or an Eschmark may result in damage to nerves due to excessive pressure. The use of bandage type tourniquets should be discouraged. It is impossible to know the amount of pressure being applied to the tissue below it. There are two key points to remember when using tourniquets:

- Tourniquet application should not be longer than 120 minutes.
- Elastic, rubber type bandages should be avoided.

Thermoregulation during Anesthesia- Hypothermia is a common problem that can be avoided.

- Cover the patient with blankets.
- Increase the temperature of the operating theater.
- Use a hat in pediatric patients to avoid the loss of heat from the head. Place warm blankets around the adult patient's head.
- Use a heat-moisture exchanger, if available. This device fits in the anesthesia circuit between the endotracheal tube and anesthesia circuit. It helps prevent heat loss from the respiratory tract. It also keeps the respiratory tract moist. As air is inspired, the temperature of the air is warmed and moistened. An endotracheal tube bypasses the body's normal warming mechanism of inhaled air.
- Intravenous fluids should be warmed, if possible, prior to administration. Warming should be gentle and not exceed 40° C. Do not use an autoclave or microwave oven!

General and regional anesthesia affects the patient's ability to control their temperature. General and regional anesthesia causes vasodilatation, resulting in heat loss. Inhaled anesthetics disrupt the hypothalamus ability to control body temperature. Heat is lost by the following mechanisms:

- Radiation- heat radiates from the body when surrounded by a cooler environment.

- Conduction- heat from the body is transferred to cooler objects that it comes into contact with (i.e. operating room bed).
- Convection- air warmed by the body rises, creating a current of air. Cool air moving over the patient results in heat loss.
- Evaporation- as fluids evaporate from the body, cooling will occur. This can occur during an alcohol prep of the patient. The patient should be kept covered and dry whenever possible.

These mechanisms all contribute to lowering the patient's body temperature. Hypothermia can impact your patient adversely in several ways:

- Delayed emergence by decreasing the patient's ability to metabolize anesthetic medications and increase the amount of inhaled agent dissolved in blood and tissues.
- Coagulation abnormalities resulting in increased blood loss.
- Shivering during recovery from anesthesia. This should be avoided. Shivering increases oxygen consumption by up to 300%. This may result in hypoxia and increased work of the heart. Shivering should especially be avoided in the geriatric patient, pediatric patient, and in those with cardiovascular disease. Shivering can be treated in the recovery area with the application of warm blankets. Keep the patient dry and covered. In the adult patient, meperidine in a dose of 12.5 mg IVP may help stop or reduce shivering. This may be repeated once for a total of 25 mg.
- Increased risk for wound infections, tissue necrosis, and pressure sores.

Monitoring the Patient during Anesthesia

Monitoring Stages of Anesthesia with Guedel's Signs and Stages of Anesthesia

Guedel's signs and stages of ether anesthesia may prove useful in your assessment of the patient under general anesthesia with halogenated inhalational anesthetic agents. These signs will not be helpful if you are performing an anesthetic with ketamine. The use of other anesthetic medications will also affect some of these signs. For example, if you use muscle relaxants you will not be able to assess the patient's muscle tone. The use of intravenous induction agents such as thiopental will often bypass the first two stages of anesthesia. Knowledge of Guedel's signs are particularly helpful during an inhaled anesthetic induction (i.e. pediatric inductions with halothane). During an inhaled anesthetic induction, signs will begin with stage 1, progressing through stage 2 and 3 as the depth of anesthesia increases. During recovery from an inhaled general anesthetic, the stages will be reversed as the patient regains consciousness. There are several signs that you can assess.

- Pupils
- Respiratory activity (if spontaneously breathing)

- Muscle tone (in the absence of muscle relaxants)
- Reflexes; including eye reflexes, pharyngeal/laryngeal reflexes, and lacrimation (tear formation)

According to Guedel there are 4 stages of anesthesia:

Stage 1	Amnesia and Analgesia
Stage 2	Delirium
Stage 3	Surgical Anesthesia – this stage of anesthesia contains 4 levels
Stage 4	Overdose

Stage 1 Amnesia and Analgesia: The first stage occurs from the beginning of the anesthetic to the loss of consciousness. During this stage the patient will demonstrate the following:

- Able to open eyes on command
- Breathe normally
- Maintain protective reflexes
- Tolerate mild painful stimuli

Stage 2 Delirium: The second stage starts with the loss of consciousness. It ends with the appearance of a regular pattern of breathing and loss of eye lid reflex. During this stage excitement is noted. Children will often exhibit this stage during an inhaled induction. The patient may demonstrate the following during this stage:

- Movement of limbs and tense struggle
- Irregular breathing
- Breath holding
- Pupils become dilated but reactive to light
- Vomiting or laryngospasm, especially if patient experiences stimulation during this stage

Stage 3 Surgical Anesthesia: This stage begins with the resumption of a regular breathing pattern and ends at the cessation of respiration. Surgery generally occurs during one of the four levels of stage 3. There will be no response to surgical incision at this stage.

Level 1: The patient may exhibit the following signs during this level:

- Pupillary dilatation may occur but the pupils will become smaller
- Absence of pupillary reaction to light
- Eye lid reflex disappears

- Respiration is regular
- Vomiting reflex is abolished

Level 2: The patient may exhibit the following signs during this level:

- Eyes become fixed in the midline
- Decrease in the activity of the intercostal and thoracic muscles during respiration
- Laryngospasm reflex disappears
- General muscle tone becomes more flaccid

Level 3: The patient may exhibit the following signs during this level:

- Intercostal muscle activity decreases to the point of cessation
- Respiration may come from only the diaphragm
- Pupils become more dilated

Level 4: The patient may exhibit the following signs during this level:

- Paralysis of intercostal muscles
- Cessation of spontaneous respiration
- Pupils become very dilated

Stage 4 Anesthetic Overdose: This stage represents an overdose. Action must be taken to decrease the inhaled anesthetic or cardiac arrest may occur. The patient may exhibit the following signs:

- Cessation of spontaneous respiration
- Severe bradycardia and hypotension
- Cardiac arrest
- Absence of all reflexes

These signs will help guide you in the assessment of your patient. No single sign can be considered reliable. The patient's vital signs and medical conditions must be taken into consideration during your assessment of anesthetic depth. Spontaneous ventilation may be one of the more sensitive signs, when assessing the depth of anesthesia, under an inhaled anesthetic. The use of muscle relaxants will eliminate this sign. Eye movement and pupillary size is also a good indicator of anesthetic depth. However, the use of atropine will render this sign unusable. Lacrimation or tearing, is considered a sign of light anesthesia.

Monitoring Neuromuscular Blockade

The most reliable and objective method of monitoring the degree of neuromuscular blockade is the peripheral nerve stimulator. A peripheral nerve stimulator is commonly used with nondepolarizing

muscle relaxants. Monitoring the patient with a peripheral nerve stimulator will help to determine the following:

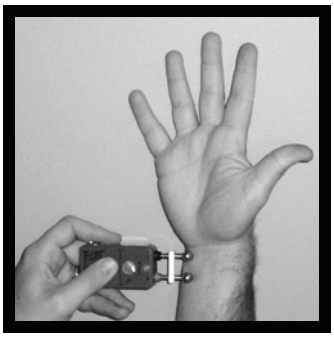
- When to intubate the patient
- Degree of neuromuscular blockade induced by a muscle relaxant during surgery
- Degree of recovery from neuromuscular blockade during emergence from anesthesia

There are several methods of monitoring the patient with a peripheral nerve stimulator. Two of the most common tests are train of four (TOF) and tetanus. TOF monitoring consists of 4 pulses of stimulation, delivered at a low frequency for 2 seconds at 0.5 second intervals. TOF monitoring consists of comparing the first response of simulation to the fourth response. For clinical purposes, simply counting the number of twitches is sufficient to determine the extent of neuromuscular blockade. Attempts to reverse neuromuscular blockade should not occur until there is at least one twitch available, however it is safer to wait until there are 3 or more twitches visible.

Twitches Visible	Percentage of Receptors Blocked	Clinical Significance
0 twitches visible	100%	Appropriate for intubation
1 Twitch visible	90%	Appropriate for intubation and surgical relaxation
2 twitches visible	80%	Appropriate for surgical relaxation
3 twitches visible	75%	For long procedures requiring muscle relaxation additional muscle relaxant may be required. Appropriate number of twitches for reversal medications.
4 twitches visible	0-75%	Patient may be able to move but may be weak. Appropriate number of twitches for reversal medications.

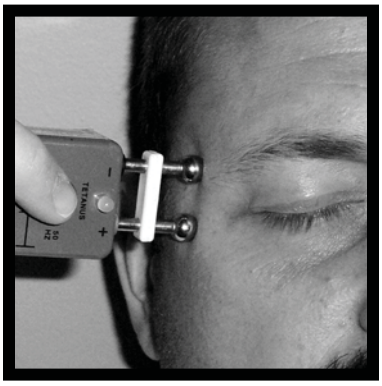
Tetanus is a second test performed with a peripheral nerve stimulator. Tetanus is an intense stimulation that lasts for 5 seconds, resulting in muscle contraction. If the contraction of the muscle does not fade, it should be understood that up to 70% of the receptors may still be blocked. If tetanus fades, it indicates that greater than 70% of the receptors may be blocked. TOF should be performed before tetanus. At the end of tetanic stimulation there is an immediate and temporary increase in acetylcholine, enhancing TOF response

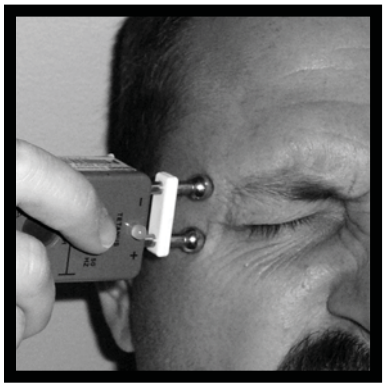
Anatomically, two common areas are used to assess neuromuscular blockade with a peripheral nerve stimulator: the ulnar nerve and the facial nerve. The ulnar nerve can be stimulated at the elbow or the wrist.



Stimulation of the ulnar nerve will result in thumb movement. The muscle that is responsible for movement is called the adductor pollicis.

Stimulation of the ulnar nerve at the elbow.





Alternatively, the facial nerve can be stimulated. The peripheral nerve stimulator is placed along the facial nerve, found inferior and lateral to the eye. Stimulation of the facial nerve will cause stimulation of the orbicularis oculi muscle. This results in movement of the eye brow and muscles that surround the orbit of the eye.

In addition to a peripheral nerve stimulator, clinical signs can be used to assess the degree of recovery from neuromuscular blockade. The use of clinical signs may not be as accurate as the peripheral nerve stimulator. Commonly a head lift or hand grip is used. The patient must have recovered from anesthesia enough to cooperate and follow verbal commands. If the patient is able to lift their head off the bed for 5 seconds, then this may indicate that 33% or less of the receptors are occupied. Alternatively, a strong, sustained hand grasp will indicate that 33% or less of the receptors are occupied. Clinical signs should be used with a peripheral nerve stimulator to help determine the degree of recovery from neuromuscular blockade.

Monitoring Of Vital Signs

The patient's heart rate, blood pressure, pulse oximetry reading, and respirations should be monitored and documented on the anesthesia record prior to the induction of general or regional anesthesia. Documentation of the patient's vital signs is an important aspect of anesthesia care. During an anesthetic you should be vigilant in monitoring the patient's vital signs. This will avoid preventable complications.

Heart Rate- Can be counted by palpating the superficial temporal, carotid, or radial artery. Count the pulse for 15 seconds and multiply it by 4 for the pulse rate per minute. If you have a precordial or esophageal stethoscope, use it to listen and count the heart rate. The precordial or esophageal stethoscope allows simultaneous assessment of the patient's heart and lungs. If available, an electrocardiogram (ECG) should be used. An ECG is helpful in identification of arrhythmias or cardiac arrest, guiding the anesthesia provider in the management of the patient.

Tachycardia may indicate many things. For example, it may indicate the need for additional fluids, excessive blood loss, or light anesthesia. Bradycardia may be caused by traction on certain organs. This reflex is called a vagal reaction. Hypoxia or an anesthetic overdose may also cause bradycardia or tachycardia. Whenever there is a change in heart rate, you should always check the patient's ventilation and oxygen status to be certain that these are satisfactory. Heart rate should be documented every 5 minutes. The patient's heart rate should be monitored continuously by ECG; heart rate reading from a pulse oximeter, and/or precordial/esophageal stethoscope.

Age	Normal Heart Rate Range	Bradycardia	Tachycardia
Adult	60-100 beats per minute	Less than 60	Greater than 100
Children 1-8 years	80-100 beats per minute	Less than 80	Greater than 100
Infants 1-12 months	100-120 beats per minute	Less than 100	Greater than 120
Neonates 1-28 days	120-160 beats per minute	Less than 120	Greater than 160

Blood Pressure- Should be taken every 5 minutes for stable patients. More frequently if the patient's blood pressure is unstable. The blood pressure cuff's width should be one-third to one-half of the distance between the elbow and shoulder. An age appropriate cuff should be used. If the blood pressure cuff is too large for the patient, then your reading may be lower than the actual blood pressure. If the blood pressure cuff is too small, your readings will be higher than the patient's actual blood pressure. Blood pressure can be auscultated with a stethoscope or palpated

for the systolic number only. Your patient's blood pressure should be recorded on your anesthesia record every 5 minutes.

Age	Normal Systolic Blood Pressure	Normal Diastolic Blood Pressure
Adult	90-140 mmHg	60-90 mmHg
Child 1-8 years	80-110 mmHg	
Infant 1-12 months	70-95 mmHg	
Neonate 1-28 days	Greater than 60 mmHg	

Respirations- If the patient is breathing spontaneously you should continuously monitor your patient's respiration. Record the respiratory rate every 5 minutes. The quality of the patient's respirations can help guide you.

Age	Normal Respiratory Rate
Adult	12-20 breaths per minute
Children 1-8 years	15-30 breaths per minute
Infant 1-12 months	25-50 breaths per minute
Neonate 1-28 days	40-60 breaths per minute

Normal- may not need to be assisted with ventilation and may be at an adequate depth of anesthesia.

Shallow- may require assistance with ventilation. May indicate that the patient is 'too deep'. The concentration anesthetic may need to be decreased.

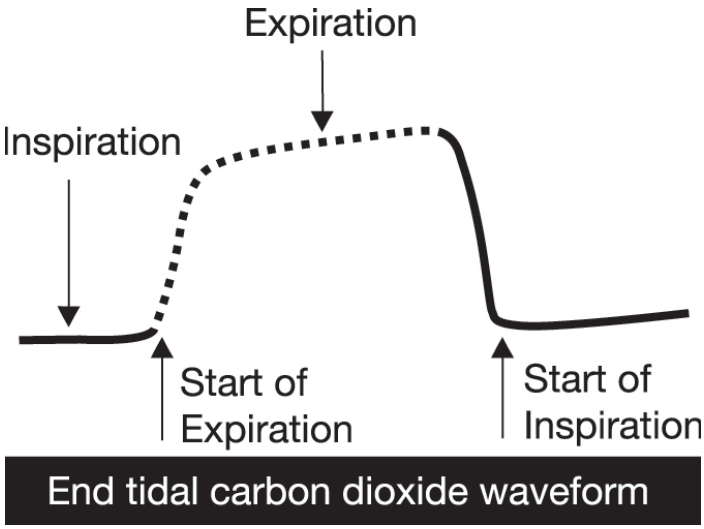
Labored- may indicate that anesthesia is light. The patient may require additional anesthetic/analgesics.

Pulse Oximetry- This monitor will display the patient's oxygen saturation and heart rate. The significance of pulse oximetry is it will often alert the anesthesia provider to hypoxia before detrimental physical signs are seen. Physical signs of hypoxia include bradycardia, darkened blood, and cyanosis. If pulse oximetry is available it should be used during general anesthesia, regional anesthesia, and surgical cases in which sedative medications are used. Even during short surgical cases a pulse oximeter should be used. It takes only minutes of hypoxia for brain damage or death to occur. The pulse oximetry reading should be greater than 95% in normal patients when administering oxygen with your anesthetic. It should be recorded on your anesthetic record every 5 minutes. Pulse oximetry should be monitored continuously. During the recovery period the patient's oxygen saturation should be 95% or more if you have supplemental oxygen. If supplemental oxygen is not available for use during the recovery period, the patient should maintain a reading of 90% or greater. Ensure that the patient has an adequate depth and rate of respirations. A patient may exhibit an acceptable level of oxygenation by the pulse oximeter, but may be retaining

carbon dioxide due to ineffective respiration. Hypercarbia can result in tachycardia, hypertension, decreased level of consciousness, and acidosis. If the patient has shallow respirations or airway obstruction, a chin lift should be performed. If the patient's respirations remain shallow or continue to experience an obstruction, ventilation should be actively assisted or controlled. Consideration should be given to the insertion of an oral or nasopharyngeal airway. It may be difficult to get a correct pulse oximetry reading if the patient's extremities are cold or if the patient is has an irregular heart rhythm (i.e. atrial fibrillation). It is important to keep the patient warm for proper monitoring and treatment during surgery and in the postoperative period.

Oxygenation	Oximetry Reading
Normal	95-100%
Mild hypoxia	91-94%
Moderate hypoxia	86-90%
Severe hypoxia	Less than 85%

Capnography- The use of capnography has improved the margin of safety for patients undergoing general anesthesia. Capnography is the continuous measurement of expired carbon dioxide. An example of the wave form is shown below.

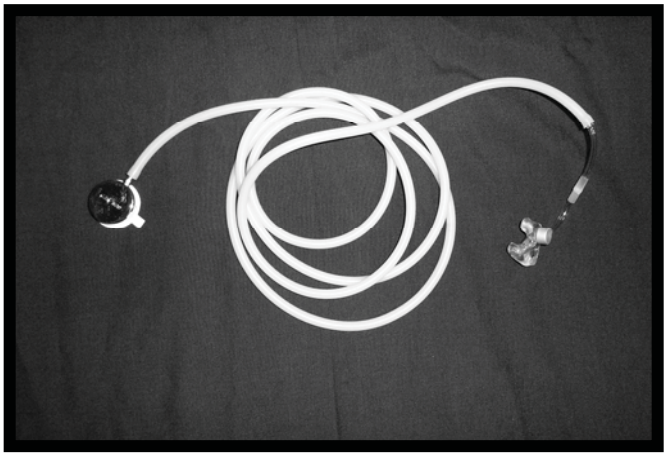


End tidal carbon dioxide waveform

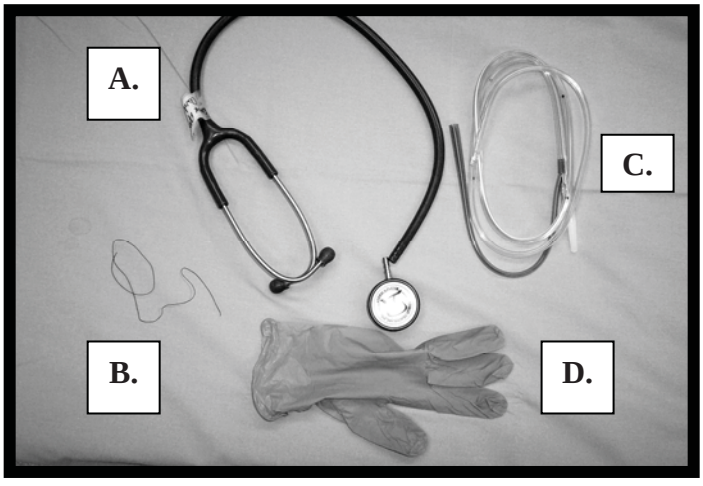
The normal range for end tidal carbon dioxide (ETCO2) is 35-45 mm Hg. Capnography is especially useful to identify the correct placement of an endotracheal tube in the trachea. If the endotracheal tube is placed in the esophagus there will be no end tidal carbon dioxide, or there will be four or less gradually declining waveforms. Anesthesia providers record the presence of more than four waveforms on the anesthesia record to document the correct placement of the endotracheal tube. Capnography can help the anesthesia provider diagnose a number of changes in the patients' condition. This makes capnography especially useful in acting as an early warning to the anesthesia provider. The changes in the waveform may be gradual or sudden.

No ETCO2 Waveform	Increases in the ETCO2 Waveform	Decreases in the ETCO2 Waveform
Esophageal Intubation (sudden)	Hypoventilation (gradual)	Hyperventilation (gradual)
Disconnection of the anesthesia circuit (sudden)	Malignant Hyperthermia (usually sudden or rapidly increasing)	Severe Hypotension (sudden)
	Rebreathing of carbon dioxide or an exhausted CO2 absorbant	Cardiac Arrest (sudden)
		Partial circuit leak (sudden or gradual)

Precordial/Esophageal Stethoscope- These devices allow you to continually listen to and assess the patient's heart rate and lung sounds. It can alert you to problems such as light anesthesia, accidental extubation, need for suctioning secretions, accidental advancement of the endotracheal tube, and cardiac arrest. This form of monitoring should be used for all anesthetic cases. Precordial stethoscopes are available in reusable and disposable forms.

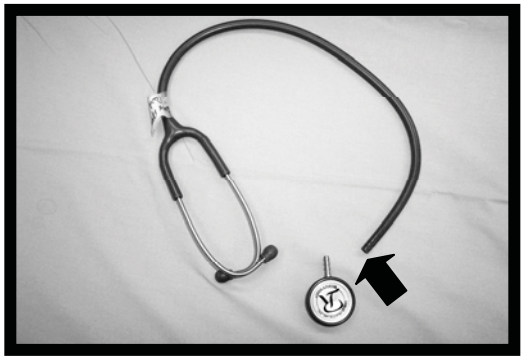


Esophageal stethoscopes are available commercially. They are single use items. In addition, an improvised, single use esophageal stethoscope can be created with common materials. Below are pictures of how to create an improvised esophageal stethoscope as outlined in Anaesthesia at the District Hospital, Michael B. Dobson, WHO, 2000.



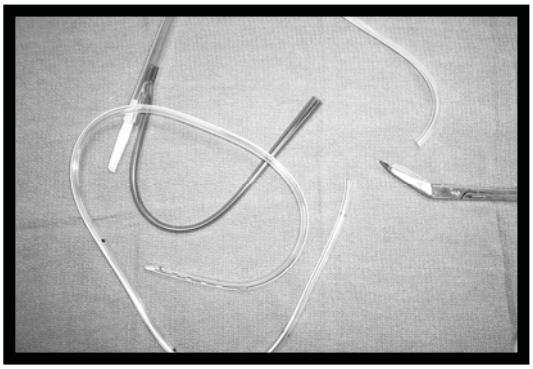
Equipment Needed

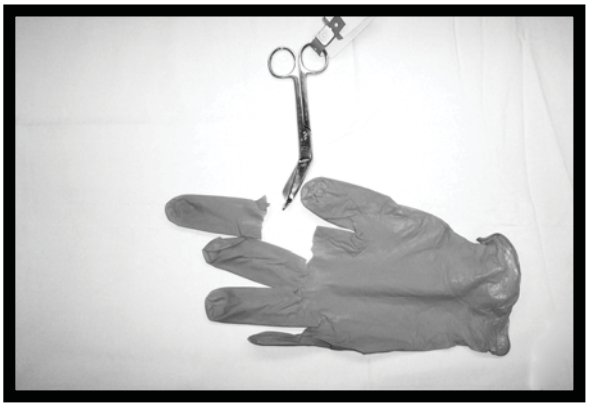
A. Stethoscope with a removable bell
B. Suture
C. Nasogastric Tube
D. Glove



Remove the bell.

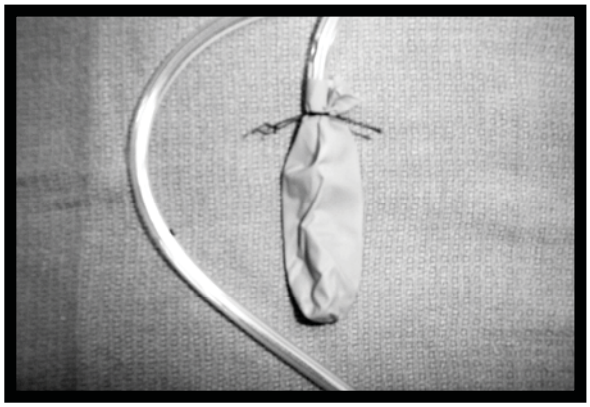
Cut the nasogastric tube.

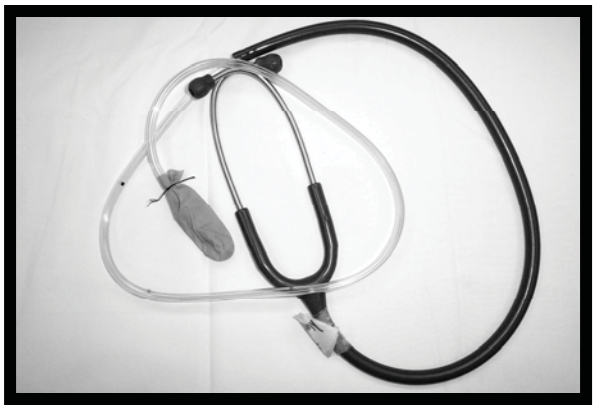




Cut the tip of a glove.

Secure the tip of the glove over the distal end of the NG tube. It must be secure to prevent it from coming off in the esophagus!





Place the cut end of the NG into the bell end of the stethoscope. Now you have an improvised esophageal stethoscope.

References:

1. Update in Anaesthesia. Issue 15 (2002) Article 15. Positioning on the Operating Table. Dr. Lauren Barker.
2. Anaesthesia at the District Hospital. Michael B. Dobson. World Health Organization 2000.
3. Basics of Anesthesia. Robert K. Stoelting, Ronald D. Miller. 3rd edition. Churchill and Livingstone, New York. 1994.
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Airway Management

Chapter Seven
Airway Management

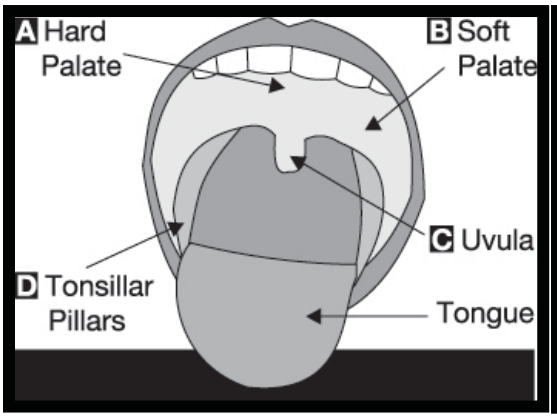
Failure to identify a difficult airway prior to the induction of anesthesia can lead to a paralyzed patient that cannot be ventilated or intubated. Most cases of aspiration occur during the management of a difficult airway. Cardiac arrests following the induction of anesthesia are often the result of difficulty with ventilation and oxygenation. The majority of patients that experience a cardiac arrest related to difficulty in maintaining ventilation and oxygenation will die or have permanent brain damage.

Preoperative Assessment of the Airway

Preoperative assessment of the airway begins with careful questioning of the patient about their medical history. Look for a history of shortness of breath (dyspnea), difficulties swallowing (dysphagia), hoarseness or weakness of the patient's voice, wheezing or stridor, and history of trauma to the airway. Does the patient have loose or missing teeth, pain with neck movements, difficulty opening their mouth, or a history of difficult intubation? Does the patient exhibit shallow respirations, increased rate of respiration, retractions with inspiration, or symptoms of being short of breath? These factors may lead you to conclude that difficulties may be encountered during the induction of anesthesia with oxygenation, ventilation, and/or intubation.

Physical Exam of the Patient

Ask the patient to open their mouth. If the patient's soft palate, uvula, or uvular base can be seen, then intubation should be easy as long as they are able to extend their neck.

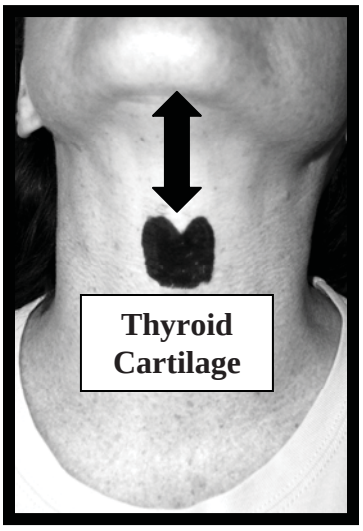


1. If A B C D are seen	= Easy intubation
2. If only A B C are seen	= May be a difficult intubation
3. If only A is seen	= Most likely it will be a difficult intubation

The Mallampati/Samsoon-Young classification is commonly used to grade the oropharyngeal view.

Classification	Anatomical View	Potential Difficulty of Intubation
1	Uvula, faucial pillars, and soft palate	Should be easy
2	Faucial pillars and soft palate	Should be easy
3	Soft and hard palate	Potentially difficult
4	Hard palate	Most likely difficult

Another test that is helpful, prior to intubation, is called the thyromental distance.



Place your fingers on the patient's neck as the patient extends their head. You should be able to place three fingers between the top of their thyroid cartilage and chin. If there are less than three finger breadths, then intubation may be challenging. When you perform laryngoscopy, the soft tissue is moved out of the way. If there is not sufficient room for tissue movement, then your view may be affected. If the patient has a tumor, burns, or scarring, then the ability to move tissue out of the way to view the glottic opening, during laryngoscopy, may also be impaired.

The importance of the patient being able to extend their neck should not be overlooked. The extension of the patient's neck brings the larynx into view by aligning the anatomy of the oral cavity, pharyngeal cavity, and tracheal opening into a straight line. When the patient's neck is not extended, these three anatomical areas do not line up. This makes viewing the vocal cords and intubation difficult.

Features that May Make Intubation Difficult

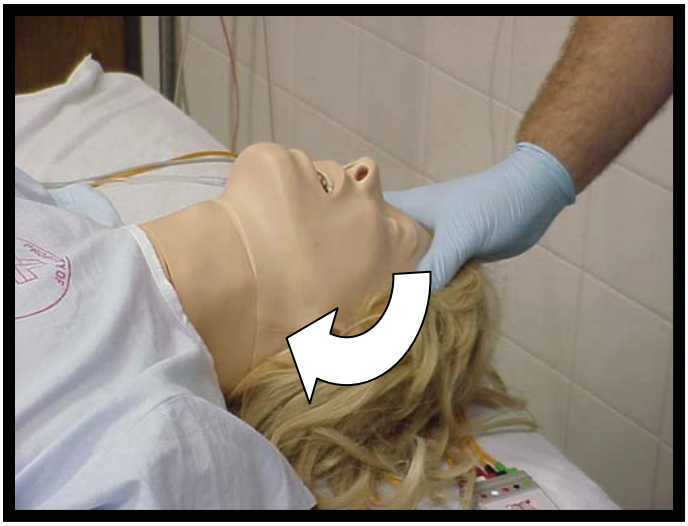
Physical features that may complicate intubation include the following:

- Large/protruding or small/receding jaw
- Large tongue
- Protruding 'buck' teeth
- Loose and missing teeth

- Cleft palate
- Inability to open their mouth very wide
- Pain with opening the mouth
- Short, muscular neck
- Deviated trachea
- Any condition that limits neck mobility
- Obesity
- Burns, scars, or tumors under the chin or on the neck. These conditions may affect the mobility of soft tissue during intubation.

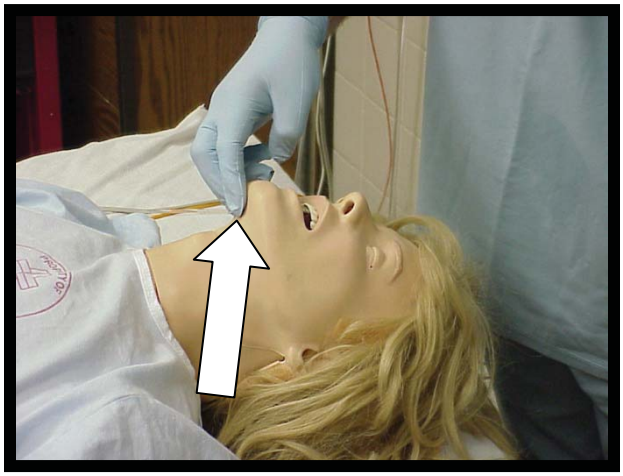
Airway Management

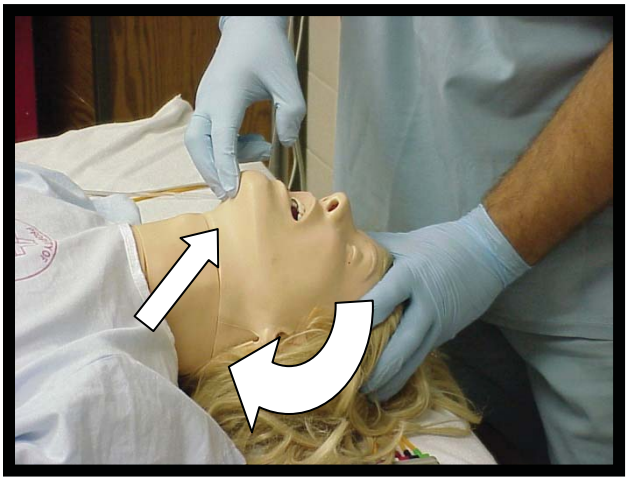
Maintaining a clear and patent airway is essential. Without a patent airway, the patient will become hypoxic and hypercarbic. This may result in death or brain damage. When a patient receives sedative or anesthetic medications, there is a relaxation of the pharyngeal muscles. This can cause the tongue and other tissue to relax and occlude the airway. This occlusion may be partial or complete. By extending the head and lifting the chin the obstruction may be diminished or eliminated.



Head Tilt – The patient's head is tilted backwards and the neck is hyperextended. This maneuver is contraindicated in the presence of possible cervical injury. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

Chin Lift – Place two fingers under the bony portion of the lower jaw, near the chin, and push the patient's chin upward with moderate pressure. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

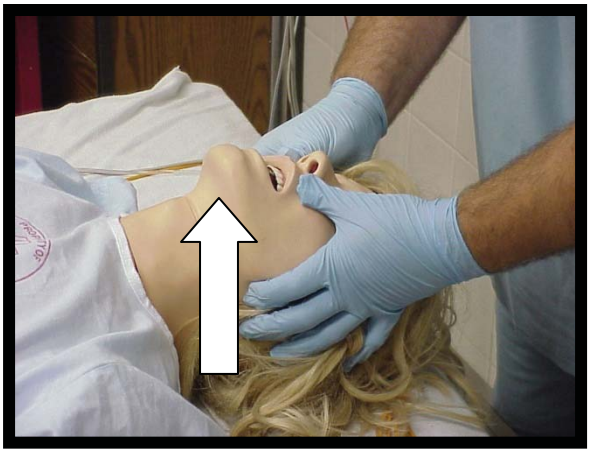




The **head tilt and chin lift maneuver** are often done collectively. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

An alternative technique of opening up the airway is to place your fingers at the angle of the jaw and pull gently up and out. This is called a jaw thrust.

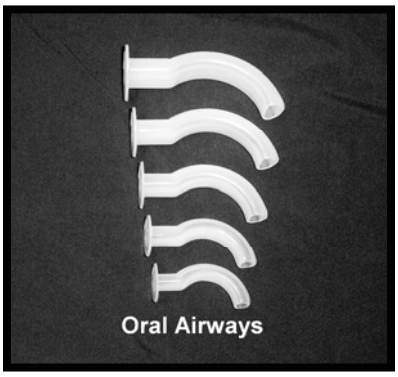
Jaw Thrust – Grasp the angles of the patient's lower jaw and lift with both hands. The jaw thrust can be done with the head tilt, as pictured above, or it can be done alone without the head tilt. The jaw thrust without head tilt is the technique of choice for a patient with a suspected neck injury since it causes the least amount of movement in the cervical spine. *(Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*



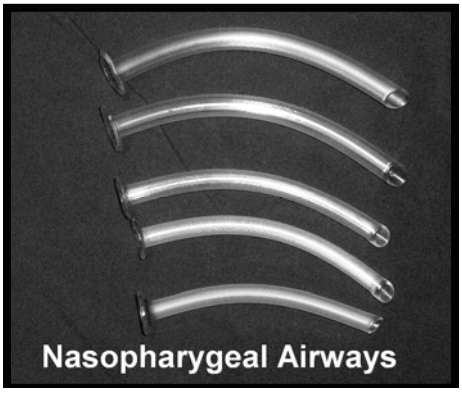
When using a chin lift or jaw thrust, it is important to ensure that your patient is exchanging air adequately.

Artificial Airways

Oropharyngeal or nasopharyngeal airways help to maintain a clear airway by displacing the tongue and other tissue from the posterior portion of the hypopharynx.



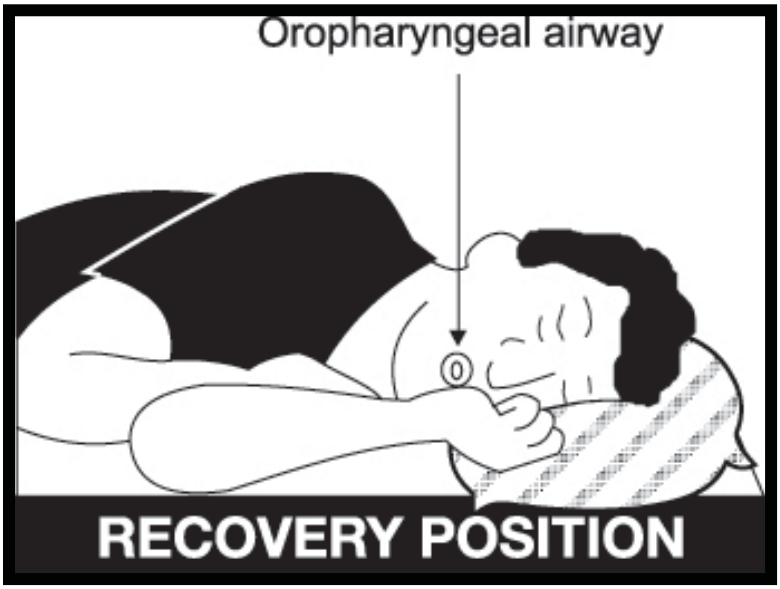
The oral airway may be lubricated before insertion; generally water based lubricating gel or water will do. Mineral oil should never be used. Inhalation of mineral oil can lead to a lipoid pneumonia. Insert the airway with the tip facing up. Then rotate the oral airway into position in the pharynx. Ensure that the patient is adequately anesthetized. If the patient is not anesthetized this may cause choking, coughing, or gagging. Never force an oral airway into place. This may cause trauma and bleeding. Alternatively, an oral airway can be inserted tip down with the aid of a tongue depressor.



A nasal airway can also be used. This can be used in a patient who has difficulty opening their mouth. It should be lubricated and gently inserted. Only water based lubricating gels should be used. Do not force a nasal airway or a serious nose bleed may occur. Do not place a nasopharyngeal airway in patients with facial or nasal fractures. Placing a nasopharyngeal airway is

not as stimulating as an oral airway. If a nasal airway is not available then an endotracheal tube can be used. It should be inserted so that the tip is above the epiglottis.

The use of an oral or nasal airway is helpful in the management of patients recovering from general anesthesia. An artificial airway should be used in combination with a 'recovery' position.



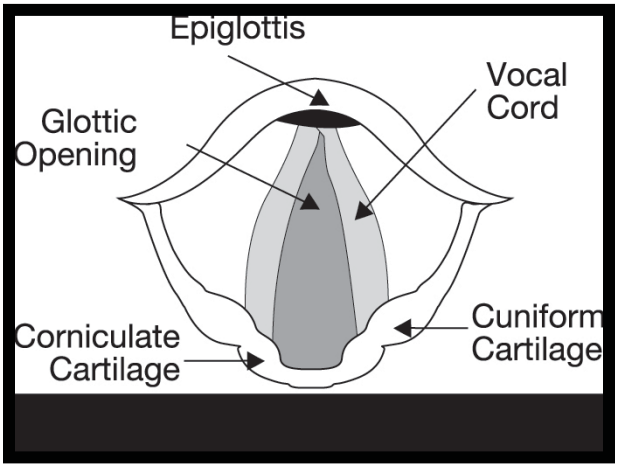
This semi-prone position helps to prevent secretions from causing a laryngospasm, coughing, and possible airway occlusion. The use of oral and nasal airways, with the recovery position, does not replace good care of the patient. The anesthesia provider should remain with the patient until they are awake enough to maintain their own airway. Monitoring should include an electrocardiogram, blood pressure, pulse oximetry, continual assessment of respiration, and ventilation. The patient should have adequate air exchange. If the patient does not maintain adequate respiration and ventilation, then intubation and/or assistance with a bag-mask-valve device should be considered. The patient should never be left unmonitored.

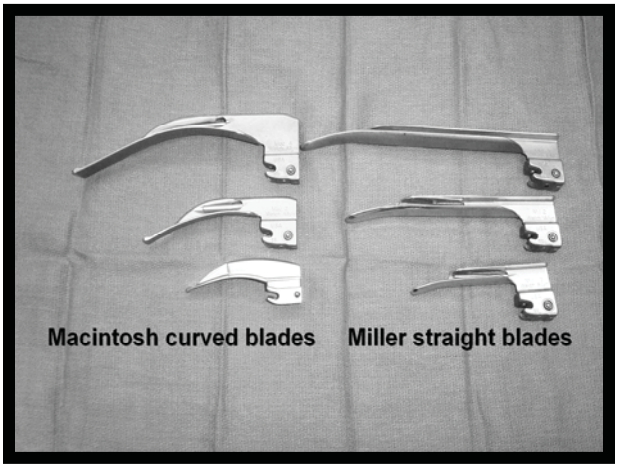
Indications for Tracheal Intubation

- To provide a patent (clear, unobstructed) airway.
- To prevent inhalation (aspiration) of gastric contents.
- To facilitate the need for frequent suctioning of the lungs.
- To facilitate positive pressure ventilation.
- For operative sites involving the face, mouth, or airway.
- A surgical position other than supine.
- To provided adequate ventilation in the patient who is difficult to ventilate by mask.
- For patients with diseases involving the upper airway.

Tracheal Intubation

An endotracheal tube is the best way to provide a clear and patent airway. An endotracheal tube protects the patient against aspiration of gastric contents. You will need a functioning laryngoscope and a laryngoscope blade. Laryngoscope blades will either be curved or straight. A straight blade is made to pick up the epiglottis. A curved blade is made to fit into the area anterior to the epiglottis called the vallecula. A curved blade will indirectly expose the glottic opening, by picking up the epiglottis, when you perform laryngoscopy.





Age	Straight Blade Size	Curved Blade Size
Newborn	0	
Infant	0-1	
Toddler	1-2	
Child	2-3	2
Adult	2-3	3-4

Laryngoscope blades come in different sizes. This allows for the intubation of patients of various size and age. It is important to use a blade that is appropriate for the size and age of the patient. If the blade is too small or too large it may make laryngoscopy and intubation more difficult.

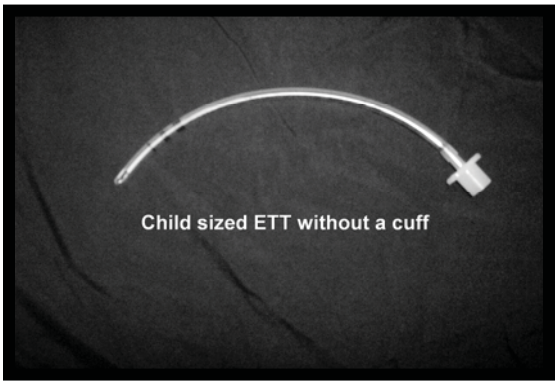
The size of the endotracheal tube should be based on the patient's age and size. Knowledge of the differences between the adult and pediatric airway is important.

Differences between Adult and Pediatric Airways

- The pediatric patient has a larger head and tongue when compared to the adult.
- The epiglottis in children is narrow, short, protruding, and U shaped.
- The pediatric patient has narrow airway passages.
- The larynx is higher in the infant (located at the level of the 3rd and 4th cervical vertebrae) than in the adult (located at the level of the 5th and 6th vertebrae).
- The pediatric patient has a short trachea and neck when compared to an adult.
- The cricoid cartilage is the narrowest point of the airway in children less than 8-10 years. The narrowest portion of the adult airway is the glottis.
- The hyoid bone is not calcified in the infant.

Pediatric Endotracheal Tube Recommendations

1. An uncuffed endotracheal tube is recommended for children under 8 years of age. The reason is to decrease pressure to the cricoid cartilage, reducing the incidence of post extubation croup (discussed later in this chapter & Pediatric Anesthesia chapter).
2. The endotracheal tube should have a leak at 15-20 cm H2O. If you cannot check this with a pressure manometer, you should ensure that you have a slight air leak when ventilating the patient. The air leak should not lead to difficulty in ventilating the patient. If you are unable to generate 15 cmH2O, then the endotracheal tube may be too small. If you have absolutely no air leak, then your endotracheal tube may be too large for the patient.
3. A child sized cuffed endotracheal tube may be used for emergency surgery when the child has recently eaten. This will help protect against aspiration. As you fill the endotracheal tube cuff with air, you should just put enough air to stop an air leak as you ventilate. You will need to monitor the patient closely for post intubation croup in the postoperative period.



Estimation of Endotracheal Tube Size in Children

- For children older than 2 years of age, the endotracheal tube can be estimated by: age/4 + 4 (age divided by 4 plus 4).
- The little finger of the child can be compared to the endotracheal tube size. This simple measure allows for comparison of the endotracheal tube with finger size before inserting the endotracheal tube or removing from packaging.

You should have available an endotracheal tube size below and above what you estimate for the pediatric patient. For example, if you calculated a 4.5 sized endotracheal tube, a 4.0 and a 5.0 sized endotracheal tube should also be available. The formula for estimating the correct endotracheal tube size is only a guide. A simple method of estimating the size of the endotracheal tube is to compare the diameter of the child's small finger to the diameter of the endotracheal tube. If they are the same size, then the endotracheal tube should be the correct size. It is still important to have an endotracheal tube that is a half size smaller and a half size larger. If the endotracheal tube is too large there will be no leak at a pressure of 20 mmHg. If the endotracheal tube is too small it will be difficult to ventilate the patient due to a large air leak. Having a size larger and smaller will give you the option to replace the endotracheal tube with a more appropriate size.

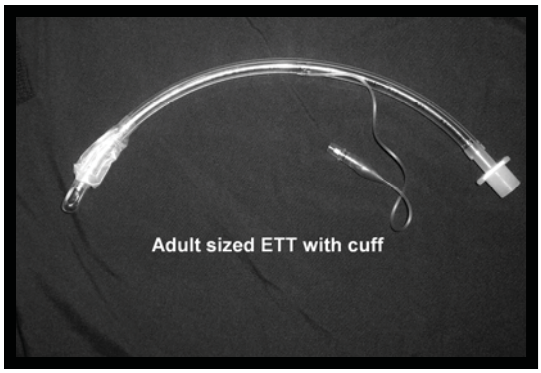
Endotracheal Tube Size by Age

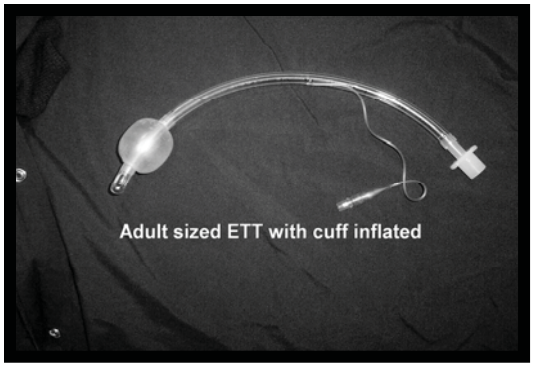
6 months – 1 year	**3.5-4.0**
2 years	**4.5**
4 years	**5.0**
6 years	**5.5**
8 years	**6.0**
10 years	**6.5**
12 years	**7.0**

The endotracheal tube size by age table is only a guide. In some countries children may be slightly smaller or larger than the typical age chart.

Endotracheal Tube Size in the Adolescent and Adult

An adult or adolescent female will usually require a 7.0 to 7.5 sized endotracheal tube. An adult or adolescent male will usually require a 7.5 to 8.0 sized endotracheal tube. Petite adults may require a 6.0-6.5 sized endotracheal tube. Always check the cuff, ensuring it inflates and does not have a leak before insertion. When inflating the endotracheal tube cuff on adults, add just enough air to prevent an air leak. Do not over inflate the endotracheal tube cuff. This may lead to mucosal necrosis!





Estimation of Endotracheal Tube Insertion Depth in Children

- For children under 1 year of age: 6 + weight (in KG)
- Over 2 years of age: $12 + \frac{age}{2}$
- Or multiply internal diameter of the endotracheal tube by 3 to estimate insertion depth.

Age	Approximate Depth in Centimeters (cm) At the level of the teeth
Newborn to 6 months	9-10 cm
1 year old	11 cm
2 year old	12 cm
4 year old	14 cm
6 year old	15 cm
8 year old	16 cm
10 year old	17 cm
12 year old	18 cm
Teen aged to Adult	20-22 cm

The estimation of endotracheal tube insertion depth is used only as a guide. A simple method used to estimate the length of insertion is to look at the distance from the corner of the pediatric patients' mouth to the ear canal. Double the distance. This should approximate the depth of insertion. When inserting an endotracheal tube, always listen to the lungs on both sides. Make sure that the breath sounds are equal and bilateral. If the endotracheal tube is inserted too far, breath sounds may be auscultated only on the right side. If this is the case, slowly bring the endotracheal tube back until breath sounds are auscultated equally on both sides of the lungs. It is important to use your stethoscope to listen for any sounds over the stomach. If you hear no breath sounds over the lungs,

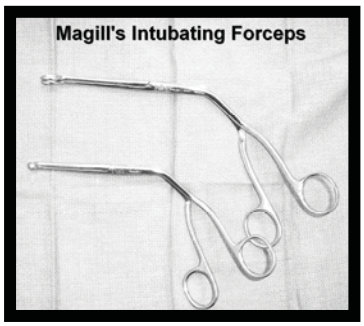
but hear abnormal sounds over the stomach when you attempt to ventilate the patient, then the endotracheal tube is not in the trachea. Remove the endotracheal tube immediately.

Endotracheal Tube Insertion Depth in the Adolescent and Adult

The endotracheal tube should be inserted so the cuff is passed beyond the vocal cords. For most adults the depth is approximately 20-22 cm. For the petite adult it may be slightly less. For the very large adult it may be slightly more. It is important to inflate the cuff and auscultate over the lungs and stomach. Make sure that the breath sounds are equal and bilateral with no sounds coming from the stomach.

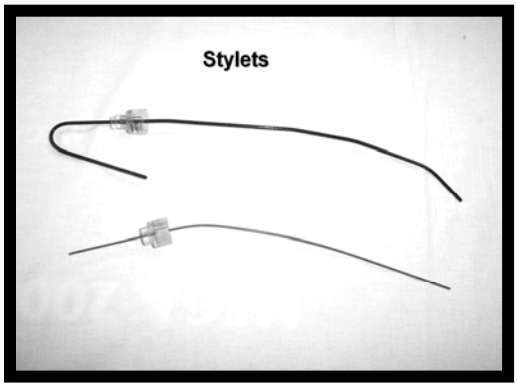
Magill's Forceps

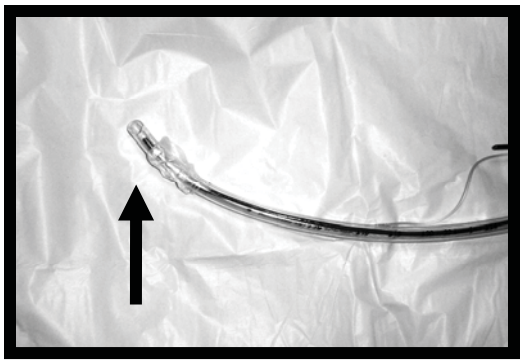
A Magill's forcep is helpful for endotracheal tube manipulation if difficulty is encountered in positioning the endotracheal tube. Be careful not to damage the endotracheal tube cuff with the forceps. Magill's forceps are often used to manipulate the endotracheal tube during a nasal intubation.



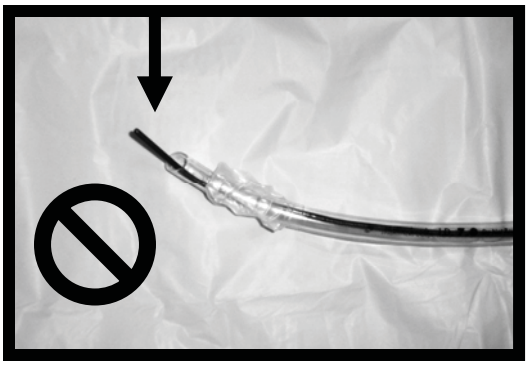
Stylet

A stylet can be helpful in creating a shaped, stiff endotracheal tube. The tip of the stylet should not be allowed to protrude beyond the end of the endotracheal tube. A protruding stylet may cause trauma to the patient's airway. **Do not force the endotracheal tube when placing it with a stylet.** This may cause trauma to your patient. The proper procedure for using a stylet is to have an assistant remove the stylet once the tip of the endotracheal tube is just past the vocal cords. Hold the endotracheal tube firmly while your assistant removes the stylet. This will prevent accidental extubation of the patient. Once the stylet is removed, advance the endotracheal tube to its appropriate depth.





Correct Stylet Placement



Incorrect Stylet Placement

Preparing for Intubation

When assembling equipment for intubation, have the following:

- Laryngoscope with appropriate sized blades for the age and size of the patient.
- Appropriate sized endotracheal tube for the patient's age and size. For pediatric patients, have one size bigger and one size smaller than the size calculated. For example, if you calculated that your patient should have a 4.5 sized endotracheal tube, have on hand a 4.0 and a 5.0 sized endotracheal tube. In pediatric patients, use an endotracheal tube without a cuff. For adolescents and adults, make sure the cuff works and does not leak.
- Magill's forceps
- Suction with a flexible suction catheter and/or rigid suction tip.
- A working anesthetic circuit with an appropriate sized face mask. Make sure to check the circuit for a leak. This is done by placing your finger over the mask end of the anesthesia circuit, filling it full of oxygen, and making sure it holds the oxygen without a leak. If your anesthesia circuit leaks, then you may not be able to ventilate the patient.
- A bag mask valve device should be available in case of anesthesia circuit failure.
- An extra oxygen source should be available in case your primary source of oxygen fails.
- An assistant to help with intubation.
- Oral and nasopharyngeal airways
- Tape to secure the endotracheal tube.

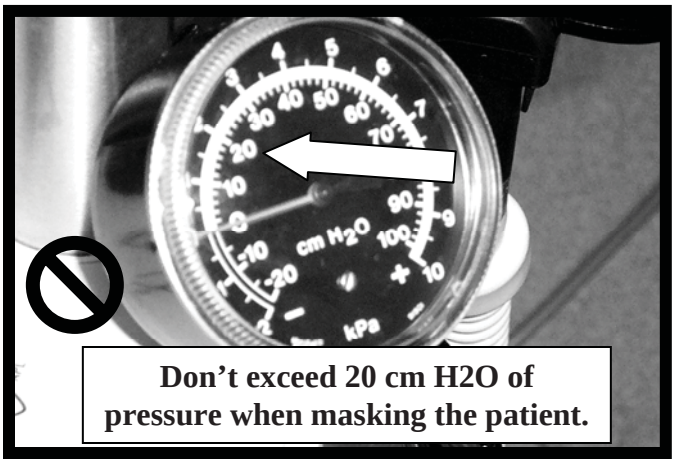
Positioning the Patient for Intubation

Positioning the patient is important to the success and ease of intubation. The neck should be slightly flexed and head extended (sniffing position) to allow for the best view of the larynx. In

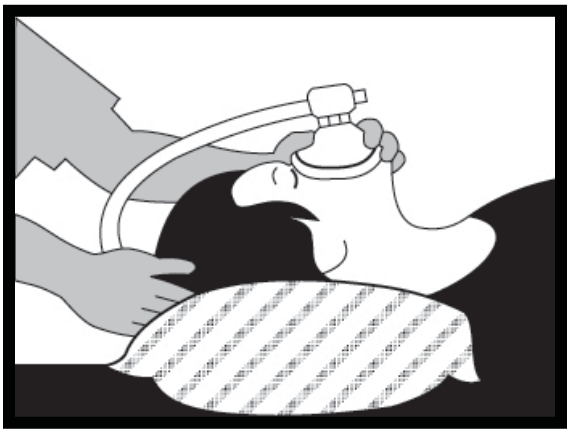
adults, one or two pillows or blankets should achieve this. In children, no pillow is needed. In infants it may be necessary to place a small pillow under the shoulders.

Steps of Intubation

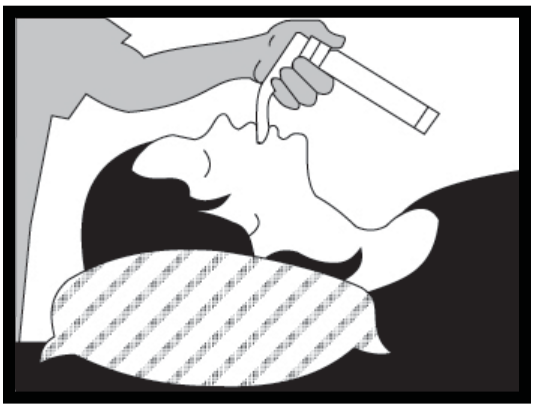
The first step in an anesthetic induction is to pre-oxygenate the patient with 100% oxygen. This will remove nitrogen from the lungs. Remember that the air we breathe contains only 21% oxygen. The induction of general anesthesia will abolish or diminish the patient's ability to spontaneously breathe. If difficulties are encountered with the establishment of a patent airway, then the patient has an enlarged reservoir of oxygen, increasing the margin of safety. Pre-oxygenation is accomplished with a mask held tightly against the patient's face. Pre-oxygenate the patient for 3-5 minutes. Alternatively, ask the patient to take 4-8 deep, vital capacity breaths. This should be completed prior to the anesthetic induction. Once general anesthesia is induced, mask ventilate the patient unless you are performing a rapid sequence induction.



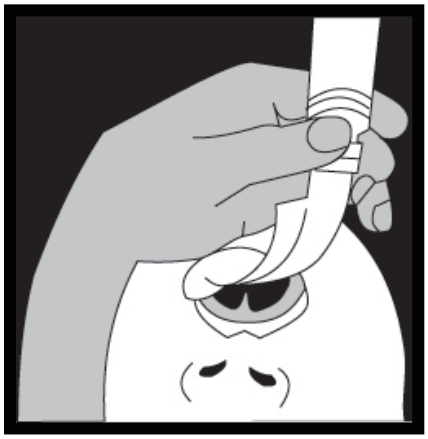
Do not use excessive pressure when mask ventilating the patient. If there is a pressure gauge on the anesthesia circuit, do not exceed 20 cmH2O. Generating a pressure greater than 20 cmH2O may introduce air into the stomach.



Mask ventilation may be difficult in patients with a full beard, patients without teeth, obese patients, and patients that have a decreased mobility of the neck. Be prepared! Have an alternate airway plan available to maintain a patent airway.



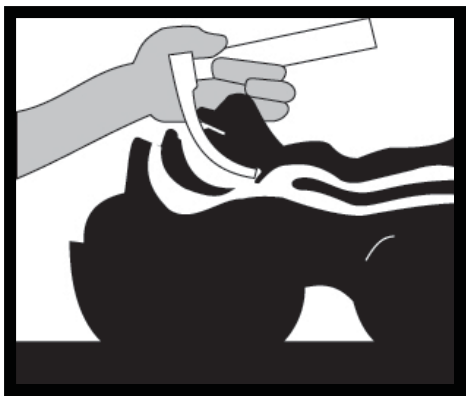
The next step is to take the laryngoscope in the left hand. Place the blade gently into the right side of the patient's mouth.

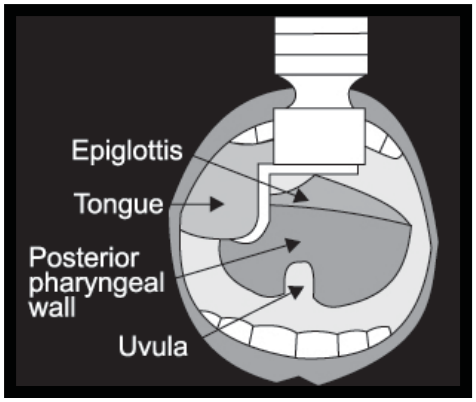


Advance the blade until the uvula is visualized. During this process the laryngoscope blade is slid to the midline of the mouth, shifting the tongue to the left.

At this point the blade should be in the middle of the mouth.

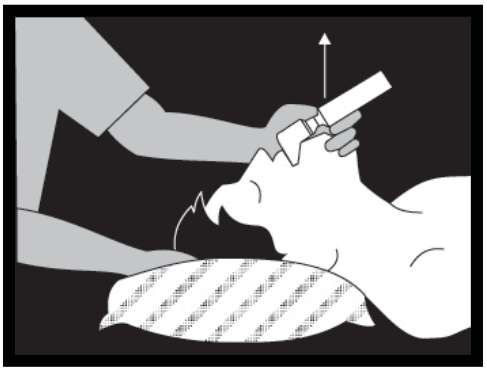
Gently advance the blade until the epiglottis comes into view.





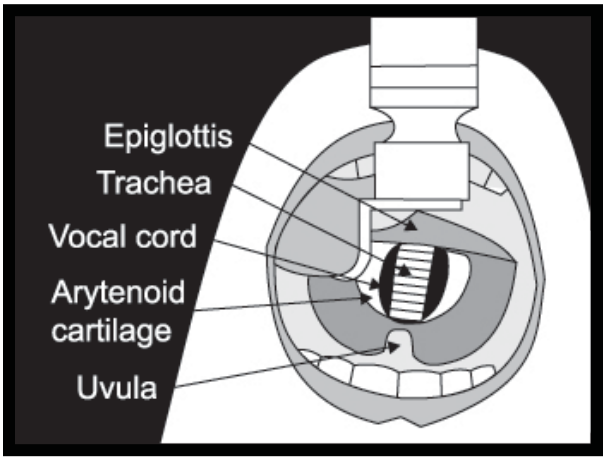
In the illustration a curved blade is being used. The tip of the curved blade will go into the vallecula. When using a straight blade the anesthesia provider will pick up the epiglottis.

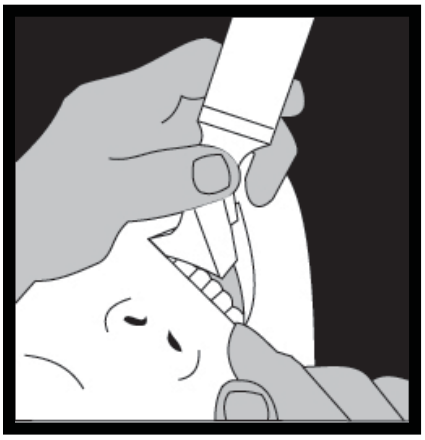
At this point check to make sure that the patient's lips and tongue are not caught between the laryngoscope blade and the teeth.



Gently lift the laryngoscope upwards toward the ceiling. Take care not to rock the laryngoscope back and forth. Make sure pressure is not applied to the patient's teeth. This will result in dental trauma.

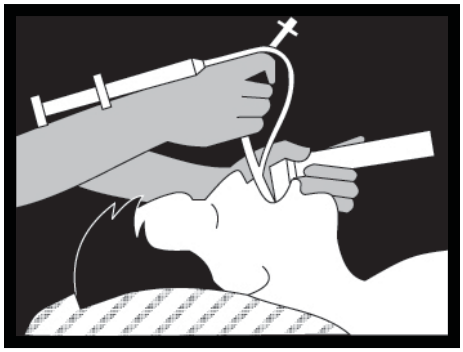
You should be able to visualize the vocal cords anteriorly and the arytenoid cartilage posteriorly.





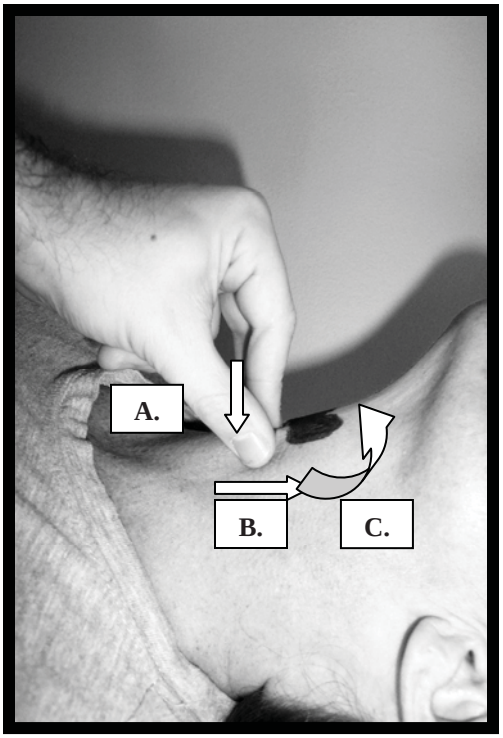
If you are having trouble seeing the patient's anatomy, have an assistant retract the patient's right upper lip. This may improve your view.

At this point your assistant should hand you the endotracheal tube. Place the endotracheal tube through the vocal cords.



If using a stylet, place the tip of the endotracheal tube at the level of the vocal cords. Have your assistant remove the stylet prior to advancing the endotracheal tube. The end of the stylet should never protrude from the end of the endotracheal tube. If you do not have a clear view, your assistant may press down on the thyroid/cricoid cartilage. Shift the thyroid/cricoid cartilage backwards, upwards, and to the patient's right. This is known as laryngeal manipulation and may help bring the glottic opening into view. Retracting the patient's right upper lip upwards may facilitate the passage of the endotracheal tube

Laryngeal Manipulation



A. Downward
B. Upward
C. To the Right

May be applied to the cricoid or thyroid cartilage.

Confirming Endotracheal Tube Placement

After placement of the endotracheal tube, it is absolutely necessary to confirm that its placement is correct. This is to ensure that the endotracheal tube has not been accidentally placed in the esophagus. The presence of a carbon dioxide waveform on a capnography monitor generally indicates correct placement of the endotracheal tube. Confirm the presence of equal and bilateral breath sounds. Advancing the endotracheal tube too far will result in the auscultation of breath sounds on one side of the lungs. A right or left mainstem intubation is identified by unilateral breath sounds. If breath sounds are absent and air is heard entering the stomach during ventilation, then the endotracheal tube is in the esophagus. Remove it right away. Using a stethoscope is the best way to assess endotracheal tube placement in the absence of a capnography machine. Additional methods will also help confirm correct placement. These methods should be used in addition to auscultation of the patient's lungs, not as a replacement.

Other Methods of Confirming Endotracheal Tube Placement

- Esophageal detection device
- Watching the endotracheal tube go between the vocal cords
- Using the anesthesia bag to ventilate and seeing the chest rise
- Pushing lightly on the patient's chest and feel air come back

- Patients oxygen saturation remains in the 90's
- Observing that the patient is pink and not cyanotic
- Vapor or condensation in the endotracheal tube

Confirmation of Correct Endotracheal Tube Placement
Trachea vs. Esophagus

Test	Result	How Reliable is it?
End tidal carbon dioxide testing	**Correct**: positive wave form **Incorrect position**: no waveform	Certain- is the best test
Esophageal detection device (i.e. 50 ml syringe with self inflating bulb)	**Correct**: air is easily aspirated **Incorrect:** the bulb does not aspirate air	Certain- unless the patient has a lot of air in the stomach.
Watch endotracheal tube go between vocal cords	**Correct:** easy view	Certain- unless visualization was poor.
Pulse oximetry	**Correct:** the reading easily comes up and reads within the normal range for the patient. **Incorrect:** the reading declines and continues to decline despite ventilation.	Certain
Listen with stethoscope	**Correct**: bilateral and equal breath sounds are noted. **Incorrect:** no breath sounds are noted/gurgling sound is noted over the stomach.	Probable- sounds can radiate and fool the anesthesia provider.
Ventilate the patient	**Correct:** easy to ventilate, chest rises. **Incorrect:** difficult to ventilate, stomach gurgles, chest does not rise.	Probable- the anesthesia provider can sometimes find it hard to distinguish between esophageal and tracheal placement of the endotracheal tube.
Observe the patient	**Correct**: the patient remains pink. **Incorrect:** the patient becomes cyanotic.	Certain/probable- by the time the patient becomes cyanotic the patient is very hypoxic.
Pushing on the patient's chest/condensation in the endotracheal tube	**Correct:** air comes back/condensation occurs. **Incorrect:** air does not come back/no condensation noted.	Probable- other techniques are more accurate.

Mainstem Bronchus Intubation

Advancing the endotracheal tube too far between the vocal cords, results in a mainstem bronchus intubation which needs to be corrected. If it is not rapidly corrected, problems will be encountered keeping the patient oxygenated, may cause atelectasis (collapse of the alveoli) in one of the patient's lung fields, and may cause trauma due to excessive pressures associated with ventilation. The key to detecting this complication is auscultation of the lungs with a stethoscope immediately after intubation. It is also important to auscultate the lungs with a stethoscope anytime there is a change in the pulse oximetry, change in the ease of ventilation, and any time the patient's head or body is repositioned for surgery. Auscultation will help confirm that the endotracheal tube has not been moved. The most common site of a mainstem bronchus intubation is the right side. Signs and symptoms of a mainstem bronchus intubation may include the following:

- Drop in pulse oximetry reading
- Unequal breath sounds
- Wheezing

Measures to take when a mainstem bronchus intubation occurs:

- Pulling the chin up may pull the endotracheal tube back enough to identify this initially.
- Occurs more easily in infants and children since there is a small distance between the trachea and the right and left mainstem bronchus.
- Neonates and infants are difficult to auscultate since breath sounds may be radiated throughout the chest. Listen for breath sounds on the lateral side (right and left) of the chest in pediatric patients.
- After deflating the cuff, pull the endotracheal tube back under direct visualization with the laryngoscope until lung sounds are equal and bilateral.

Esophageal Intubation

All anesthesia providers will intubate the esophagus from time to time. It is essential to recognize this complication rapidly. Without rapid intervention, the patient will suffer harm. If the endotracheal tube is not in the trachea, abnormal sounds will be auscultated over the stomach with attempted ventilation. There will be an absence of breath sounds over the patient's lung fields with ventilation. Ventilation may be difficult. If endotracheal tube placement is uncertain, remove it, mask ventilate the patient with 100% oxygen, and start over.

Failed Intubation

If your first attempt to intubate fails, your next step is to mask ventilate the patient with 100% oxygen. If you have trouble moving air, reposition the airway or use an oral or nasal airway. Mask ventilate the patient with 100% oxygen, to a pulse oximetry reading of greater than 95%, then

attempt intubation again. If unsuccessful after a couple of attempts, you will need to decide on how to proceed. If possible, it may be helpful to have another anesthesia provider attempt intubation.

Your options will depend on the particular surgery and situation you are in. Some options may include:

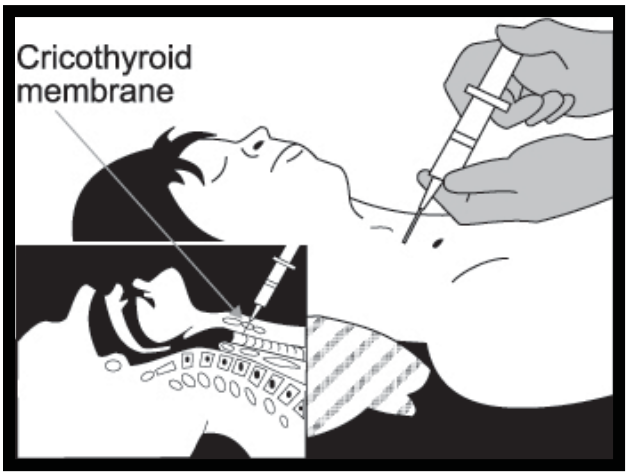
- If the procedure can be done with mask ventilation, spontaneous respiration under inhaled anesthesia, a laryngeal mask airway (LMA), or ketamine anesthesia, then proceed as long as you can ventilate the patient easily.
- Allow the patient to wake up and cancel surgery.
- Allow the patient to wake up and proceed with a local or regional anesthetic, if appropriate.
- If the surgical procedure is emergent and there are no alternatives, then you need to consult with the surgeon about this problem. If the patient's survival depends on the surgery being performed, then an emergency tracheotomy may be required if all other options have failed.
- Patients who are having a surgical procedure that is emergent should have cricoid pressure maintained.

Common reasons for intubation failure include:

- Anatomical variations
- Over extension of the patient's head and neck
- Placing the laryngoscope blade too fast or too far
- Not identifying anatomical structures
- Not watching the endotracheal tube go through the vocal cords

Failed Ventilation

If you cannot move air with the anesthesia mask, reposition the head, place an airway, and try again. If you are still unable to move air, then this constitutes an emergency. If you have alternative airways available, such as a LMA, you may wish to attempt to establish an airway with them. The patient will die if you are not able to oxygenate and ventilate them.



One emergency measure that can be performed is the insertion of a 12 to 14 gauge needle through the cricothyroid membrane into the trachea. This needle can be attached to an oxygen source at 4 liters per minute by using a 2 ml plastic syringe barrel as a connector. Attach the Luer tip of the syringe to the cannula and the wide end to the oxygen tubing. This way of delivering oxygen may keep the patient alive for a few minutes while

preparations are made for alternatives such as emergency tracheostomy or alternatively allowing the patient to awaken from the anesthetic.

Causes of Endotracheal Tube Obstruction

The endotracheal tube may become obstructed due to a number of causes:

- Thick secretions in the upper airway.
- Foreign body or dried mucous in the endotracheal tube.
- The end of the endotracheal tube is against the patient's bronchus or other tissue.
- Kinking or compression of the endotracheal tube.
- Endotracheal tube cuff moves to cover the outlet of the endotracheal tube.

Additional Complications Related to Intubation

Post Extubation Croup

Post extubation croup is more common in children. The peak incidence occurs in children aged 1-4 years. The subglottic region is the narrowest portion of a child's airway. This problem is more likely to occur in patients with a history of infectious croup or post extubation croup. Post extubation croup is characterized by stridor (high pitched noise associated with breathing), a barking and brassy cough, hoarseness, and suprasternal, intercostal, or subcostal retractions (indicating that the patient is working hard to breathe). These symptoms occur due to edema in the subglottic region. Knowledge of the cause and the use of a correct sized endotracheal tube, with a small airleak, will decrease this complication to an incidence of 0.1% or 1 in 1,000 cases.

Factors associated with post extubation croup:

- Age 1-4 years
- Tight fitting endotracheal tube with no air leak
- Traumatic or repeated intubation
- Prolonged intubation
- Tissue irritants from the endotracheal tube (cleaning solutions such as cidex)
- Use of an endotracheal tube with a cuff
- Patient coughing while intubated
- Frequent repositioning of the head while intubated
- History of post extubation croup or infectious croup

Clinical course of post extubation croup:

1. Symptoms occur within 1 hour of extubation. The maximum intensity of symptoms occurs within 4 hours. Symptoms should completely resolve in 24 hours.

2. Treatment should include humidified oxygen and hydration (taking into account the amount of IV fluids given to the patient during surgery.) Racemic epinephrine should be administered, if available, (0.5 ml of 2.25% and 2.5 cc of NS) by aerosolized inhaled respiratory treatment. Alternatively Nebulized epinephrine 0.5% in a dose of 0.5 ml, diluted in 1.5 ml of normal saline should be administered.
3. Corticosteroids should be administered to decrease tissue swelling (i.e. dexamethasone 4-8 mg IV).
4. Patient should be closely monitored after treatment for several hours. If concerns remain about the patient, they should be closely monitored overnight.

Laryngospasm

A laryngospasm occurs when the vocal cords come together. This prevents or reduces the amount of air the patient can inspire or expire. This complication occurs more commonly in the pediatric population during the induction or emergence from anesthesia. It is caused by:

- Inadequate depth of anesthesia
- Excessive oral secretions
- Manipulation of the airway, or surgical manipulation during light anesthesia

Treatment includes:

1. Continuous positive pressure with oxygen
2. Suctioning secretions
3. If the laryngospasm does not break with positive pressure ventilation administer atropine 0.01-0.02 mg/kg and succinylcholine 0.15-0.3 mg/kg IV. Some clinicians don't use atropine when administering succinylcholine for the first time. If the clinician does not administer atropine, then atropine should be drawn up and readied for administration. The patient should be monitored closely for bradycardia. Succinylcholine and atropine can be administered by intramuscular injection. The dose of succinylcholine for intramuscular injection is 4 mg/kg
4. Reintubation if necessary

Aspiration of Gastric Contents

Patients undergoing emergency surgery with a full stomach, the pregnant patient, bowel obstruction, the obese patient, diabetics, and patients with gastric reflux disease are at risk for aspiration. Even a well conducted rapid sequence induction may result in this complication. Aspiration can occur during induction of anesthesia, during a difficult intubation, or emergence. Signs and symptoms include:

- Gastric contents in the endotracheal tube despite correct placement in the trachea.
- Wheezing, rales, or rhonchi (the most common site that aspiration is noted is on the right side of the lung).

- Hypoxia (large particles of food can block the lung passages).
- Signs of aspiration may take a few hours to develop on chest x-ray.

Treatment is supportive and includes:

- Suction the endotracheal tube. DO NOT lavage the endotracheal tube. This is not effective and may worsen the situation.
- Bronchoscopy may be required to remove large food particles, if available.
- The patient may require postoperative ventilation.
- Cough, deep breath, and incentive spirometry for patients who are not intubated. Supplemental oxygen may be required. Observe the patient for signs of respiratory distress.
- Corticosteriods may be considered. It is unknown if these agents are helpful.
- Broad spectrum antibiotics may be considered if solid food particles have been aspirated or bacterial pneumonia occurs.

The Patient with an Upper Respiratory Infection

General anesthesia for elective surgery should not be performed on a patient with an upper respiratory infection. An active or recent upper respiratory infection within 2-4 weeks of a general endotracheal anesthetic increases the incidence of respiratory complications. Complications include wheezing, hypoxemia, bronchospasm, atelectasis, and laryngospasm.

Factors that favor postponement of an elective procedure include:

- Fever
- Wheezing
- Stridor
- Croup

If it is necessary to have surgery, in the case of an emergent surgical procedure, then a respiratory treatment (aerosol treatment with a bronchodilator) should be administered preoperatively. A slow, careful induction should be performed. The patient will require close monitoring postoperatively for complications. A regional anesthetic may be a suitable alternative.

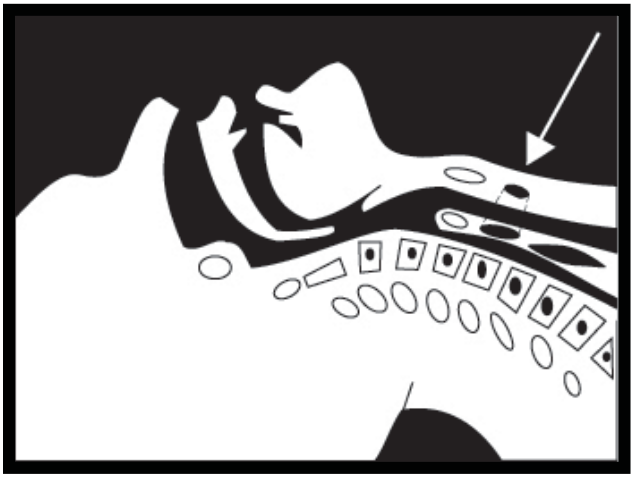
Pharmacologic Aspiration Prophylaxis

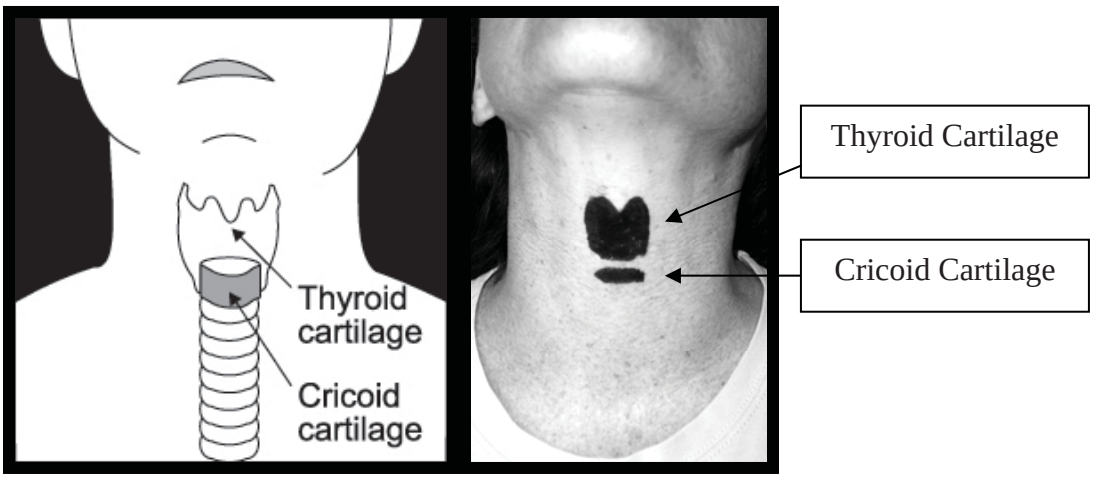
Adult patients at risk for the aspiration of gastric contents should have pharmacologic aspiration prophylaxis prior to the use of cricoid pressure and rapid sequence induction. Damage to lung tissue, caused by aspiration, is related to the volume and acidity of the aspirated gastric contents. A combination of medications may help reduce the volume and acidity of gastric contents, in addition to cricoid pressure/rapid sequence induction. These medications should be administered, if available, as long as there are no contraindications. A histamine 2 (H2) blocker, such as famotidine 20 mg IVP, should be administered 30-60 minutes prior to anesthesia. H2 blockers help decrease

gastric acid secretion and the volume of gastric secretions. Onset of famotidine is within 30 minutes and peak effect is between 30 minutes and 3 hours. Metoclopramide is a prokinetic medication. It will promote gastric emptying and increase lower esophageal tone. Metoclopramide should be administered slowly, in a dose of 10 mg IVP, 30-60 minutes prior to anesthesia. Onset is within 1-3 minutes and peak effect is less than 1 hour. Do not administer metoclopramide to patients with a bowel obstruction, gastrointestinal bleeding, or pheochromocytoma. A non-particulate antacid such as sodium citrate should be administered immediately prior to the induction of anesthesia. Never use a particulate antacid. If aspiration occurs, the particulate may result in a more severe form of aspiration pneumonia.

Cricoid Pressure and Rapid Sequence Induction

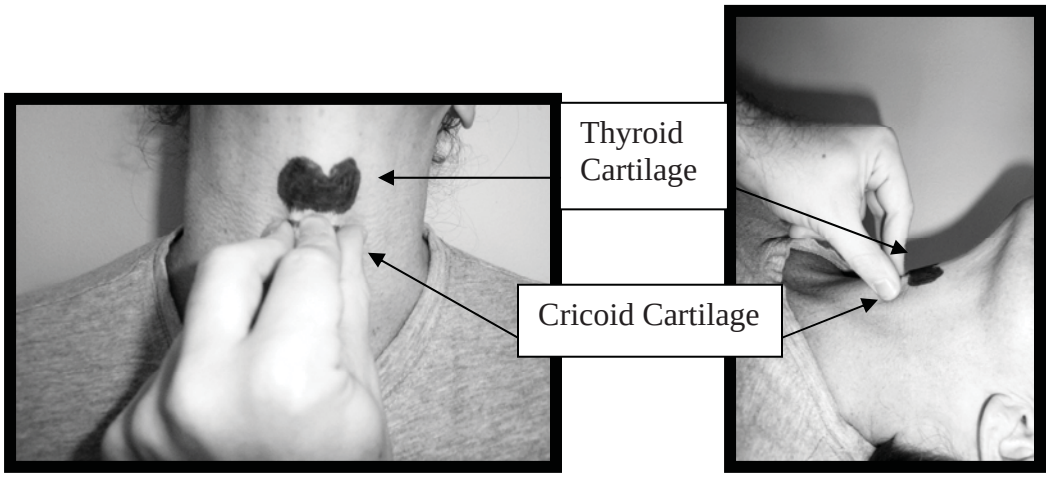
Cricoid pressure is a technique that allows the anesthesia provider to induce general anesthesia while reducing the incidence of aspiration of gastric contents. It is performed on patient's who require emergency surgery and have eaten recently, pregnant patients, bowel obstruction, diabetics, or patients with a history of frequent gastroesophageal acid reflux.





During the application of cricoid pressure an assistant places downward pressure on the patient's cricoid cartilage. The cricoid cartilage is the only complete cartilaginous ring in the airway. The pressure applied closes off the posterior lying esophagus. This prevents gastric contents from regurgitating into the oropharynx and into the lungs. The first step is to locate the cricoid cartilage. It is located directly below the thyroid cartilage. Place the thumb and second finger on either side of

the cricoid cartilage. The index finger or first finger should rest in the middle of the cricoid cartilage. Direct downward pressure should be applied.

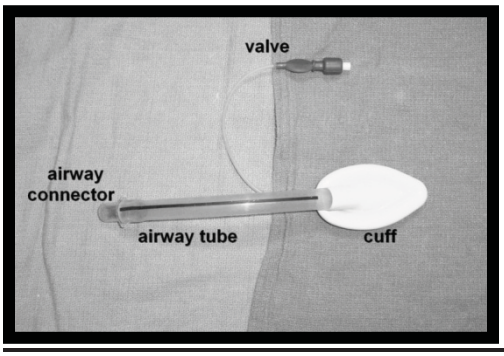


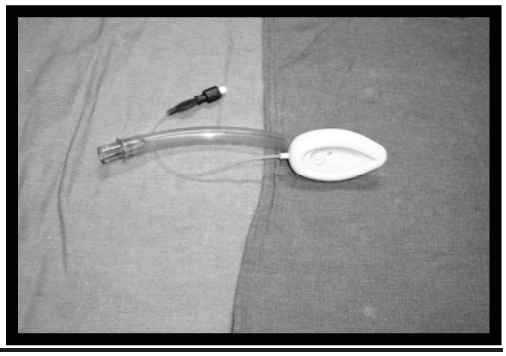
Prior to the loss of consciousness, only 1-2 kg of pressure should be applied. The amount of cricoid pressure should be increased to 3-4 kg of pressure as soon as the patient loses consciousness. Excessive pressure applied prior to the patient losing consciousness will result in retching or choking. The appropriate amount of pressure can be tested by applying pressure to an infant scale. A 50 ml syringe of air can simulate the correct amount of pressure as well. Fill the syringe with air to the 50 ml mark. Occlude the outlet of the syringe. Press the plunger down from 50 ml to 33 ml. This should approximate 3 kg of pressure. Too much pressure may prevent a clear view of the glottic opening. Too little pressure may not be effective to prevent aspiration of gastric contents. Cricoid pressure should not be released until the anesthesia provider confirms the proper placement of the endotracheal tube.

Prior to performing a rapid sequence induction, it is important to explain to the patient what you are going to do and why. This will make your patient more cooperative and less apprehensive about the application of cricoid pressure. The procedure should be as follows:

1. Assemble medications and airway equipment. Start an IV.
2. Use a gastric tube to suction out the patients stomach, if possible.
3. Pre-oxygenate the patient with 100% oxygen.
4. Induce the patient with thiopental sodium or propofol. Once consciousness is lost, have an assistant apply cricoid pressure as succinylcholine is administered. A nondepolarizing muscle relaxant may be used if the patient has a contraindication to succinylcholine.
5. Once the patient starts to fasciculate, intubate.
6. Once correct endotracheal tube placement has been confirmed, the assistant may release cricoid pressure.
7. Place a gastric tube to suction out what may remain in the patient's stomach.
8. Prior to extubation, ensure the patient is fully awake, and able to follow commands before the endotracheal tube is removed.

Laryngeal Mask Airway





The laryngeal mask airway is an alternative to mask ventilation during a general anesthetic. The laryngeal mask airway does not protect against the aspiration of gastric contents.

The advantages of a laryngeal mask airway include:

- Technically easier to insert when compared to intubation.
- Less traumatic to the patient when compared to intubation.
- Provides for easier ventilation when compared to a general anesthetic with a mask.
- Can be used as an emergency airway during failed intubation.

The laryngeal mask airway **should not** be used in the following situations:

- Emergency surgery in patients who have eaten recently.
- Obese patients
- Any patient who may have delayed emptying of the stomach (i.e. pregnancy).
- Pulmonary diseases such as pulmonary fibrosis. The patient will have poor lung compliance from a 'stiff' lung, requiring high ventilation pressures.
- Should not be used for surgical positions other than supine.

Complications related to the use of the laryngeal mask airway include:

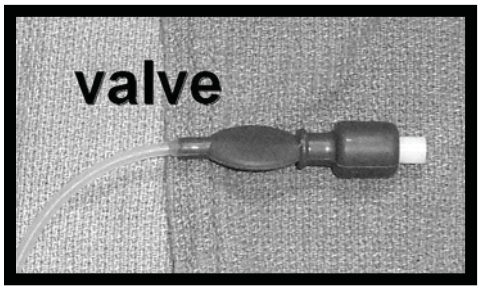
- Aspiration
- Sore throat
- Tongue numbness or cyanosis. Ensure that the tongue is not trapped between the teeth and the laryngeal mask airway.
- Laryngospasm. Induce general anesthesia as you would for any other general anesthetic. If the patient is not rendered unconscious or administered a light anesthetic, a laryngospasm may occur.

Laryngeal Mask Airway Size Based on Patient Weight

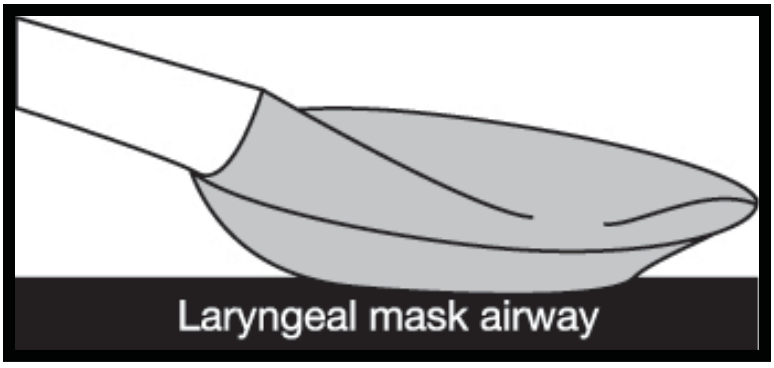
Laryngeal mask airway size	Patient size and weight	Maximum air for cuff inflation
1	Neonates and infants (up to 5 kg)	4 ml
2	Infants and children (10-20 kg)	10 ml
3	Children (30-50 kg)	20 ml
4	Small Adults (50-70 kg)	30 ml
5	Adults (70-100 kg)	40 ml

Steps for laryngeal mask airway insertion:

1. Attach an empty syringe to the valve. Fill the laryngeal mask airway with air, ensuring that it inflates. Ensure there are no leaks or bulges in the cuff.

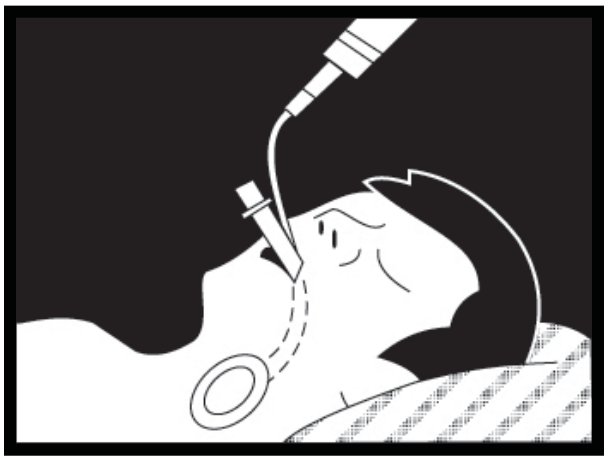


2. Remove all the air from the cuff, making it flat. Place a water soluble lubricant to the posterior portion of the cuff. If the lubricant is placed on the anterior surface, it may obstruct the outlet of the laryngeal mask airway.



3. Pre-oxygenate the patient and induce general anesthesia. Once the patient is induced, open the patient's mouth, and hold the laryngeal mask airway like a pen. Press the tip of the cuff against the hard palate, inserting the laryngeal mask airway into the hypopharynx until it meets resistance.

4. Inflate the laryngeal mask airway until there is an adequate seal. Do not put more than the maximum recommended amount of air into the cuff. Connect the laryngeal mask airway to the anesthesia circuit. Auscultate lung sounds, ensuring that they are equal and bilateral. If there is any difficulty in ventilation, deflate the cuff and reposition.



5. A bite block is placed to prevent the patient from biting down on the laryngeal mask airway. A bite block is usually created by rolling up 4X4's and placing it between the teeth. An oral airway will not work.

6. At the conclusion of the anesthetic, allow the patient to awaken. The patient should be able to follow commands and open their mouth, allowing the removal of the laryngeal mask airway. Ensure that the patient is breathing adequately before removing the laryngeal mask airway.

Minimum Anesthetic Airway Equipment

Managing the airway is essential to safe anesthetic care. The following list includes the minimum equipment that should be available.

- Adequate oxygen supply, spare cylinders full and available
- Anesthesia face masks: infant to adult size. Should have a face mask for every sized patient.
- Oropharyngeal airways: infant to adult size. Should have airways available for every sized patient.
- Laryngoscope: Should have adult and pediatric sized laryngoscope and intubating blades. Ensure that you have spare bulbs and batteries immediately available.

- Endotracheal tubes, oral and nasal endotracheal tubes: Should have adult and pediatric sized endotracheal tubes from 2.5 mm to 8.5 mm (internal diameter) in 0.5 mm increments.
- Urethral bogies (stylets) to be used as intubating stylets
- Magill's forceps, both adult and pediatric size
- Endotracheal tube connectors
- Breathing hose and connectors: T-piece for oxygen, 1 meter and 30 cm tubing
- Breathing valves
- Breathing systems for continuous flow of anesthesia
- Suction apparatus
- Functional bag mask valve mouth device

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CPR

Basic Resuscitation Review

Chapter Eight
Basic Resuscitation Review

The purpose of this chapter is to review the skills required for basic resuscitation for adults, children, and infants. CPR is an acronym for cardio-pulmonary resuscitation. CPR is essential during the resuscitation of a patient experiencing a cardiac arrest. Anesthesia related cardiac arrest is generally caused by an anesthetic overdose, significant hypovolemia, or hypoxia. Properly performed CPR is essential to patient survival. It is important to determine the cause of cardiac arrest and to rapidly treat the cause.

Adult Resuscitation

The first steps of resuscitation are critical to survival. It is important to recognize when a patient is experiencing a cardiac arrest. Monitoring the patient's pulse, ECG, and pulse oximetry is critical! The next step is to rapidly treat the patient by performing chest compressions, ventilation, and determining the cause. Perform rescue breathing for patients experiencing a respiratory arrest. Your prompt action may save a life!

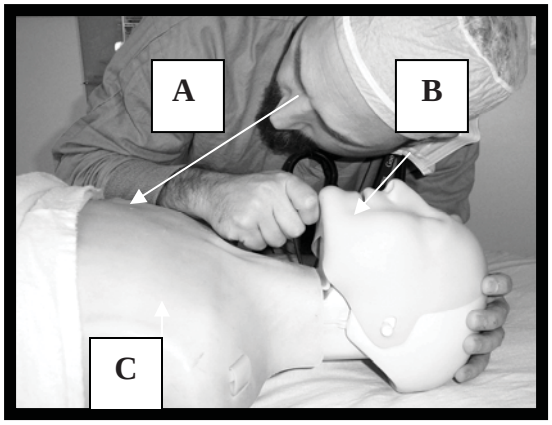
Adult Respiratory Arrest

A respiratory arrest occurs when a patient stops breathing. A primary respiratory arrest may be caused by many things. In the hospital setting, respiratory arrest is usually associated with anesthesia or medications that depress respiration. A primary respiratory arrest is not caused by a cardiac arrest, BUT if not treated promptly, the patient's lack of oxygen will result in brain damage and subsequent cardiac arrest. For the first few minutes the heart will continue to pump blood, but without oxygen the patient will rapidly develop cardiac arrest. Identifying when a respiratory arrest occurs, establishing a patent airway, and providing rescue breathing are the first steps in resuscitating the victim of a primary respiratory arrest. The term 'ABC's' are used to help remember the first steps of any resuscitation. 'A' stands for airway- you must have a clear and patent airway. 'B' stands for breathing- if the patient has a clear airway but is unable to breathe on their own, then you must provide rescue breathing. If the patient is able to breathe adequately on their own, once the airway is clear, then this may be the only intervention that required. 'C' stands for circulation, which we will cover in the CPR section.

Rescue breathing can be performed without supplemental oxygen. Air contains about 21% oxygen. After it is exhaled, it still contains 16% oxygen. During normal respiration our bodies only use 5% of that oxygen. The 16% left has enough oxygen to support a patient not breathing on their own. However, if there is an oxygen source nearby, it should be utilized to give the patient additional oxygen.

When you find a patient who appears to be unconscious, gently shake their shoulder and ask if they are all right. If the patient is prone, then they should be rolled as one unit to a supine position. Keep their head, shoulders, torso, and legs in alignment as they are moved to their back. Do not twist their head, neck, and back. This is important because a neck injury may have been sustained during a traumatic event, such as a fall. If the patient is not moved as one unit and you twist their neck or body you could cause further injury.

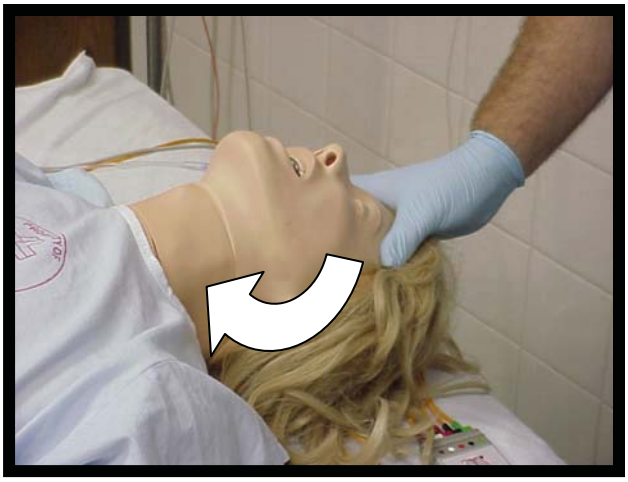
Assess the patient for breathing. "Look, listen, and feel" for the presence of breathing. Look for movement of the chest, listen for the sounds of breathing, and feel for chest and air movement from the patient's nose and mouth.

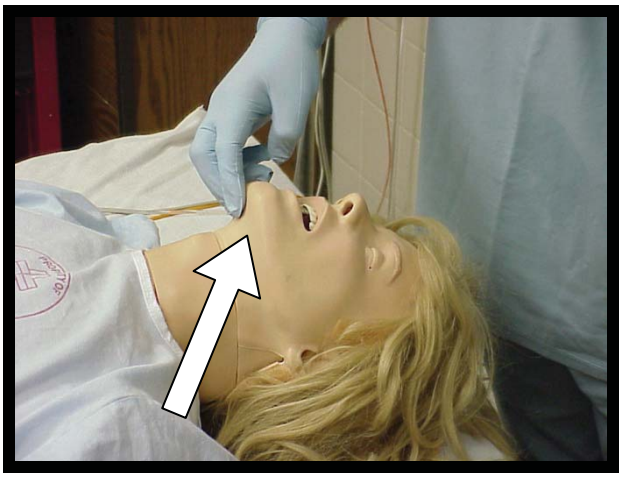


A. Look
B. Listen
C. Feel

If the patient is breathing adequately, place the patient in a recovery position. If the patient is not breathing, open the airway. This is accomplished by placing one hand on the forehead and the other under the chin. When a patient is unconscious, the tongue and tissue of the hypopharynx relax and may occlude the airway.

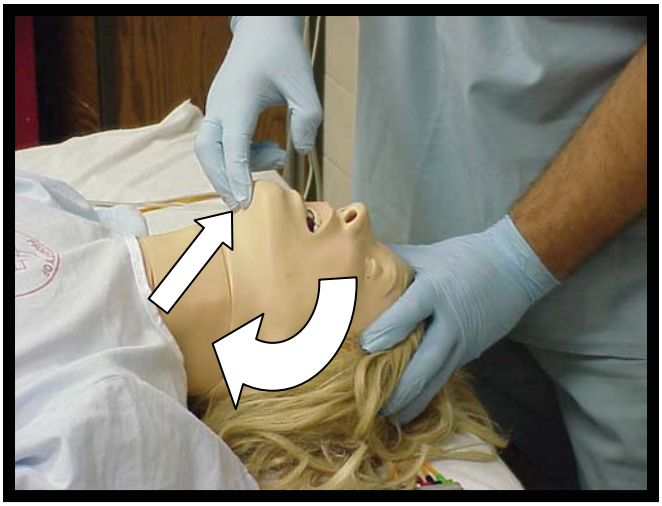
Head Tilt – The patient's head is tilted backwards and the neck is hyperextended. This maneuver is contraindicated in the presence of possible cervical injury. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*



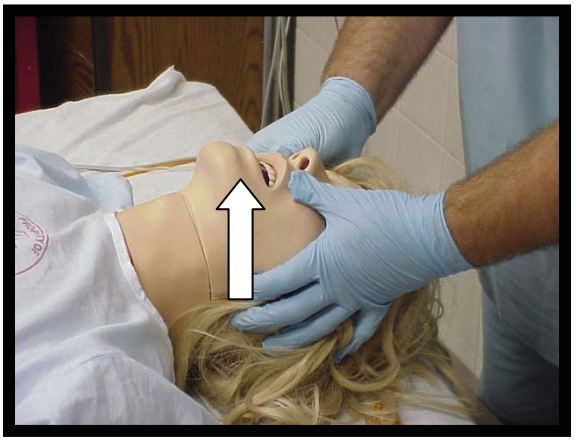


Chin Lift – The rescuer places two fingers under the bony portion of the lower jaw, near the chin, and pushes the patient's chin upward with moderate pressure. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

The **head tilt and chin lift maneuver** are often done collectively. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*



An alternative technique to open the airway is to place your fingers at the angle of the jaw and pull gently up and out.



Jaw Thrust – The rescuer grasps the angles of the patient's lower jaw and lifts with both hands. The jaw thrust can be done with the head tilt, as pictured above, or it can be done alone without the head tilt. The jaw thrust without head tilt is the technique of choice for a patient with a suspected neck injury since it causes the least movement of the cervical spine. (*Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

If there is adequate breathing, then keep the airway open. If there is no respiration, gasping, weak respirations, or other signs of inadequate breathing, then you need to prepare to perform rescue breathing. Rescue breathing can be accomplished by the following methods; mouth to mouth, mouth to nose, mask to mouth breathing, and by using a bag-valve-mask device.

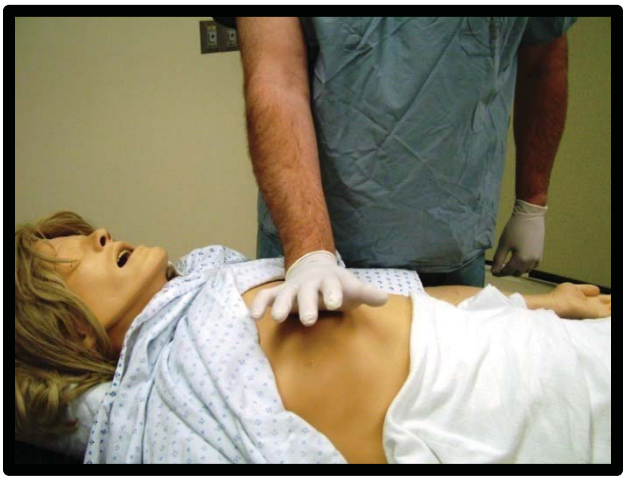
With the mouth to mouth technique, open the airway. Pinch the nose with the thumb and forefinger of your free hand. This is done so that exhaled air does not come out of the patient's nose instead of going into the lungs. Take a deep breath. Place your mouth over the patient's mouth and give two slow breaths. Each breath should take 1 second. Make sure that the patient's chest rises. Pause briefly between each breath to allow for passive exhalation. If the first attempt at rescue breathing does not result in a chest rise, then reposition the airway and try again. If it is not possible to ventilate the patient by mouth, then the nose can be used. Just tilt the head back, create a tight seal around the nose, and give two slow breaths through the nose. Make sure that the chest rises. Again, pause briefly between each breath to allow passive exhalation. Alternatively, if one is available, a mask or bag-mask device may be used.

After two initial breaths, check for a pulse using the carotid artery. This should only take about 10 seconds. If there is a pulse present you will need to administer 10-12 breaths per minute or one every 5-6 seconds. Allow time for passive exhalation. If the patient starts to have adequate spontaneous respiration with a palpable pulse, place them in a recovery position. If there is no pulse you will need to start chest compressions.

Adult CPR

If you find a patient who is unresponsive, not only are you checking for possible respiratory arrest as covered previously, you will also need to assess the patient for the three signs of cardiac arrest: no response to stimulation, absence of breathing, and an absence of circulation. For the patient that is under an anesthetic, your first sign may be an absent pulse. Vigilance is always required! As an anesthesia provider you must monitor the patient constantly for such complications. Often, impending cardiac arrest will be heralded by hypotension and changes in the patient's heart rate and rhythm.

First, check for responsiveness. If unresponsive and not breathing, position the airway, and give 2 breaths. Check for a pulse using the carotid artery. The pulse from the carotid artery is stronger and more reliable than a radial pulse. All of these actions need to take place very rapidly. Delays will result in a lower survival rate.

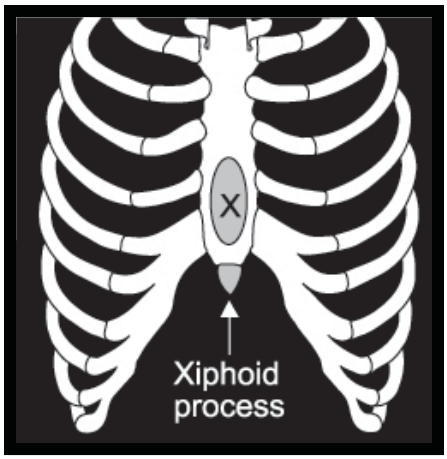


To begin external cardiac compressions, the rescuer should place the heel of one of his/her hands between the patient's nipples at the center of the chest. The sternum should be compressed about 4-5 cm (1.5 to 2 inches). *(Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA)*

The rescuer's free hand should be placed on top of the hand already positioned on the patient's chest. The rescuer should keep their arms straight with shoulders directly over the patient's sternum. Rescuers should "*push hard, push fast"*, at a rate of 100 compressions/minute.

The rescuer's free hand should be placed on top of the hand already positioned on the patient's chest. The rescuer should keep their arms straight and shoulders directly over the adult patient's sternum. *(Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA*).

Evidence appears to support the premise that a rapid compression rate benefits the patient in terms of blood flow and blood pressure. The chest should be allowed to completely recoil after each compression. Interruptions to chest compressions should be minimized to as few as possible. If external cardiac compression is done correctly, systolic blood pressure will reach 60-80 mmHg and diastolic pressure will be zero. Mean blood pressure in the carotid artery seldom exceeds 40 mmHg. Cardiac output from chest compression is approximately one fourth to one third normal. As a result, compressions must be regular, smooth, and uninterrupted.



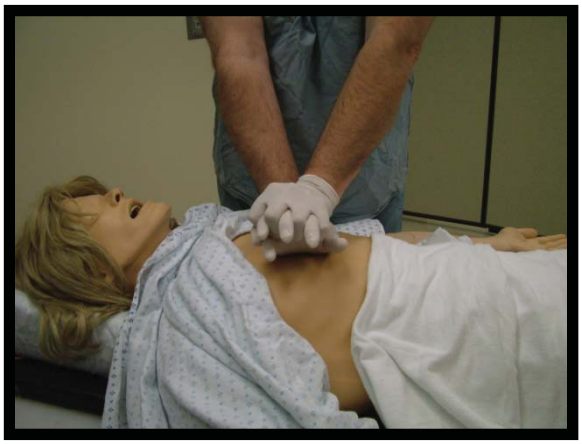


Photo on the right, *Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.*

The depth of compressions is also important. In the adult it should be 1.5 to 2 inches (4-5 cm). Compression with a depth that is less than this will be ineffective. Excessive depth in chest compressions can cause unnecessary trauma. Deliver 30 compressions followed by 2 rescue breaths. This 30:2 ratio is used if you are the only rescuer or if there are two. When there is no endotracheal tube, you will need to deliver 2 breaths followed by 30 compressions, followed again by 2 breaths, followed by 30 compressions, etc. Once an endotracheal tube is in place, or if there is one already in place, and you have two rescuers, one can perform compressions while the other ventilates the patient. Ventilations, 6 breaths per minute, should be simultaneously delivered without interrupting the compression rate, while the person doing chest compressions should do compressions continuously at a rate of 100 per minute. If an oxygen source is available, always use it! An easy way to maintain your compression rate is to count and say "1" (as you compress down) "and" (as you relax your pressure) "2 and 3 and 4 and"… Be sure to release all the pressure that you are delivering to the patient's chest between each compression. When you compress the heart, blood moves out of the heart. When you release this pressure, then blood flows into the chest and heart. With each compression keep your hand in contact with the sternum and your arms locked. Do not 'bounce' but always maintain contact!

When performing chest compressions, the victim should be on a flat, firm, level surface. If the patient is positioned with the head up, then blood that you pump by CPR may not reach the brain. This will decrease the patient's chance of survival. If you attempt compressions on a bed or mattress, they will not be effective because the patient's body will 'move' with each compression. You should be able to palpate a pulse with each effective compression.

Putting it all together:

1. Is the patient responsive?

Assess responsiveness- gently shake the patient, talk, or shout to get their attention. If they are unresponsive, send someone for help.

2. Is an airway open?

Position the airway by chin lift or jaw thrust. 'Look, listen, and feel' for spontaneous breathing. If breathing, place in the recovery position and closely monitor the patient.

3. Is the patient breathing?

If the patient is not breathing, provide two rescue breaths. The chest should rise. Allow time between each breath for passive exhalation. If the first breath does not raise the patient's chest, reposition the head and try again.

4. Does the patient have a pulse?

Check for circulation, after 2 successful breaths, at the carotid artery. If there is a pulse but no spontaneous breathing, provide rescue breathing at a rate of 10 to 12 breaths per minute (once every 5-6 seconds).

5. Are chest compressions necessary?

If no pulse, place your hands on the center of the chest between the patient's nipples. Compress at a rate of 100 compressions a minute, accomplished by a compression to ventilation ratio of 30: 2 ventilations. Compressions should be at a depth of 1.5 to 2 inches (4-5 cm).

6. Is the patient responding after 5 cycles?

The patient should be rapidly assessed for spontaneous breathing and circulation after every 5 cycles (2 minutes) of CPR. During assessment, chest compressions should be interrupted for no longer than 10 seconds.

7. Does the patient need continued CPR?

If there is not a spontaneous return of breathing or circulation, continue CPR. Assess the patient every few minutes for spontaneous respiration and circulation.

8. Is a second rescuer available?

If a second rescuer appears, then one can adminster ventilations while the other performs compressions (30:2 ratio). If the person performing compressions gets tired, they can switch duties.

9. Is an endotracheal tube in place?

If there are two rescuers available and an endotracheal tube is in place, then compressions should occur at a rate of 100 per minute. Ventilations should occur at a rate of 6 breaths per minute without interrupting chest compressions.

Pediatric Resuscitation

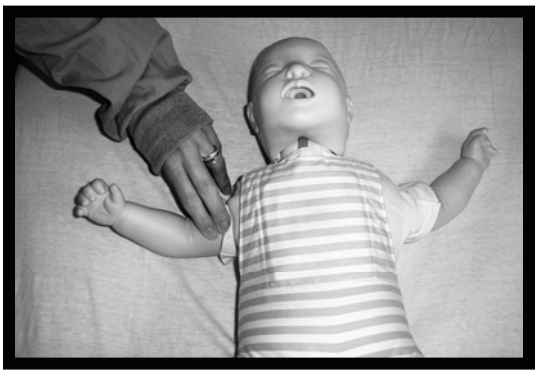
Common causes of arrest during an anesthetic for a pediatric patient are the same as an adult: anesthetic overdose, hypovolemia, and hypoxia. A child is defined, for resuscitation purposes, as a patient aged 1 – 8 years. An infant is defined as less than 1 year. There are definite differences between adults, children, and infants in the performance of resuscitation. Pay close attention to the differences.

Rescue Breathing for Child and Infants

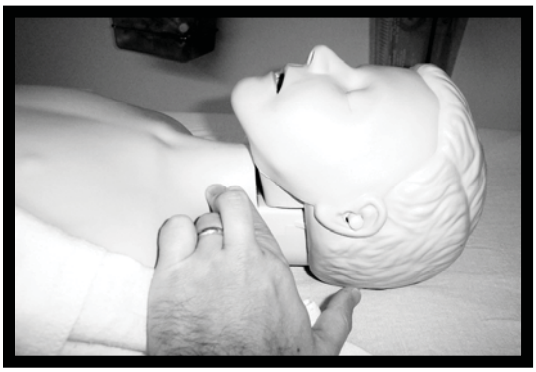
If the child/infant is not breathing, open the airway. This is accomplished by placing one hand on the forehead and the other under the chin. When a child/infant is unconscious, the tongue and tissue in the hypopharynx relax and may occlude the airway. This is one of the most common causes of an airway obstruction. After the airway is open, 'look, listen, and feel'. If there is adequate breathing, keep the airway open. If there is no respiration, gasping, weak respirations, or other signs of inadequate breathing, then you need to prepare to perform rescue breathing. Depending on the age, rescue breathing can be accomplished by the following techniques; mouth to mouth, mouth to nose, mask to mouth, mouth to mouth and nose, or by using a bag-mask-valve device.

With the mouth to mouth technique you need to open the airway. Pinch the nose with your thumb and forefinger of your free hand. This is done so that the air you exhale does not come out of the patient's nose instead of going into the lungs. Take a deep breath and give two slow breaths, making sure the chest rises. Only give enough of a breath to cause the chest to rise. Do not over inflate the child or infant's lungs. Your lung capacity is much larger than a child's or infant's. Pause briefly between each breath to allow for passive exhalation. For children (age 1-8 years), mouth to mouth or mouth to nose is acceptable. If using an ambu-bag, it is important not to deliver too much air, causing trauma. The ambu-bag should be age appropriate. In other words, you should not use an adult ambu-bag for an infant, but use an infant sized resuscitation bag. Always give just enough of a ventilation to make the chest rise. For infants (1 year or less), the best technique is mouth to mouth and nose. If your mouth is too small to cover the nose and mouth of an infant, provide ventilation through the infant's nose while maintaining the mouth closed, so air will not escape. If the infant is large and you can create a good seal so that no air escapes, then administer mouth to mouth resuscitation. If an endotracheal tube is in place, use it for ventilation.

After 2 breaths, assess for circulation. Remember the A, B, C's. Airway, breathing, and circulation. Check for a pulse at the carotid artery in children. Check for a pulse at the brachial artery in an infant.



Infant- Brachial Pulse

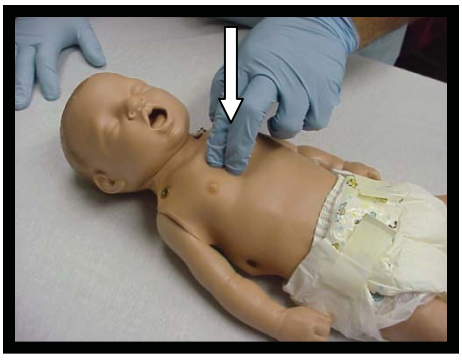


Child- Carotid Pulse

If a pulse is present and greater than 60 beats per minute, but there is an absence of spontaneous breathing, provide rescue breathing at a rate of 1 breath every 3-5 seconds or 12-20 breaths per minute. Once spontaneous breathing returns, place the child in a recovery position. If there is no pulse, or the rate is less than 60 beats per minute, with signs of poor circulation such as cyanosis, then you will need to start chest compressions.

Child/Infant CPR

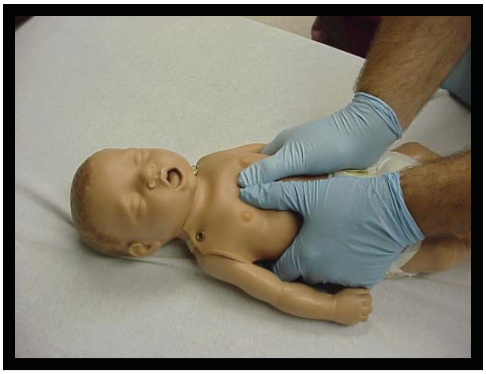
The rate of compressions for a child or infant is 100 compressions per minute. Perform compressions on the center of the chest between the patient's nipples. Be careful to avoid the tip of the sternum, known as the xiphoid process. Since the size of infants and children are different, hand placement is different. With a child, use one hand to perform compressions. With an infant, use the one handed (two finger technique).

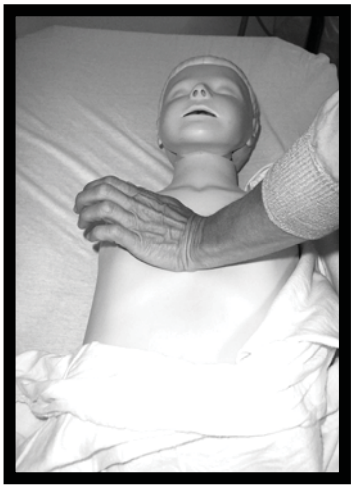


In infants, the sternum is compressed with the tips of two fingers when only one rescuer is present. This frees the rescuer's other hand to open the airway for ventilations. *(Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

An alternative to the use of a single hand or two finger technique is the use of a two handed technique. This technique uses the thumb and is used when two rescuers are present.

If two rescuers are present, one rescuer can perform compressions with the thumbs of their encircling hands while the other rescuer performs ventilations. *(Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*





Hand placement for one handed CPR on child. Compressions should be straight down.

The depth of compressions are different from the adult. Compress, in both infants and children, to a depth of one third to one half the diameter of the chest. To assess if the compressions are adequate, a pulse should be palpable. When the patient is a child or infant, one rescuer should use a 30:2 compression/ventilation ratio while two rescuers should use a 15:2 compression/ventilation ratio. The patient should be rapidly assessed for spontaneous breathing and circulation approximately every 5 cycles (2 minutes) of CPR. Check for a brachial pulse in infants and carotid pulse in children.

Putting it all together – infant or child CPR:

1. **Is the child/infant responsive?**

   Assess responsiveness- gently touch the victim, talk, or shout to get their attention. If the child/infant is unresponsive, send someone for help.

2. **Is the airway open?**

   Open the airway by head tilt, chin lift, or jaw thrust. 'Look, listen, and feel' for breathing.

3. Is the child/infant breathing?

If the child/infant is not breathing, administer two slow breaths. Just enough to allow the chest to rise. Pause to allow for passive exhalation. Do not over ventilate the child or infant.

4. Does the child/infant have a pulse?

Check for a pulse. In an infant, check for a brachial pulse; in a child check for a carotid pulse. If there is a pulse, and it is over 60 beats per minute, continue with rescue breathing alone.

5. Are chest compressions necessary?

If the heart rate is less than 60 beats per minute, with signs of poor circulation, then start chest compressions. The chest compression to ventilation ratio in the child and infant is 30:2 for one rescuer. If there are two rescuers, a 15:2 compression / ventilation ratio should be used. Use one hand for compressions on a child, use two fingers on an infant. Compress the chest only one third to one half of the chest diameter. Use the center of the chest between the patient's nipples.

6. Is the child/infant responding after 5 cycles of chest compression to ventilation?

The patient should be rapidly assessed for spontaneous breathing and circulation approximately every 5 cycles (2 minutes) of CPR. If circulation has not returned, continue chest compressions and ventilations. Reassess every few minutes for a return of spontaneous circulation.

7. **What do I do when the child/infant regains a pulse that is faster than 60 beats per minute?**

If spontaneous circulation returns, and you determine by counting the pulse that is greater than 60 beats per minute, check the patient for spontaneous respiration. If an infant/child is breathing spontaneously, place the infant/child in a recovery position, then monitor them closely. If the pediatric patient has a pulse but no spontaneous breathing, then perform rescue breathing.

Note: The Guide to Basic Resuscitation (Afghanistan) was published prior to the new recommendations for CPR. The manual contains excellent information concerning CPR. The following changes should be substituted for the previous recommendations. The major changes include: 100 compression for all ages with a 30 compression to 2 ventilations; with 2 person CPR for

children and infants the ratio is 15 compressions to 2 ventilations; hand placement for all ages should be in the middle of the chest between the nipples. The current chapter of this manual contains the new changes.

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Cardiac Arrest in the Operating Room and Allergic Reactions

Chapter Nine
Cardiac Arrest in the Operating Room and Allergic Reactions

The administration of anesthesia is an important job. Vigilance on the part of the anesthesia provider is essential. It is important that you protect your patient from harm. You must always monitor the patient closely. There are many times that cardiac arrest can be avoided in the operating room, through proper preparation and close monitoring. Potent medications can depress the patient's heart function and stop the vital function of breathing. You have a responsibility to "do no harm". Certain medications and equipment may not be available in all practice settings. This chapter presents only the basic techniques/medications used for the treatment of cardiac arrest. For practice settings that have access to advanced medications/equipment the reader should seek other resources.

There are several causes of cardiac arrest in the operating room. The most common cause of cardiac arrest is hypoxia and hypercarbia, due insufficient ventilation and oxygenation. Other causes include: preexisting cardiac disease, acute myocardial infarction, pulmonary embolus, and severe hypovolemia. Severe hypovolemia is caused by dehydration or hemorrhage. It is important to remember that virtually all general anesthetics cause some degree of cardiac depression and associated peripheral vasodilatation. It is important to monitor the patient's electrocardiogram (ECG) for heart rate and rhythm changes. Oxygen saturation and blood pressure should also be monitored. It only takes three to four minutes of hypoxia to cause severe brain damage. If an ECG is available it should be used for all anesthetic cases. If a cardiac defibrillator is available it should be used to treat ventricular tachycardia and ventricular fibrillation. Vigilant monitoring of the patient for early recognition of cardiac arrest is critical. Treatment of cardiac arrest without an ECG is extremely difficult, since the rhythm cannot be identified. This chapter will cover the treatment of cardiac arrest without an ECG and with an ECG. Please review the previous chapter for information on basic CPR techniques. High quality CPR is important in the resuscitation of patients.

Equipment and Medications:

- Oxygen
- Pulse oximetry (if available)
- ECG (if available)
- Suction
- Intravenous line or access
- Laryngoscope, endotracheal tubes, resuscitation bag and mask

- Atropine, epinephrine, and lidocaine
- Defibrillator (if available)

Cardiac Arrest without an ECG in Adults

Prompt recognition is essential for timely and successful treatment. Delays in treatment will result in a decreased likelihood of successful resuscitation. Upon recognition of an absent pulse, you will need to follow these steps:

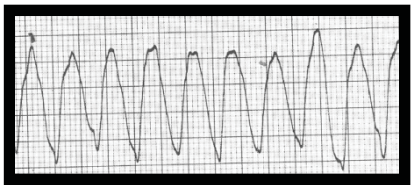
1. Call for additional help.
2. Shut off all anesthetics, give 100% oxygen, and rapidly infuse intravenous (IV) fluids.
3. A, B, C's (Airway, Breathing, and Circulation). Check the airway. If the patient does not have an endotracheal tube, is there an airway obstruction? If using an endotracheal tube, are you able to ventilate the patient easily with no obstruction? Is the endotracheal tube in the trachea or esophagus? If secretions or vomitus are present, then suction the oropharyngeal area. Are there equal breath sounds when you ventilate? Are you sure the cylinder you are using still contains oxygen? Is there a disconnection in your anesthetic tubing? Are you sure the cylinder you are using is indeed oxygen? Hypoxia is a common cause of cardiac arrest.
4. Start CPR. If the patient is not intubated, the airway should be secured with an endotracheal tube. Ventilate with 100% oxygen.
5. Consider possible causes for cardiac arrest: hypoxia, hypercarbia, drug overdose, allergic reaction, myocardial infarction, pulmonary embolism, electrolyte disturbances, tension pneumothorax, and hypovolemia. Identify and treat the cause.
6. Administer 1 mg epinephrine IV. Repeat the dose every three to five minutes while continuing chest compressions and ventilation. If there is no IV access, dilute 2 mg of epinephrine in 10 ml of saline and squirt it down the endotracheal tube. An alternative to epinephrine is vasopressin. Vasopressin is given as a 40 unit dose IV. It is given only once. Vasopressin is recommended for pulseless ventricular tachycardia or ventricular fibrillation. Without ECG confirmation this may be hard to determine. If vasopressin does not help in the resumption of a pulse, then continue resuscitation with epinephrine.
7. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR. Checking a pulse should take no longer than 10 seconds.
8. After two-four doses of epinephrine consider a 1mg dose of atropine IV. Atropine is recommended for a slow conduction rate pulseless electrical activity (PEA). Without ECG confirmation this may be hard to determine. You can repeat the atropine dose in three to five minutes for a total of 3 mg of atropine or 0.04 mg/kg.
9. Continue CPR until resumption of a pulse or the code is called off by a physician.

Adult Symptomatic Bradycardia

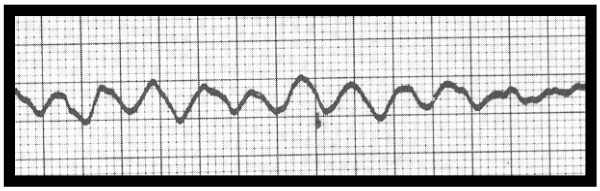
1. Consult the surgeon about the problem.
2. Decrease or shut off anesthetics (if the bradycardia is severe).
3. Ensure that your airway is clear and you are administering 100% oxygen. Ask the surgeon to stop the surgery for a few minutes.
4. Administer atropine, up to1 mg IV. If this does not increase the heart rate to an acceptable level, then repeat every 3-5 minutes for a total of 3 mg or 0.04 mg/kg.
5. If atropine is not successful consider an epinephrine drip. Mix 1 mg of epinephrine in 500 ml of normal saline (2 mcg of epinephrine per l ml). Use an infusion pump (if available) to infuse the epinephrine mixture at 1-5 ml per minute. If you do not have access to an infusion pump, you can titrate epinephrine, but this should be done with extreme care because a lethal dose of epinephrine can easily be administered.
6. If bradycardia persists, consider stopping the surgical procedure and waking the patient. Consult with the surgeon about further management of the patient.

Adult Cardiac Arrest with an ECG

Adult Ventricular Tachycardia or Ventricular Fibrillation



Ventricular Tachycardia



Ventricular Fibrillation

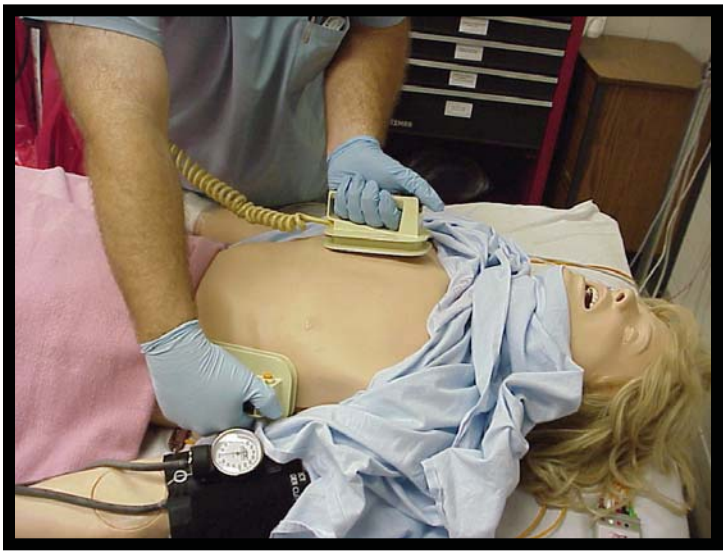
The definitive treatment of ventricular tachycardia (pulseless) and ventricular fibrillation is defibrillation.

Without a defibrillator:

1. Call for additional assistance.
2. Shut off all anesthetics, give 100% oxygen, and open up the IV fluids.
3. ABC's, CPR, and ventilation of the patient.
4. 1mg epinephrine every three to five minutes or a 40 unit dose of vasopressin IV (a onetime dose). Vasopressin is recommended for pulseless ventricular tachycardia or ventricular fibrillation. If the single dose of vasopressin does not result in the resumption of a pulse, continue resuscitation with epinephrine.
5. Continue the resuscitation until the resumption of a pulse or the physician has stopped the code.

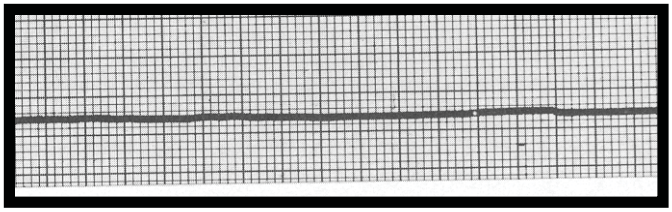
With a defibrillator:

1. Call for additional assistance.
2. Shut off all anesthetics, give 100% oxygen, and open up the IV fluids.
3. ABC's, CPR, and ventilation of the patient.
4. Prepare for non-synchronized defibrillation.
5. Start at 200 joules. If this does not return the patient to a normal rhythm, defibrillate at 200-300 joules. If this has no effect, defibrillate at 360 joules.
6. If defibrillation does not return the patient to a normal rhythm with a pulse and blood pressure, continue CPR and ventilation.
7. 1mg epinephrine every three to five minutes or give 40u vasopressin IV (a onetime dose). Vasopressin is recommended for pulseless ventricular tachycardia or ventricular fibrillation. If the single dose of vasopressin does not result in the resumption of a pulse, continue resuscitation with epinephrine.
8. Repeat defibrillation at 360 joules 60 seconds after each dose of epinephrine.
9. After two or three does of epinephrine without a spontaneous pulse, administer 1 to 1.5mg/kg lidocaine IV. Lidocaine is acceptable for ventricular tachycardia and/or ventricular fibrillation that do not respond to defibrillation.
10. If the patient does not return to a normal rhythm, then continue with CPR, epinephrine, and defibrillation.
11. Continue resuscitation until the resumption of a pulse or the physician has stopped the code.



During defibrillation, the operator should apply approximately 25lbs (11-12 kg) of pressure on the paddles while simultaneously pressing both paddle discharge buttons with the rescuer's thumbs. *(Courtesy: Department of Nurse Anesthesia, Virginia Commonwealth University. Richmond, VA.)*

Adult Asystole or PEA



1. Call for additional help.
2. Shut off all anesthetics, give 100% oxygen, and rapidly infuse IV fluids.
3. ABC's, CPR, and ventilations.
4. Consider the possible causes: hypoxia, hypercarbia, drug overdose, allergic reaction, myocardial infarction, pulmonary embolism, electrolyte disturbances, and hypovolemia. Identify and treat the cause.
5. 1mg epinephrine IV. Repeat every three to five minutes while continuing chest compressions and ventilation. If no IV access, dilute 2mg of epinephrine in 10ml of saline. Squirt down the endotracheal tube.
6. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR.
7. After two to four doses of epinephrine consider 1mg atropine IV. Atropine is recommended for a slow conduction rate PEA. Repeat atropine every three to five minutes for a total of 3mg of atropine or a 0.04 mg/kg.
8. Continue CPR until resumption of a pulse or a physician stops the code.

Pediatric Resuscitation

Common causes of cardiac arrest, in the pediatric population, during anesthesia include hypoxia, hypercarbia, anesthetic overdose, or hypovolemia.

Cardiac Arrest in Children without an ECG

Prompt recognition is essential for timely and successful treatment of cardiac arrest. If cardiac arrest is not treated, death will rapidly occur. Each delay in treatment results in a decreased likelihood of successful resuscitation. Upon recognition of an absent pulse you will need to follow these steps:

1. Call for additional help.
2. Shut off all anesthetics, 100% oxygen, and rapidly infuse intravenous fluids.
3. A, B, C's. Check the airway. If the patient does not have an endotracheal tube, is there an airway obstruction? If using an endotracheal tube, are you able to ventilate the patient easily with no obstruction? Is the endotracheal tube placed in the trachea and not the esophagus? If there are secretions or vomitus present, then suction the oropharyngeal area. Are there equal breath sounds when you ventilate? Is the anesthetic tubing disconnected? Are you sure the cylinder you are using contains oxygen?

4. CPR. If the patient is not intubated the airway should be secured with an endotracheal tube. Ventilate with 100% oxygen.
5. Consider possible causes: hypoxia, hypercarbia, drug overdose, allergic reaction, myocardial infarction, pulmonary embolism, electrolyte disturbances, and hypovolemia. You will need to identify and treat the cause.
6. Give an initial dose of 0.01mg/kg epinephrine. Additional doses of 0.l-0.2mg/kg epinephrine should be administered every three to five minutes, while continuing chest compressions and ventilation.
7. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR.
8. Continue CPR until resumption of a pulse or a physician stops the code.

Pediatric Bradycardia

1. Stop surgical stimulation. Decrease or shut off the anesthetic.
2. 100% oxygen. Secure the airway if not already done. Ensure the endotracheal tube is placed properly by auscultation. Ensure the intravenous line is working. Rapidly infuse intravenous fluids. If there is no IV call for assistance. Intra-osseous access is an option. (Refer to Pediatric Anesthesia chapter). Intra-osseous medication doses are the same as intravenous.
3. If the blood pressure is not low, administer a fluid bolus of 10 ml per kg IV. Administer atropine by one of the following methods:
    a. Intravenous: 0.01-0.02mg/kg (10-20 mcg per kg). The minimum dose of atropine is 0.1mg or 100mcg in the pediatric patient
    b. Intramuscular injection:0.02mg/kg
    c. Endotracheal tube: Mix the 0.1mg/kg epinephrine with 5ml of normal saline and squirt down the endotracheal tube. Follow this with five ventilations.
4. Monitor the heart rate.
5. If blood pressure is low, administer 0.01mg/kg epinephrine IV. If there is no IV access administer 0.1mg/kg epinephrine via the endotracheal tube. Dilute the calculated dose of epinephrine with 5ml of normal saline and squirt down the endotracheal tube. Follow with five ventilations.
6. Repeat epinephrine every three to five minutes.
7. Consider additional doses of atropine at 0.02mg/kg IV. The maximum dose of atropine for a child is 0.5mg. For a teen-aged child 1mg.
8. Watch for resumption of a normal pulse.

Cardiac Arrest in the Pediatric Patient with an ECG

Pediatric Ventricular Tachycardia (pulseless) and Ventricular Fibrillation

The definitive treatment of ventricular tachycardia (pulseless) and ventricular fibrillation is defibrillation.

Without a defibrillator

1. Call for additional assistance.
2. Shut off all anesthetics, 100% oxygen, and infuse IV fluids rapidly.
3. ABC's, CPR, and ventilation.
4. 0.01mg/kg epinephrine IV. Subsequent does of epinephrine are administered in doses of 0.1mg/kg. You may use alternative routes such as the endotracheal tube or intra-osseous if IV access is not available. The endotracheal tube dose is 0.1mg/kg epinephrine, diluted with 5ml normal saline and followed by five ventilations.
5. Continue resuscitation until the resumption of a pulse or a physician stops the code.

With a defibrillator

1. Call for additional assistance.
2. Shut off all anesthetics, 100% oxygen, and infuse IV fluids rapidly.
3. ABC's, CPR, and ventilation.
4. Prepare for non-synchronized defibrillation.
5. Start at 2 joules per kg. If not effective, 3 joules per kg. If not effective, 4 joules per kg.
6. If defibrillation does not return the patient to a normal rhythm with a pulse and blood pressure, continue CPR and ventilation.
7. 0.01mg/kg epinephrine IV. Subsequent does of epinephrine are administered in doses of 0.1mg/kg. You may use alternative routes such as the endotracheal tube or intra-osseous if IV access is not available. The endotracheal tube dose is 0.1mg/kg epinephrine, dilute with 5ml normal saline and follow with five ventilations.
8. Repeat defibrillation at 4 joules per kg, 30 to 60 seconds after each dose of epinephrine.
9. If not successful, continue CPR and ventilation. Administer 1mg/kg lidocaine, wait 30 seconds, and defibrillate at 4 joules per kg.
10. If not successful, continue CPR and ventilation. Subsequent doses of epinephrine are administered in doses of 0.1mg/kg. Defibrillate 30 seconds after each dose of epinephrine. May repeat after three to five minutes.
11. Consider repeating lidocaine.
12. If not successful, continue CPR, epinephrine, and defibrillation.
13. Continue resuscitation until the resumption of a pulse or a physician stops the code.

Pediatric Asystole/PEA

1. Call for additional help.
2. Shut off all anesthetics, 100% oxygen, and rapidly infuse intravenous fluids.
3. ABC's, CPR, and check the airway.
4. Consider possible causes: hypoxia, hypercarbia, drug overdose, allergic reaction, myocardial infarction, pulmonary embolism, electrolyte disturbances, tension pneumothorax, and hypovolemia. Identify and treat the cause.

5. 0.01mg/kg epinephrine IV initially. Additional doses of epinephrine should be administered every three to five minutes at a dose of 0.lmg/kg, while continuing chest compressions and ventilation. If no IV acces, the endotracheal tube or intra-osseous route can be used. The dose of epinephrine is 0.1mg/kg per endotracheal tube. Dilute the epinephrine with 5ml of normal saline and squirt down the endotracheal tube. Follow this with five ventilations.
6. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR.
7. Continue CPR until resumption of a pulse or the code is called stopped by a physician.

Allergic Reactions and Treatment

Allergic reactions can be severe, life threatening, and swift. They are caused by an exaggerated immunological response. All medications have the potential to cause an allergic reaction. Anesthetic related drugs that have been known to cause allergic reactions include: thiopental sodium, succinylcholine, nondepolarizing muscle relaxants, ester and amide local anesthetics, antibiotics, plasma expanders (i.e. dextran, starches, gelatins), and latex. If the patient has an anaphylactic reaction it must be treated quickly. The symptoms that you may observe include:

- Tachycardia
- Severe Hypotension
- Rash, flushing
- Laryngeal edema
- Wheezing, bronchospasm

There are five basic steps in the treatment of this potentially catastrophic event:

1. Secure the airway. Administer 100% oxygen. Stop the anesthetics.

2. Replace intravascular volume.
   ADULTS: May require 1 to 4 liters of ringers lactate or normal saline for severe vasodilatation. Start additional intravenous lines if necessary.
   CHILDREN: Require less fluid than adults. Start with a fluid bolus of 10ml per kg. Repeat as necessary.

3. Stop the reaction. Epinephrine will restore the membranes, decrease/stop the reaction from continuing, and relax the bronchial smooth muscles. It is the most effective medication to treat a severe allergic reaction.
   ADULTS: If the patient is experiencing a minor allergic reaction, adminster 5-10mcg/kg epinephrine IV. Repeat as necessary to stop the reaction and restore the blood pressure to a normal level. If no IV access epinephrine may be adminstered in a dose of 0.3-0.5mg subcutaneously. If the reaction is severe with impending

cardiovascular collapse, then treat the patient with 0.1 mg to 1mg of epinephrine.
CHILDREN: 10 mcg/kg epinephrine IV. If you have no IV you can administer epinephrine IM in the following doses:

Older than 5 years	0.5 ml of 1:1000 concentration
4 years of age	0.4 ml of 1:1000 concentration
3 years of age	0.3 ml of 1:1000 concentration
2 years of age	0.2 ml of 1:1000 concentration
1 year of age	0.1 ml of 1:1000 concentration

Alternately, dilute an ampule of epinephrine 1:1000 (1mg per ml) with 9ml of 0.9% sodium chloride. The resulting concentration will be 100 mcg per 1ml. Repeat epinephrine every 10 minutes if necessary, based on clinical symptoms.

Antihistamine medications are useful in decreasing the histamine release caused by an anaphylactic reaction.
ADULTS: Initial dose of 10mg IV of chloropheniramine. Repeat every six to twelve hours. Maximum dose 40mg in 24 hours. Alternative medications are diphenhydramine and promethazine: 50mg promethazine IV or IM, 50-100mg diphenhydramine IV.
CHILDREN: Ages 1 to 5, chloropheniramine can be administered in doses of 2.5-5mg subcutaneously only! Children 6 to 12 years of age, chloropheniramine can be administered a dose of 5-10mg IM. Alternatively, promethazine can be administered in children over the age of 2 years in a dose of 0.1 mg/kg or diphenhydramine in a dose of 0.5-1mg per kg.

4. Treat respiratory symptoms. Salbutamol (also known as albuterol) may be administered by inhalation. The inhaler spray delivers 100 mcg (micrograms) per puff. Start with 1-2 puffs. Have the patient take a deep breath as you depress the inhaler. Have the patient hold their breath for 15 seconds. Wait 5 seconds and repeat as needed. If the patient is intubated, several puffs should be administered via the endotracheal tube, followed by several ventilations.
ADULTS: Administer up to 20 puffs of salbutamol at for severe bronchospasm. For an aerosol treatment, 1ml of 0.5% albuterol in 3ml of normal saline.
CHILDREN: Administer up to 20 puffs of salbutamol for severe bronchospasm. For an albuterol aerosol treatment, add 0.5ml of 0.5% albuterol to 3ml of normal saline.

Alternatively, you can administer aminophylline by IV infusion.

ADULTS: Administer 250 mg (up to 6mg/kg) over 20 minutes, followed by an infusion of 0.5mg/kg/min. If you are unable to administer aminophylline by infusion, you may repeat the dose in 8 hours, as needed.

CHILDREN: The dose of aminophylline is 5mg/kg mixed in 5% glucose solution, given over 20 minutes, and followed by an infusion of 0.9mg/kg/min.

PRECAUTIONS WITH AMINOPHYLLINE

>Aminophylline can become toxic very easily. Give the loading dose over a minimum of 20 minutes. Monitor infusions closely. An infusion pump should be used.

> If signs of toxicity are observed (vomiting, tachycardia, fever, convulsions, rash, or apnea) stop its administration. You may restart aminophylline, after the toxic signs have stopped, at a reduced dose.

> If the patient has taken aminophylline in the last 24 hours, start with a half dose of aminophylline.

> If available, an inhaled or aerosolized bronchodilator, such as salbutamol, is preferred over aminophylline.

5. Corticosteriods enhance the effects of epinephrine.

   ADULTS: Dexamethasone IV or IM in a dose of 8mg or hydrocortisone IV or IM in a dose of up to 200 mg.

   CHILDREN: 2-4mg dexamethasone IV or IM for ages 0-5 years of age; 4-8mg IV or IM for ages 6 to12. Alternatively, hydrocortisone 2-4mg/kg IV or IM. The onset for corticosteriods can be several hours to work but are helpful in the management of an allergic reaction.

Allergic reactions may take several hours to fully resolve. The patient will require close observation during their recovery from this complication.

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Recovery Basics

Chapter Ten
Recovery Basics

The patient recovering from anesthesia should be monitored for common problems in the postoperative period to ensure their safety, providing for a smooth and uneventful recovery. Common complications may include, but are not limited to, the following:

- Hypoxemia related to airway obstruction or inadequate respiration
- Hypoventilation which results in hypoxemia and hypercarbia
- Hypotension
- Hypothermia
- Pain
- Nausea and vomiting
- Changes in heart rate and rhythm

Emergence from Anesthesia

During emergence, it is important to ensure that your patient has fully recovered from muscle relaxants. Residual neuromuscular blockade is a common problem. A peripheral nerve stimulator should be utilized to assess the degree of recovery from muscle relaxants. If a peripheral nerve stimulator is not available, you should ensure that the patient is able to follow commands, squeeze your hand tightly, and lift their head for 5 seconds. If the patient remains weak from nondepolarizing muscle relaxants, you should administer a reversal agent to promote adequate return of skeletal muscle function. If the patient remains weak after the use of succinylcholine, leave them intubated until they have adequate strength to be extubated. The patient's ability to respond appropriately to verbal commands can help reassure the anesthesia provider that the patient is not too "sleepy" from their general anesthetic. If the patient is too "sleepy" to respond to verbal commands, they may not be able to breathe adequately or protect their airway from regurgitation of stomach contents, possibly aspirating. If the patient is too "sleepy" to respond to verbal commands or too weak, the endotracheal tube should be left in until they are strong and alert to remove it safely.

Recovery Area Location and Equipment

The recovery area should be close to the operating theater. It should be staffed with specially trained nurses or by a staff member trained in anesthesia. The recovery area should have supplemental oxygen, suction, blood pressure measuring device, pulse oximeter, and ECG monitoring capabilities. With limited resources, the most important monitors to have available would be a pulse oximeter and a blood pressure cuff.

You should apply supplemental oxygen to most patients. Young healthy patients may not need additional oxygen. A pulse oximeter reading greater than 90%, with an adequate respiratory rate and depth of ventilation should be ensured. For patients who are elderly, have respiratory, or coronary disease, supplemental oxygen should be administered. Oxygen can be administered through several oxygen delivery methods, including a nasal cannula, face mask, or Venturi mask.

The amount of oxygen delivered to the patient will depend on the oxygen flow rate and delivery method. A nasal cannula is appropriate for administering up to 6 liters of oxygen per minute. These values are the approximate concentration of oxygen that are delivered by a nasal cannula.

Oxygen Flow Rate	Approximate O2 % Delivered
1 liter per minute	21-24%
2 liters per minute	25-28%
3 liters per minute	29-32%
4 liters per minute	33-36%
5 liters per minute	37-40%
6 liters per minute	41-44%

A simple face mask can be used to deliver between 6-10 liters per minute of oxygen, delivering up to 60% oxygen. A face mask with an oxygen reservoir (also known as a non-rebreathing oxygen mask) can deliver between 6 to 15 liters of oxygen per minute, delivering up to 95-100% oxygen. The values below are approximate levels of oxygen delivered by a simple mask and a face mask with an oxygen reservoir.

Oxygen Delivery Device	Oxygen Flow Rate	Approximate O2 % Delivered
Simple Face Mask	6-10 liters per minute	35-60%
Face Mask with O2 Reservoir	6 liters per minute	60%
Face Mask with O2 Reservoir	7 liters per minute	70%
Face Mask with O2 Reservoir	8 liters per minute	80%
Face Mask with O2 Reservoir	9 liters per minute	90%
Face Mask with O2 Reservoir	10-15 liters per minute	95-100%

A Venturi mask will deliver a precise oxygen concentration to the patient. The percent of oxygen delivered is dependent upon the predetermined oxygen setting. At a flow rate of 4-8 liters of oxygen per minute, an oxygen concentration of 24%, 28%, 35%, or 40% can be delivered. At a flow rate of 10-12 liters of oxygen per minute, an oxygen concentration of 40% or 50% can be delivered.

Reporting to Other Care Providers

If you are not responsible for recovering the patient, provide the next caregiver with the following information:

- Patient's name, age, and family
- Surgical procedure

- Preoperative, anesthetic, and adjunct medications administered
- Preoperative and intraoperative vital signs
- Current medical conditions
- Home medications
- Allergies
- Estimated blood loss and urine output
- Fluid and/or blood replacement
- Complications during surgery and/or the anesthetic
- Any concerns about the patient

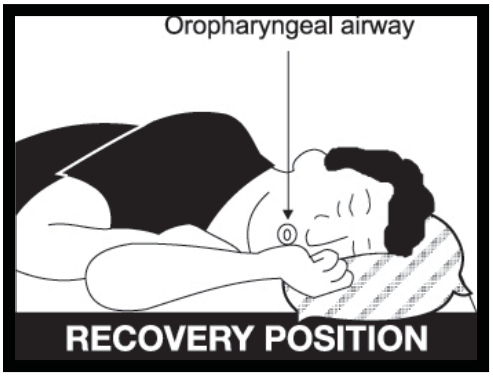
Good communication promotes safe care.

Patient Monitoring during Recovery

The A, B, C's (airway, breathing, and circulation) should be used during the recovery period. Remembering this prioritizes the care for the patient.

Airway- Is the first priority.

- Monitor the patient for adequate air exchange.
- Keep the airway clear from obstruction. An oral or nasopharyngeal airway can be used if necessary**. Artificial airways should not replace good care!**
- The patient should be in a side lying 'recovery' position, if possible.



- A pulse oximeter will help determine if the patient is oxygenating their blood adequately.

Breathing- Is the second priority.

- Look for chest movement. Feel for air as it is exhaled from the patient's nose and mouth. Are the respirations shallow, normal, or deep?
- Count the number of respirations per minute. Count the number of respirations in a 15 second time period and multiply it by 4. Is the patient breathing faster or slower than normal?

- If the patient is breathing slowly, try to determine the cause. Has the patient received opioids that depress respiration? If the respiratory rate is less than 8 breaths' per minute, attempt to arouse the patient verbally and shake their shoulder. If opioid induced, naloxone will reverse respiratory depression.
- Faster than normal respirations may indicate that the patient is in pain, hypovolemic, or not exchanging air well. Investigate the cause and treat the patient right away.
- Look at the patient's color. Is the patient pink or cyanotic? If they are cyanotic around the lips and tongue, they may be hypoxic.
- A pulse oximeter is invaluable in determining if the patient has adequate oxygenation.
- Do not hesitate to assist the patient with a bag mask device if the patient's oxygen saturation is low or the patient is not breathing adequately.

Circulation- Is the third priority.

- Count the number of pulsations felt for 15 seconds. Multiply this by 4. This will give you the pulse rate. Always 'palpate' the pulse to make sure that the pulse oximeter is correct.
- Bradycardia may need to be treated with oxygen and atropine.
- Tachycardia may indicate pain or hypovolemia.
- Assess the quality of the pulse.
- If the pulse is weak, it may be because the patient is hypothermic or hypovolemic. Take the patient's blood pressure. Hypotension and tachycardia may alert you to postoperative bleeding/hypovolemia.
- If an ECG is available, it should be used to monitor for heart rhythm changes
- Observe the patient's dressings frequently for signs of bleeding.

Beyond the A, B, C's

Consciousness- The patient's level of consciousness should be assessed. There are three categories of consciousness:

- Fully awake
- Arouses to verbal stimulation
- Not responding to verbal or tactile stimulation

Pain- The amount of pain the patient is experiencing can be assessed by asking them to rate it. Use a scale of 1-10. One indicates no pain, and ten would be the most pain the patient has ever experienced. This will help guide in determining if the patient requires additional analgesics. Remember that the patient's respirations may be depressed after receiving opioids. Monitor and observe the patient at all times.

Nausea and Vomiting- Nausea and vomiting should be treated with anti-emetics. Vomiting and/or retching can be detrimental to the patient's fluid status and electrolytes, contributing to dehydration. In addition, vomiting and/or retching may disrupt surgical repairs.

Temperature- Any deviation from normal temperature is a concern during the recovery period. A patient with a high temperature may be experiencing malignant hyperthermia. Review the signs and symptoms/treatment in the anesthesia medication chapter. Conversely, being hypothermic can affect the patient's ability to clot blood, wound healing, and increase the risk of infection. Keep the patient covered and dry. Shivering can lead to increased oxygen consumption, resulting in hypoxemia. If the patient is shivering excessively but awake and responsive to verbal stimuli, then a small dose of 12.5 mg of meperidine can be administered IV to stop the shivering. This dose may be repeated once if the first dose does not stop the shivering.

Documentation

The following should be documented:

- Oxygen saturation
- Supplemental oxygen
- Respiratory frequency and depth
- Heart rate and blood pressure
- Level of consciousness. Is the patient awake and alert, or is the patient sleepy and not responsive? Does the patient follow commands? Is the patient confused?
- Upon arrival, empty the urinary collection bag. Measure the urine output and document the amount of urine disposed of.
- Assess the patient's dressings. Are they dry? Are they saturated with blood?
- Temperature should be documented upon arrival to recovery and before the patient leaves the recovery area.
- Document any medications or fluids administered during the recovery period.

Discharging the Patient

The patient should not be discharged to the ward until the following criteria are met.

- The patient should be awake and able to follow verbal commands.
- The patient should be able to maintain their airway without the help of a jaw thrust/chin lift or oral/pharyngeal airway.
- The patient's respiratory rate and depth should be adequate.
- The ability to cough, gag, and swallow should be present.
- The patient should maintain a pulse oximeter reading of 90% or greater.

- The patient's pulse rate and blood pressure should be stable. They should not be too low or too high.
- The patient should be warm and not discharged to the ward cold and shivering.

A scoring system is often used to determine if the patient should be dismissed to the ward. A common scoring system is called the Aldrete Scoring System. There are 5 categories that are used to determine the degree of recovery: activity, respiration, circulation, consciousness, and color. There are 3 possible responses to each category that are scored. The total score determines if the patient should be discharged to the ward, or kept in the recovery area longer. To be discharged to the ward a total score of 9 or more is generally required. Below is a sample of the Aldrete scoring system

Category	Response	Score
Ability to move extremities	Moves all 4 extremities= Moves 2 extremities Does not move	2 1 0
Respiration	Takes deep breathes and coughs Short of breath, shallow respirations Not breathing	2 1 0
Circulation	Blood pressure +/- 20 mmHg of preop level Blood pressure +/- 20-50 mmHg of preop level Blood pressure is +/- 50 mmHg of preop level	2 1 0
Consciousness	Fully awake Arouses to verbal stimulation Not responding	2 1 0
Color	Normal Pale, jaundiced, blotchy or dusky Cyanotic (bluish)	2 1 0
Total Score		

Conclusion

The patient requires close monitoring during the recovery period. The patient is still at risk for complications as they recover from anesthesia.

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Pediatric Anesthesia

Chapter Eleven
Pediatric Anesthesia

Pediatric patients are not small adults. There are several anatomical and physiological differences. These differences impact the effects and techniques of anesthesia administration. Pediatric patients can be divided into four groups based on age.

- Newborn- Birth through the first 24 hours.
- Neonate- 1 to 30 days of extra uterine life.
- Infant- 1 month to 12 months of age.
- Child- 1 year to the onset of puberty.

In this chapter physiologic and anatomic differences and their impact on anesthesia will be addressed. In addition basic perianesthesia considerations in caring for the pediatric population will be discussed.

Physiological Differences

Oxygen Consumption

Oxygen consumption for a neonate is two times greater than that of an adult. The neonate's cardiovascular and respiratory systems compensate to meet this demand by increasing cardiac output and alveolar ventilation.

	Neonate	Infant	5 year old	Adult
Oxygen Consumption (ml/kg/min)	6	5	4	3

Cardiovascular Physiology

Cardiac output for a neonate is 30-60% greater than an adult. This helps meet the increased oxygen consumption requirements. In addition, the neonates' hemoglobin level is higher.

	Neonate	Infant	5 year old	Adult
Hemoglobin Level (g/dl)	17	11-12	13	14
Hematocrit %	55	30-35	38	

High hemoglobin levels are required because of the presence of fetal hemoglobin. Fetal hemoglobin does not release oxygen as easily as regular hemoglobin. By 2-3 months of age, the infant experiences a physiologic anemia as regular hemoglobin replaces fetal hemoglobin. Anemia is defined as hemoglobin levels less than 13 g/dl in a newborn and 10 g/dl in an infant that is 6 months or older. Hemoglobin below these levels impairs oxygen's carrying capacity and may be detrimental if the patient has co-existing diseases. Currently literature does not describe what an acceptable hemoglobin level is in this patient population. In addition, the neonates' ability to constrict blood vessels in response to bleeding is less effective than adults. Careful monitoring of blood loss during surgery is critical.

The blood volume of the pediatric patient is highest as a neonate and declines with age. Knowledge of the approximate blood volume is important when calculating total blood volume and estimated blood loss. For example, a 4 kg neonates' total blood volume would be calculated as follows: 4(kg) X 85 (ml/kg) = 340 ml total blood volume.

	Premature	Neonate	Infant	5 year old	Adult
Blood Volume (ml/kg)	90-100	85	80	75	65

Following birth, there is the loss of a low resistance placental circulation. Subsequently, there are increases in systemic vascular resistance and left ventricular pressure. The left and right ventricle cardiac output equalizes. The left ventricle of the neonates' heart is "stiff". In other words, the left ventricle will distend with increasing volume, but not to the extent of the adult left ventricle.

Cardiac output in the pediatric patient is dependent on heart rate. Monitoring of the pediatric patient's heart rate can be accomplished with a precordial stethoscope, ECG, and pulse oximetry. Prompt recognition and treatment of bradycardia is critical. Bradycardia is defined as a heart rate that is less than 80 beats per minute in children 1-8 years, less than 100 beats per minute in infants aged 1-12 months, and less than 120 beats per minute in neonates. It is the most common rhythm prior to cardiac arrest in the pediatric patient. The most common cause is hypoxia. Other causes include vagal stimulation (suctioning, surgical traction, etc.), overdose of anesthetic medications, hypothermia, and increased intracranial pressure.

Treatment of Bradycardia

Ensure that you are delivering 100% O2
Listen to lung sounds
Stop inhaled anesthetic agents
Stop surgical stimulation
Reassess the patients' vital signs

⬇

If the patient does not exhibit cardiac compromise noted by hypotension and poor perfusion (slow capillary refill, poor color), then watch for the return of a normal heart rate and bolus the patient with 10 ml/kg of a crystalloid solution. Consider the administration of atropine in a dose of 0.01-0.02 mg/kg (the minimum dose should be 0.1 mg).

⬇

If the patient exhibits cardiac compromise, then treat the patient in the following manner:
Epinephrine 0.01 mg/kg IVP (0.1 mg/kg per ETT)- this may be repeated every 3-5 minutes
Start chest compressions if heart rate remains below 60 beats per minute and continues to demonstrate cardiac compromise despite the administration of medications, fluids, 100% oxygen.
Atropine in a dose of 0.02 mg/kg IV should be considered (minimum dose is 0.1 mg)

The best treatment for bradycardia is prevention. Continual attention to the patient's heart rate is essential. Adjustment of inhalational anesthetics, the administration of fluids, and early intervention with atropine are important to avoid potentially devastating consequences.

The pediatric patients' blood pressure will rise as the patient ages. Knowledge of normal systolic blood pressures and heart rate will help to determine if the patient is hypotensive and/or bradycardic.

	Neonate	Infant	5 year old	Adult
Heart Rate (beats per minute)	120-160	100-120	80-100	80
Systolic Blood Pressure (mmHg)	65	90-95	95	120

The sympathetic nervous system in a pediatric patient is not as well developed as it is in an adult. This may result in an imbalance between the parasympathetic and sympathetic nervous system. This imbalance places the pediatric patient at increased risk for bradycardia. In the past atropine was administered prophylactically, either preoperatively or after the initiation of a running IV during anesthetic induction in children 1 year of age or less. Many clinicians choose not to routinely administer prophylactic atropine and instead treat bradycardia when and if it occurs. Advanced preparation in treating bradycardia is crucial. The appropriate dose of atropine to have drawn up is

0.01 – 0.02 mg/kg with a minimum dose of 0.1 mg. The maximum dose for a child is 0.5 mg. Prophylactic atropine may reduce the incidence of bradycardia associated with intubation, surgical manipulation, and the cardio-depressant effects of general anesthesia. Bradycardia will develop more frequently when using a straight blade due to the stimulation associated with lifting the epiglottis. Atropine should be administered prior to a first dose of succinylcholine in the neonate and prior to the second dose in older patients. Succinylcholine administration should not be routine in pediatric patients due to the risk of hyperkalemic cardiac arrest. The use of muscle relaxants is often not needed for intubation with an adequate level of anesthesia.

Pulmonary Physiology and Airway Anatomy

Alveolar ventilation in neonates is twice the adult rate. In neonates, alveolar ventilation is 130 ml/kg/minute while in an adult it is 60 ml/kg/min. This compensatory mechanism helps to meet the increased oxygen demands of the pediatric patient. Metabolic rate is higher than that of an adult. Subsequently, carbon dioxide production is higher when compared to carbon dioxide production of an adult. Increased ventilation results in a normal carbon dioxide level. Infants and young children are unable to increase tidal volume effectively. Conditions that lead to respiratory distress result in a compensatory increase in respiratory rate.

	Neonates	Infants	Child	Adults
Respiratory Rate	35	25	20	15

Since pediatric patients have an increased metabolic rate and carbon dioxide production, they require a higher ventilatory rate than adult patients do. Carbon dioxide monitoring helps in determining the appropriate ventilatory rate. The pediatric patient's lungs have less oxygen reserve than an adult's lungs do. The functional reserve capacity (the amount of air left in the lungs after a normal expiration; it is the amount of gas that maintains distention of the alveoli) is much smaller in infants and neonates when compared to the adult.

	Neonates	Infants	Child	Adult
Functional Reserve Capacity	25 ml/kg	25 ml/kg	35 ml/kg	40 ml/kg

During anesthesia, airway obstruction can result in hypoxia very quickly. For this reason pulse oximetry is essential. During all phases of anesthesia care, the patient should be closely monitored for apnea or airway obstruction. Induction and emergence are especially critical periods to monitor for these complications.

Control of respiration is immature in neonates. Responses to hypoxia are unpredictable and may lead to apnea. Premature neonates and infants are at risk for apnea after general anesthesia regardless of the choice of agent. The premature neonate and infant are at risk for apnea up to 60 weeks of post conceptional age. To calculate post conceptional age, add the number of weeks the baby was in uterero, to the number of weeks since its birth. Patients at risk should be kept in a monitored environment for 24 hours after a general anesthetic. The patient should be monitored for apnea and hypoxemia with equipment that is available in your institution, by trained personnel.

Neonates and infants have a soft, compliant chest wall. Intercostal and sternal retractions are noted when an airway obstruction is present or with an increase in the work of breathing. The diaphragm is largely responsible for ventilation in this patient population. Conditions that lead to abdominal distention may lead to a decrease in effective respiration. Examples include abdominal distention from: abdominal bleeding, closure of an omphalocele, gastroschiesis, bowel obstruction, and from air being introduced into the stomach during mask ventilation.

The anatomy of the pediatric airway is different compared to an adult.

- The pediatric patient is prone to airway obstruction related to a proportionally larger head, short neck, and large tongue. Positioning of the patients airway is an important consideration. Overextension can result in airway obstruction in the neonate.

- Infants and neonates exchange air primarily through their nasal airway.
- The larynx is higher in the infant and child (cervical vertebrae 3-4) than in the adult (cervical vertebrae 5-6).
- The epiglottis is large, stiff, and U shaped. Most anesthesia providers use a straight blade for pediatric intubation. The straight blade allows the anesthesia provider to directly pick up the epiglottis. The curved blade is placed in the vallecula and when lifted, exposes the glottic opening. Since it picks up the epiglottis indirectly, visualization of the glottic opening may be diminished. If you do not have a straight blade available, you can use the tip of a curved blade to directly pick up the epiglottis. The choice of blade depends upon anesthesia provider preference.

- The trachea is short, and the right main bronchus is less angled. This increases the risk of a right mainstem intubation. Always confirm bilateral and equal breath sounds after intubation. Continuous monitoring of breath sounds should occur during the anesthetic with a precordial or esophageal stethoscope. Confirmation of equal and bilateral breath sounds should be made any time the head and neck position is changed. It is important to confirm bilateral and equal breath sounds on the anterior and lateral (i.e. axilla) portions of the chest.
- The glottic opening in a pediatric patient is narrower than that of an adult. The cricoid cartilage ring is the narrowest portion of the pediatric airway. Endotracheal tubes without an air leak may be too large, leading to edema of the subglottic airway. The incidence of post extubation croup has been estimated to be up to 1-6%. Symptoms of post extubation croup include an increased resistance to breathing, stridor, a "barking" cough, and respiratory retractions. Risk factors for this complication increase if the patient is between 1-4 years of age and has any of the following: tight fitting endotracheal tube without an air leak, traumatic or prolonged intubation, high pressure/low volume cuffs, coughing while intubated, and a history of post extubation or infectious croup. An air leak should be present after intubation. If you have a pressure gauge, the leak should occur around 20 mm Hg. If you do not have a pressure gauge, you should be able to easily ventilate the patient with an air leak. If it is hard to maintain adequate ventilation due to an excessive air leak, then replace the endotracheal tube with the next size up and reevaluate the air leak and ventilation. Treatment of post extubation croup can be reviewed in the airway chapter.
- When surgical procedures are performed in the airway, care must be taken to avoid 100% oxygen with an air leak. An oxygen enriched environment can lead to airway fires when cautery is used, which can be catastrophic. If you do not have medical air or nitrous oxide available to decrease the oxygen concentration, then the pharynx should be packed with sterile water or normal saline soaked gauze. It is important to count the number of gauzes placed to ensure that they are all removed at the end of the procedure. If a gauze is left in the patient, they may aspirate it during emergence and extubation. This can be life threatening! The surgeon should confirm that oxygen is not leaking around the endotracheal tube. The surgeon should be reminded of the risk of an airway fire. Cautery should only be used in short bursts when necessary.
- Choosing the correct sized endotracheal tube and approximate length of insertion is important. A simple method to estimate the diameter of the endotracheal tube is to compare the pediatric patients little finger to the size of the endotracheal tube. If they are about the same diameter, it is likely to be the appropriate size for insertion. This can also be accomplished by a simple calculation. The equation that can be used (16 + age/4) will approximate the correct size of endotracheal tube. These calculations are derived from Western countries and may not always give the correct size in other parts of the world. Regardless of the calculations, an endotracheal tube should slide easily into the trachea, and never be pushed or forced. The calculation for the correct endotracheal tube depth insertion

is to multiply the diameter of the endotracheal tube by 3. For example, an endotracheal tube that is a size of 3.0 would be multiplied by 3 to equal a depth insertion of 9 cm. Another simple method to estimate the length of endotracheal tube insertion is to look at the distance from the corner of the patient's mouth to the ear canal than double the distance. This should be the approximate insertion depth.

- Auscultation of equal, bilateral lung sounds (including the axilla) after endotracheal tube placement should always be performed. The gold standard for confirmation of correct placement of the endotracheal tube is the presence of end tidal carbon dioxide. If this monitoring equipment is not available, then other less precise forms of confirmation can be utilized in addition to auscultation. These include watching the endotracheal tube go between the vocal cords, using the anesthesia bag to ventilate and seeing the chest rise, pushing (lightly) on the patient's chest and feel air come back, ensuring that the patients oxygen saturation remains in the 90's, the patient is pink and not cyanotic, and watching for vapor or condensation in the endotracheal tube.
- Never use liquid paraffin (mineral oil) on endotracheal tubes for a lubricant. The use of this material can lead to pneumonia and can be damaging to the lungs. In addition, studies have shown that lubrication of endotracheal tubes can lead to an increase in the incidence of a sore throat and may contribute to laryngeal injury from the drying of lubricants.

Renal System and Extracellular Fluid Volume

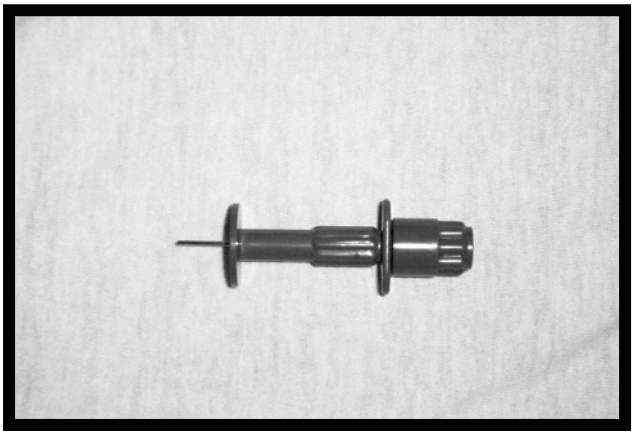
At birth, the kidney's have a decreased glomerular filtration rate, decreased sodium excretion, and decreased concentrating ability. The glomerular filtration rate will increase and reach adult levels by 12-24 months of age. Neonates and infants up to 24 months are not able to compensate for alterations in fluid balance as well as adults. This makes fluid replacement very important.

	Neonates	Infants	Child	Adult
Glomerular Filtration Rate	30-35 ml/min	60-90 ml/min	95-125 ml/min	95-125 ml/min

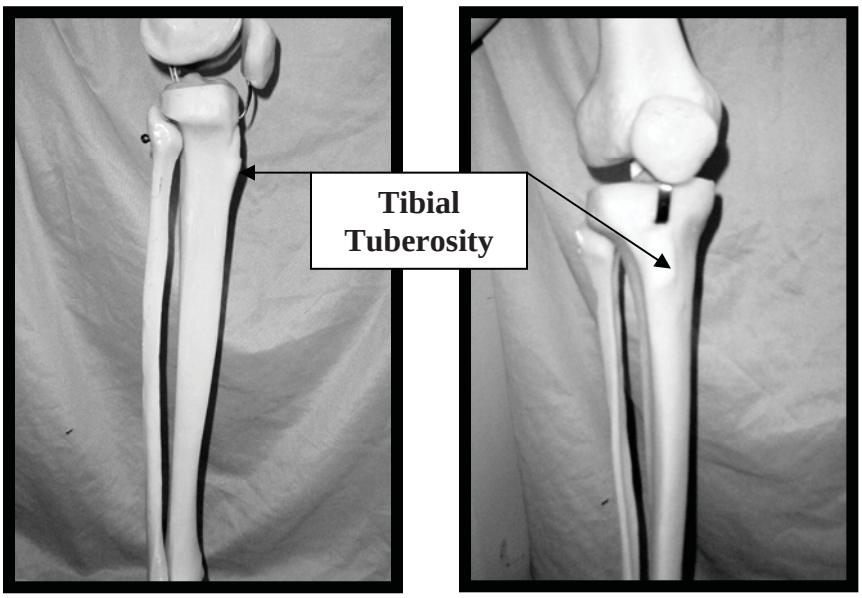
The extracellular fluid volume in the infant is twice that of an adult. Approximately 40% of the body weight in infants is extracellular fluid compared to 20% of an adults' body weight. Neonates, infants, and children fasting for anesthesia can become dehydrated more quickly than an adult. It is important to stress preoperative NPO status to parents in preparation for surgery. It is also important that fasting is not enforced too far in advance of the surgical procedure. Careful fluid calculation includes: NPO deficit, maintenance fluids, 3rd space fluid loss, and estimated blood loss replacement. Please refer to the fluid management chapter.

For the pediatric patient that is dehydrated, it is important to correct pre-existing deficits prior to anesthesia to avoid hypotension. This does not include the patient who is healthy and has fasted prior to surgery. Correcting pre-existing deficits prior to anesthesia should be reserved for the

pediatric patient who is dehydrated due to illness. The degree of dehydration can be estimated by signs and symptoms. A 5% deficit corresponds with dry skin and mucous membranes. A 10% deficit will correspond with cool limbs, loss of skin turgor, depressed fontanelles, sunken eyes, and oliguria. A 15% deficit is noted by hypotension and diminished or absent response to painful stimuli. If venous access is not possible, an intra-osseous infusion should be considered. Bone marrow is in continuous contact with the venous system. Blood can be aspirated for laboratory testing, medications and fluids can be infused through the marrow. The intra-osseous technique is not designed for long term infusion. Consider the intra-osseous technique for life threatening situations in which venous access is not possible. It should be used to stabilize the patient for only a few hours. To perform an intra-osseous infusion, you will need a skin disinfectant, intra-osseous or bone marrow needle, local anesthetic, a sterile 5 ml syringe, and a sterile 50 ml syringe. The anatomical sites that can be used include the anterior surface of the tibia or femur.



An example of an Intra-osseous needle.



Side View **Front View**

The site should be free of osteomyelitis or fracture. The technique is as follows:

- Cleanse the skin with a disinfectant.
- Identify the tibial tuberosity by palpation and move 1-2 cm, or one finger breadth, down. This is to avoid the growth plate. Needle insertion into the growth plate can result in permanent damage.
- Inject a skin wheal of local anesthetic. Continue to infiltrate local anesthetic down to the periosteum of the tibia or femur.
- Insert the intra-osseous or bone marrow needle at a 90 degree angle to the skin (perpendicular). When inserting the needle, make sure the needle is pointed slightly away from the knee joint to reduce the risk of injury to the growth plate.
- Firmly advance the needle until you feel a loss of resistance. When this occurs, the needle has penetrated the outer cortex of the bone and should be in the marrow.
- Remove the trochar/stylet and confirm that you are in the bone marrow. This is done by gently aspirating blood using a sterile 5 ml syringe.
- Secure the needle with sterile gauze and tape. Boluses of intravenous fluid using a 50 ml syringe may be administered or alternately an infusion of intravenous fluid.
- Discontinue the intra-osseous needle as soon as a vein is cannulated to avoid the risk of osteomyelitis or sepsis.

Estimation of blood volume and monitoring of blood loss is crucial. What appears to be a small amount of blood loss in an infant may be a large amount of blood loss when compared to the patients estimated blood volume. Replacement of mild to moderate blood loss during surgery is accomplished with 3 ml of crystalloid for every 1 ml of blood. For a blood loss that is moderate (< 25-30% of the total blood volume) a colloid solution such as dextran or albumin may be given. For every 1 ml of blood loss, 1 ml of colloid should be administered. The decision to transfuse the pediatric patient with packed red blood cells depends on the amount of blood loss and underlying medical conditions. In general, blood replacement should occur if the hematocrit drops below 25%, which corresponds to a hemoglobin of 8 g/dl. Each 1 ml of blood loss should be replaced by 1 ml of packed red blood cells. To raise the hemoglobin by 1 g/dl approximately 3 ml/kg of packed red blood cells should be administered. To raise the hematocrit by 10%, approximately 10 ml/kg of packed red blood cells is needed. If packed red blood cells are not available (properly typed and crossmatched) whole blood may be administered. Replace 1 ml of blood loss with 1 ml of whole blood.

Prior to any surgical procedure that may result in blood loss, a calculation of the maximal allowable blood loss should be completed prior to a blood transfusion.

	Premature	Neonate	Infant	5 year old	Adult
Blood Volume (ml/kg)	90-100	85	80	75	65

1. First estimate the total blood volume. The equation is ml per kg X patient's weight in Kg. For full term neonates the estimated blood volume is 85 ml/kg. For infants it is 80 ml/kg. For children it is 70-75 ml/kg. For example, in an 8 kg infant, the estimated blood volume would be 80 x 8 = 640 ml.
2. Next multiply the estimated blood volume (EBV) by the starting hematocrit (Hct)- the lowest acceptable hematocrit (Hct) divided by the starting hematocrit. The equation looks like this: EBV $\times \frac{Hct\ start - target\ Hct}{Hct\ start}$. For example an 8 kg infant has a starting hematocrit of 38. The anesthesia provider has determined to transfuse the infant at a hematocrit of 28. The calculation would be as follows:

$$640 \text{ ml EBV} \times \frac{38-28}{38} = 0.26$$

640 x 0.26 = 166 ml of blood loss.

At this point, the decision to transfuse would be made.

The estimation of acceptable blood loss is only a rough guide. Hemoglobin and hematocrit levels should be monitored during moderate to heavy blood loss (approaching 25% of the total blood volume) for more accurate results. The decision to transfuse a patient is dependent upon individual patient factors. In settings that do not have the ability to transfuse blood, it is important to use colloid and crystalloids for replacement. If bleeding is excessive, communication with the surgeon is important, consideration to aborting the procedure should be given.

Postoperatively, the pediatric patient should have maintenance fluids continued until the patient is taking fluids by mouth.

Temperature Regulation

Neonates and infants can rapidly loose heat, even in warm environments. Neonates and infants are at greater risk than adults for hypothermia due to a relatively high surface to volume ratio, a high metabolic rate, and insufficient body fat for insulation. Infants less than 3 months do not shiver to generate heat. It is important to take steps to minimize heat loss including a warm operating room, warm blankets, or a heating blanket. Monitoring the patients' temperature before, during, and after the anesthetic is important to detect abnormal drops or increases in temperature. Please refer to the chapter on positioning and monitoring for more information.

Pharmacology in Pediatrics

Pediatric patients respond differently to anesthetic medications when compared to adults. This is due to physiological differences that include extracellular skeletal mass, metabolic rate, renal function, and receptor maturity. The science of pharmacology involves pharmacokinetics and pharmacodynamics. Pharmacokinetics include the absorption, distribution, and elimination of medications. Pharmacodynamics include the effect of a medication on the body. The responses of the pediatric patient will be discussed. For a review of individual medications, please refer to the Medications chapter.

Inhaled Anesthetics

Uptake, distribution, and potency of volatile anesthetics are different in neonates and infants than in adults. Inhaled anesthetics include halothane, enflurane, isoflurane, sevoflurane, ether, and nitrous oxide. Induction of general anesthesia occurs faster in neonates and infants. Emergence also occurs faster. The differences between the adult and pediatric patient during induction and emergence are twofold:

- Smaller functional residual capacity (smaller lung volume).
- Greater blood flow to the vessel rich tissues such as the brain, heart, liver, and kidneys. In infants and neonates, the vessel rich tissues compose about 22% of the total body weight. In adults, the vessel rich tissues compose about 10% of the total body weight.

Minimal alveolar concentration (MAC) is a measure of potency. MAC is the concentration (%) of a volatile anesthetic that is required to prevent 50% of the patients from moving with surgical incision. MAC varies according to the age of the patient. In general, MAC is lower in neonates than in infants. MAC increases until about 2-3 months of age, peaks during infancy, and then steadily declines. During puberty there is a brief increase in MAC. After puberty, MAC will continue to decline. Below is a table comparing common volatile anesthetics and approximate MAC values with 100% oxygen. These values can be used as a rough guide.

Agent	Neonate	Infant	Small Children	Adults
Halothane	0.87%	1.1%	0.87%	0.75%
Isoflurane	1.6%	1.8%	1.5%	1.2%
Sevoflurane	3.2%	3.2%	2.5%	2.0%
Desflurane	8%	9%	7%	6%

Lower MAC requirements for volatile anesthetics in neonates are due to an immature central nervous system and circulating maternal progesterone and endorphins. As the neonates' central

nervous system becomes more mature and circulating levels of progesterone and endorphins decrease, MAC will increase until 2-3 months of age.

There is a smaller margin between adequate anesthesia and cardiovascular depression when using volatile anesthetics in neonates and infants. Hypotension can occur due to inadequate and immature compensatory mechanisms. In addition, the heart of neonate and infant is sensitive to the depressant effects of volatile anesthetics. Cardiac output is largely dependent on heart rate. The use of atropine or glycopyrrolate may help counter act these depressant effects.

Nitrous oxide is often used to supplement volatile inhalation agents such as halothane, isoflurane, and sevoflurane. Nitrous oxide is insoluble. This increases the speed of induction and emergence. When administering nitrous oxide, a minimum of 30% oxygen must be administered to prevent hypoxia. At the end of an anesthetic that includes nitrous oxide, 100% oxygen should be used for 5-10 minutes. When nitrous oxide is first discontinued it can crowd oxygen out of the alveoli of the lungs. Nitrous oxide is forty times more soluble in blood than nitrogen. When nitrous oxide is discontinued at the end of an anesthetic, nitrous oxide diffuses out of the blood into the alveoli in large volumes during the next 2-3 minutes. If the patient is allowed to breathe room air at this time, the combination of nitrous oxide and nitrogen in the alveoli will cause hypoxia. This is called diffusion hypoxia. High concentrations of oxygen (100%) after discontinuing nitrous oxide prevent this.

Halothane is a non-pungent anesthetic suitable for pediatric inhaled inductions. Care must be taken when administering halothane since there are dose dependent reductions in blood pressure, cardiac output, and heart rate. Halothane is the primary cause of bradycardia (less than 80 in children aged 1-8 years, less than 100 in infants aged 1-12 months, and less than 120 in neonates) and cardiac arrest in pediatric patients. Bradycardia should be rapidly treated by first assuring that the patients' airway is patent and there is not an airway obstruction. Halothane should be discontinued. Epinephrine in a dose of 0.01 mg/kg is the treatment of choice. Halothane can also cause cardiac arrhythmias by sensitizing the cardiac conduction system to the effects of epinephrine. Ventricular ectopy has been reported in 50% of patients at an epinephrine dose of 2 mcg/kg. If the surgeon is injecting local anesthetics with epinephrine, it is important to keep the total dose less than 10 mcg/kg when using halothane. Halothane should be discontinued if administering epinephrine for hypotension or bradycardia. Hypotension in the pediatric patient should be initially treated with a reduction/discontinuation of halothane and a 10 ml/kg bolus of intravenous fluid.

Enflurane and isoflurane are not useful agents for inhalation inductions in pediatric patients. Attempting an inhaled induction with these volatile agents may result in breath holding, coughing, and laryngospasm. Enflurane should be avoided in patients with a seizure history since it lowers the seizure threshold. Isoflurane and halothane are similar in their effects on the heart.

Sevoflurane is a non-pungent, volatile anesthetic suitable for pediatric inhaled inductions. Sevoflurane induces general anesthesia faster than halothane. In the United States, sevoflurane has largely replaced halothane for pediatric inhalation induction. There are fewer inhalational anesthetic overdoses reported with sevoflurane when compared to halothane. Sevoflurane does increase the incidence of emergence delirium in pediatric patients. The patient may be very upset, crying, thrashing about, and inconsolable. This is often a self limiting reaction. It is important to protect the patient during this time.

Ether has a pungent odor. Inhalation inductions are slower than halothane or sevoflurane and may be irritating to the patient's airway. Ether has minimal effects on the cardiovascular and respiratory systems, which make it a safe agent. The disadvantage of ether is that it is flammable when administered with air and explosive when administered with oxygen.

Intravenous Anesthetic Agents

Neonates are sensitive to intravenous anesthetic agents. Neonates have an immature blood-brain barrier and a decreased ability to metabolize medications such as opioids and barbiturates. In general, lower doses of intravenous anesthetic medications are required to produce the desired effects. There are some generalized exceptions. For example, to induce general anesthesia higher doses of propofol (on a mg/kg basis) are required when compared to an adult. The higher doses in infants and children are a result of increased extracellular volume and greater volume of distribution. Pediatric patients less than 6 months old may be more sensitive to respiratory depression resulting from opioid administration. Caution should be used when administering opioids to this age group. The pediatric patient should be carefully monitored during the postoperative period.

Nondepolarizing Muscle Relaxants

Neonates and infants may be more sensitive to the effects of nondepolarizing muscle relaxants. The neuromuscular junction of the infant is immature. On the other hand, the volume of distribution (the amount of medication required to achieve a desired concentration in the blood or plasma) is much larger due to increased extracellular volume. These two effects offset each other so the initial doses of nondepolarizing neuromuscular blocking agents are similar for neonates/infants and adult patients. The duration of action of nondepolarizing muscle relaxants may be prolonged due to immature renal and hepatic systems. Since the duration of action may be unpredictable, it is important to closely monitor the patient response with a nerve stimulator (please refer to monitoring chapter).

Reversal Medications for Nondepolarizing Muscle Relaxants

Edrophonium and neostigmine are effective agents to antagonize (reverse) the effects of nondepolarizing muscle relaxants. Clinically, the same dose (edrophonium 0.5 – 1 mg/kg with a

maximum dose of 40 mg and neostigmine 0.05 mg/kg with a maximum dose of 5 mg, calculated on an mg/kg basis) is used for adults and pediatrics. Atropine or glycopyrrolate should always be administered with or before either edrophonium or neostigmine to avoid serious side effects such as bradycardia. Atropine (0.015 mg/kg) is more appropriate for edrophonium and glycopyrrolate (0.01 mg/kg) is more appropriate for use with neostigmine. This is based on the onset and duration of action for edrophonium and neostigmine. In addition, edrophonium or neostigmine should be administered slowly to avoid side effects.

Depolarizing Muscle Relaxants

Neonates and infants require higher doses, on a mg/kg basis, of succinylcholine than the adult patient. This is due an increased extracellular volume and volume of distribution. The dose of succinylcholine in pediatrics is 1.5-2 mg/kg IVP compared to 1 mg/kg IVP in adults. Routine use of succinylcholine in pediatric anesthesia is not recommended. This is due to rare reports of cardiac arrest, secondary to high potassium levels, in pediatric patients with undiagnosed muscular dystrophy. The use of succinylcholine in pediatrics should be reserved for emergency intubation, rapid sequence induction, laryngospasm, and other emergent situations as long as it is not contraindicated. Additional information about succinylcholine can be found in the Medications Used in Anesthesia Chapter.

Practical Pediatric Considerations

Meeting the Emotional Needs of the Pediatric Patient

The pediatric patient differs from the adult patient in not only physiological terms, but also in emotional terms. Meeting the pediatric patients' emotional needs is important. The pediatric patient should see the anesthesia provider as someone they can trust and not fear. The preoperative visit is crucial in establishing a relationship with the patient and reducing the parents' anxiety. Focus attention first on the pediatric patient, then on the parents. Smile and talk softly. Allow the pediatric patient to play with the stethoscope and "listen". Tell the patient what to expect at a level that they can understand at their age. Always be honest but gentle. For example, a young child may only need to know that you are there to help them get better. Older children may want more information about what to expect.

Avoid procedures that may be upsetting to the child, such as starting an IV, in young healthy pediatric patients undergoing elective procedures. Hydration is important. However, healthy patients, that are not severely dehydrated, can be safely anesthetized by inhalational induction and then have an IV started. Then careful replacement of fluids can occur. Routinely, starting IV's in pediatric patients for the purpose of prehydration should be discouraged. Prehydration of pediatric patients should be reserved for those who are dehydrated from an acute illness.

The use of premedication, to reduce the anxiety of separation from parents, should be considered. Anti-anxiety medications reduce emotional distress. Children who are upset, crying, and fearful may be at increased risk for anesthesia related complications. In addition, a pediatric patient who is traumatized by a bad experience may carry their fears into adulthood. If you do not have access to medications that reduce anxiety, you may elect to have the parents accompany the patient to the area immediately next to the operating theatre. At this point, use your skills to help the pediatric patient into the operating theatre. Alternatively, if there is an IV started, a small sedating dose of medication will help with separation. For the pediatric patient undergoing a surgical procedure under regional anesthesia, administer medications that result in amnesia. The awake and alert pediatric patient may be distressed in the operating theatre.

The overall goal of meeting the emotional needs of the pediatric patient is to avoid a crying and distressed patient. In most cases this can be reduced or avoided with careful planning. Establishing a relationship, limiting uncomfortable procedures, and the use of premeditations can help accomplish this goal.

Preoperative Preparation

- Conduct a thorough medical history. Ask about a history of anesthetic related complications. Listen to lung and heart sounds, review the patients' vital signs, ensure that the patient has fasted, and review laboratory values. Please refer to the Pre-Anesthesia Assessment of the Patient chapter for a more in-depth review.
- During the preoperative interview, it is important to ask questions that may reveal an underlying undiagnosed medical condition, or one that may affect the anesthetic course. For example, "Is food prepared with an open fire in the home?" Or "Is the child exposed to smoking in the home?" A child who lives in an environment of smoke from meal fires/smoking may have an increased incidence of bronchospasm, even without an "official" diagnosis of asthma. This is due to the irritating effects of smoke on the bronchioles of the child. A second example would include questions that may uncover an undiagnosed cardiac condition. For example, asking if the child can keep up with others when playing or whether the neonate/infant turns blue when they cry may lead you to suspect a serious medical condition.
- If there are any questions regarding the patient's overall health, recent exacerbations of medical problems (i.e. asthma), or recent/current respiratory infection, it is acceptable to postpone elective procedures until these concerns are addressed.
- Explain to the parents the anesthetic technique, risks, complications, and what to expect in the post anesthetic period.
- Try to reduce the parents' anxiety about the anesthetic. Children can sense when a parent is anxious.

- During the preoperative visit, try to establish a relationship with the child. Use of play techniques to engage the child beforehand may make anesthetic induction acceptable. When listening to the patients' heart and lungs with a stethoscope, try to make it a game. Try to get the child to laugh and play.
- For pediatric patients that are old enough to understand, gently explain how you are going to help them. This will make the acceptance of a mask during an inhaled induction go more smoothly.
- Preoperative medications to reduce anxiety should be provided if necessary. The administration of preoperative sedatives will help the child accept an inhaled induction and reduce the amount of stress the child experiences. Midazolam (liquid form) may be administered orally in a dose of 0.25-0.5 mg/kg, not to exceed a total dose of 20 mg, 30 minutes prior to anesthetic induction to reduce anxiety. Midazolam is bitter when administered alone, so it should be mixed with an oral syrup preparation of acetaminophen or ibuprofen. Non-opioid analgesics will diminish postoperative pain. This small amount of oral intake does not generally increase the risk of aspiration. Alternatively, oral diazepam may be administered in a dose of 0.25 mg/kg, 45-60 minutes prior to anesthetic induction. Intramuscular medications should be avoided since it may increase the patients' distress.
- Preparation of anesthetic equipment and medications is essential. Pediatric patients can rapidly become hypoxic, bradycardic, and hypotensive. Ensure that all of the anesthesia equipment is functioning correctly.
- Emergency medications should be immediately available. The appropriate dosages should be calculated, based on weight, beforehand (i.e. atropine, succinylcholine, and epinephrine).
- Ensure that there are several choices of endotracheal tubes, anesthetic masks, and intubating blades. A bag-mask-valve device should be immediately available for emergent situations. Please refer to the preparing for anesthesia chapter.
- Calculate routine anesthetic medication doses and fluid requirements on a weight basis.

Basic Anesthesia Considerations

- Basic pediatric monitoring is similar to the adult. Please refer to the Positioning and Monitoring chapter. Vigilance is the key to safe care. Continual monitoring of heart and lung sounds can be provided by a precordial or esophageal stethoscope. This is one of the most important monitors during anesthesia. Listening to the patient's heart and lung sounds provides the anesthesia provider with continuous information concerning the heart rate, heart rhythm, heart sounds, respiratory rate, presence of secretions, abnormal respiratory sounds, and immediately alerts the anesthesia provider to a disconnected anesthesia circuit.
- Additional monitors include blood pressure, temperature, pulse oximetry, ECG, and end tidal carbon dioxide monitoring.

- For accurate blood pressure monitoring, the cuff should be the correct size. If the cuff is too large, it will give you lower reading than the actual blood pressure. If the cuff is too small, it will give you higher reading than what the actual blood pressure is.
- If the patient has a urinary catheter placed, monitor the urine output. Normal urine output should be 0.5 ml/kg/hour or greater.
- Anesthesia is induced by intravenous or inhalation methods.
- Inhalation inductions are preferred in young children who are not seriously ill. Premedication will help with acceptance of the mask.
- Atropine or glycopyrrolate can be administered orally or by intramuscular injection in the preoperative period. The intravenous route is used after the IV has been started during induction. Some anesthesia providers may choose to treat bradycardia when it occurs. Anesthetic agents can cause bradycardia in pediatric patients. Atropine and glycopyrrolate help prevent this complication by increasing the heart rate. Atropine can occasionally cause facial flushing, delirium, restlessness, and anticholinergic syndrome in the postoperative period. Atropine or glycopyrrolate should be administered prior to ketamine to decrease secretions.
- Have succinylcholine (4 mg/kg for IM injection, 1.5-2 mg IV, or 2 mg/kg for sublingual injection) immediately available. Atropine in a dose of 0.2 mg/kg may be administered prior to succinylcholine to prevent bradycardia.
- Inhalation inductions are easy to administer. If nitrous oxide is available, the induction can be started with 70% nitrous oxide and 30% oxygen. The volatile inhaled anesthetic should be increased slowly, every 3-5 breaths, until the desired concentration is achieved. If the volatile anesthetic agent is increased too rapidly, the patient may experience a laryngospasm, coughing, and/or breath holding.
- During induction, keep the patient calm by talking softly or singing. Try to make the induction of anesthesia a game. It is important to make this time as stress free as possible for the child.
- Provide a quiet environment during induction so the child does not become agitated.
- If the patient develops a laryngospasm during induction, first attempt to use positive pressure ventilation to overcome the obstruction. If this is not successful, treat the patient with atropine and succinylcholine. Once the laryngospasm has resolved, deepen the anesthetic.
- Ensure the patient is under an adequate level of anesthesia prior to stimulation. If the eyes are midline and pupils are not dilated, then the patient should be under an adequate level of anesthesia. If the eyes are not midline but off to the side, the patient may be too light for stimulation. An IV start, laryngoscopy, or surgical stimulation may result in coughing, laryngospasm, breath holding or bronchospasm.

- Once the patient is under an adequate level of anesthesia, an intravenous cannula may be inserted for the administration of fluids and medications. General anesthesia results in vasodilatation, making IV insertion easier.
- Replace the fluid deficit that has been calculated for the patient. Replace ½ of the fasting deficit during the 1st hour. Replace ¼ of the fasting deficit over the 2nd and 3rd hour. Provide maintenance fluid replacement for each hour of anesthesia and during recovery until the patient is able to take oral fluids.
- Replace 3rd space losses for each hour of surgery. The amount of fluid that is required for 3rd space losses is dependent upon the type of surgical procedure. Please refer to the fluid chapter.
- Replace estimated blood loss as it occurs.
- Muscle relaxants are used to facilitate endotracheal intubation. Deeply anesthetized pediatric patient may be intubated without muscle relaxant. Alternatively, a small dose of propofol or thiopental may be administered to facilitate endotracheal intubation.

Postoperative Pediatric Considerations

- Pediatric patients generally emerge from anesthesia faster than adults
- Extubation should occur only when the child is spontaneously breathing and under deep anesthesia or awake. Extubation between these two stages may lead to an increased incidence of laryngospasm.
- Do not take the patient to the recovery area until they have control of their airway.
- It is safer to take an awake and crying pediatric patient to the recovery area than one who is still anesthetized. By delaying the transfer of the pediatric patient to the recovery area, the risk of laryngospasm and other respiratory difficulties will be decreased.
- Report anesthetic or surgery related complications to the recovery staff.
- Prioritize care: airway, breathing, and circulation.
- Vital signs should be monitored frequently. Please refer to the Recovery Basics chapter.
- Should never be left alone in the recovery area.
- May be returned to the ward when stable. (i.e. vital signs are normal and the patient is awake and in control of their airway.)
- Post extubation croup or subglottic edema occurs in 1-6% of the intubated pediatric patients. Using the correct sized endotracheal with an air leak will reduce the risk of this complication. Mild symptoms include a hoarse cough. Observation and humidified oxygen may be all that is needed for mild symptoms. Symptoms of labored breathing, sternal and intercostal retractions, inadequate air exchange, and hypoxia need to be rapidly treated. Nebulized epinephrine 0.5% (1:200) or racemic epinephrine 1.25% in a dose of 0.5 ml, diluted in 1.5 ml of normal saline should be administered. The patient should be

monitored for rebound swelling for several hours after initial treatment. Steroid medications may be administered intravenously to reduce swelling.

- Infants less than 60 weeks post conception should be monitored for apnea for 24 hours after a general anesthetic.

Complications in Pediatric Anesthesia

Vigilance is essential to safe pediatric anesthesia care. The anesthesia provider should never leave the patient, at any time, to attend to other needs in the operating room. Careful preparation before the surgical case, anticipation of complications, continual monitoring of the patient, and using good judgment reduce the risk of encountering complications. Anesthesia complications occur more frequently in the pediatric population than in the adult population. A good portion of complications in the pediatric population occur due to human factors. The most common human factor is error in judgment. This includes misjudging the depth of anesthesia prior to surgical or anesthetic manipulation; wrong choice for anesthetic technique; administering anesthesia to a patient with an upper airway infection; and extubating the trachea at the wrong time. A second common human error is failure to check. This includes failure to check anesthesia/airway related equipment prior to the initiation of an anesthetic; failure to assess position of an endotracheal tube after intubation or anytime patient position has changed; and wrong medication or administering a medication by the wrong route. A third common human error is technical failure. This is when things do not go as planned. This can occur during regional or local anesthetic techniques or when intubating or mask ventilating the pediatric patient. Additional factors include inexperience, not being vigilant during the anesthetic, poor communication, poor preparation, inadequate assessment, incorrectly calculating a dose of medication, and being pressured into doing an elective case against the judgment of the anesthesia provider.

Respiratory and cardiovascular events are the two most common areas of complications. Anesthesia providers should continuously monitor pediatric patients with a precordial/esophageal stethoscope. Monitoring the patient continually, in addition to capnography and pulse oximetry, can greatly decrease complications. Patient characteristics can help the anesthesia provider anticipate potential complications. In general, infants younger than 1 year of age are at higher risk than older children for cardiac arrest. Pediatric patients who are "sicker" with an ASA classification of 3-5 have a higher incidence of mortality than pediatric patients that are healthy.

The number one cause of cardiac arrest in the pediatric population is related to cardiovascular depression from inhalational anesthetic agents. It has been found that bradycardia and hypotension occur immediately prior to a cardiac arrest. These facts stress the need for the anesthesia provider to closely monitor the amount of inhaled anesthetic being administered and to promptly treat bradycardia and hypotension. The incidence of cardiac arrest declines with age. Cardiac arrest is more likely to occur in an infant than in older children. Cardiac arrest is more likely to occur in children than in adults. Halothane is a potent cardiovascular depressant. During its administration,

extreme care should be taken to monitor the patient for complications. In general, sevoflurane, although expensive and not available in some countries, has a lower incidence of cardiac arrest than halothane. Cardiac arrest can occur due to hemorrhage and dehydration. These patients have smaller blood volumes and are at risk for excessive and inadequate fluid administration. Carefully calculating the amount of intravenous fluid to administer, monitoring blood loss, and replacing it, are important steps, to reduce this complication.

The most common respiratory cause of cardiac arrest is related to an airway obstruction caused by a laryngospasm. The most common age for this complication are children less than two. One third of the cases of cardiac arrest related to laryngospasm occurred due to an upper respiratory infection. This stresses the importance of a careful preanesthetic evaluation of the patient. Patients presenting for elective procedures with an upper respiratory infection should be postponed. When anesthetizing children 2 years and under, the anesthesia provider should promptly recognize an airway obstruction. There are two periods during an anesthetic when the patient is at greatest risk for laryngospasm. The majority of laryngospasm's occur during the induction of anesthesia. The second period is during emergence and transport to the recovery area. During these periods, the anesthesia provider should have a heightened sense of vigilance, be prepared to intervene, and intervene quickly.

Management of Postoperative Pain in Pediatric Population

Pain management for the pediatric patient is as important as it is for adults. Infants do feel pain. Children do not tolerate pain better than adults. The difficulty for infants and small children is in assessing pain. A neonate, infant, or small child is not capable of verbalizing pain as an adult would. Assessment of pain must rely on clinical signs and symptoms. Older children may be able to verbalize pain.

Pain Assessment

Neonates

For assessment of pain in neonates, the clinician must rely upon the observation of clinical signs and symptoms. The neonate in pain will demonstrate physiological and behavioral changes. The Objective Pain Scale (OPS) is an example of a tool that can be used to assess for pain in the neonate.

- Blood Pressure- Is the neonate's blood pressure elevated above normal? Is it 10%, 10-20%, or 30% higher than the preoperative blood pressure? The higher the blood pressure the more severe pain the neonate may be experiencing.
- Crying- Is the neonate crying? Does the neonate respond to being held and cuddled? A neonate that cannot be calmed down may be experiencing pain.
- Movement- Is the neonate resting quietly? Or does the neonate seem restless or thrashing about?
- Agitation- Is the neonate calm or extremely agitated?

The Neonatal Infant Pain Scale (NIPPS) is another tool that can be used with the neonate. This tool evaluates six categories:

- Facial expression- Is it relaxed or is the neonate grimacing?
- Cry- Is the neonate silent, whimpering, or vigorously crying?
- Breathing Pattern- Is the neonate breathing normally, or is the neonate breathing faster than normal? Are there changes in the breathing pattern indicating pain?
- Arms and Legs- Are the neonates' arms and legs relaxed, or are they flexed, extended and stiff?
- State of Arousal- Is the neonate sleeping or relaxed? Or is the neonate awake and fussy?

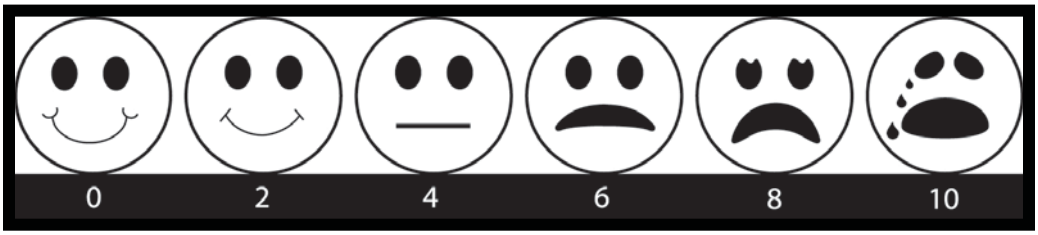
Infants and Toddlers

Pain assessment in this age group is similar to the neonate. The patient will demonstrate behavioral and physiological responses. The infant or toddler may be able to localize pain. In addition to physiological parameters such as heart rate, blood pressure, and respiratory rate, behavioral responses can be assessed. One tool is the Toddler-Preschooler Postoperative Pain Scale (TPPPS). In this tool, expressions of pain are divided into the categories of verbal, facial, and body movements.

- Verbal- Does the infant/toddler verbally complain of pain, cry, scream, groan, moan, or grunt?
- Facial- Does the infant/toddler grimace, squint their eyes, or furrow there brow? Are there any facial characteristics that indicate pain?
- Body Movements- Is the infant/toddler restless, thrashing about, or reaching at the area of pain?

Children 3-7 Years of Age

This age group is developmentally able to communicate better than those less than 3 years of age. They may be able to tell you if they have pain or do not have pain. They may be able to locate the area of discomfort. In addition to physiological and behavioral signs of pain, they may be able to use a visual scale to help determine the severity of pain. A faces rating scale or similar scale may be useful in this age group.



Children Older than 7 Years

Children older than 7 years of age are able to communicate the intensity, location, and type of pain they are experiencing.

Pain Management Strategies

There are a wide variety of pain management strategies available. The combination of local anesthetic techniques, non steroidal anti-inflammatory medications, and opioids can effectively treat pain. Pain can have several negative psychological and physiological consequences. Pain should be treated as aggressively as it is in adults. A brief overview of techniques will be covered. Please refer to the Medication chapter for a more in depth review of analgesics.

Topical Anesthesia

Topical anesthesia provides for effective but short term analgesia when applied to mucous membranes and abraded skin. The most common topical local anesthetics include lidocaine, EMLA cream, benzocaine, and tetracaine. Benzocaine application should be avoided due to the potentially life threatening complication of methemoglobinemia. EMLA cream is a preparation that can provide cutaneous analgesia through intact skin. EMLA is a mixture of 2.5% lidocaine and 2.5% prilocaine. Prilocaine, even in normal doses, carries a small but real risk of methemoglobinemia. Prilocaine should be avoided in infants and neonates.

Topical anesthesia can take several forms. For example, the application of lidocaine gel to lacerations may be helpful in reducing pain. Instillation of bupivacaine with epinephrine may provide postoperative analgesia. Careful assessment of maximum doses of local anesthetics is essential to prevent toxicity. Pay attention to the amount of epinephrine the patient receives during a halothane anesthetic to avoid cardiac dysrhymias. Topical local anesthetic eye drops are helpful for postoperative pain control after ophthalmic procedures.

Local Anesthetic Wound Infiltration

Local anesthetics injected into the skin surrounding the patients' incision can block nerve impulse conduction from nerve fibers. In addition, the surgeon may provide a field block for superficial areas of the operative site. Encourage the use of local anesthetic wound infiltration, to reduce postoperative discomfort. The following are important considerations for local anesthetic wound infiltration:

- Local anesthetic toxicity is a concern. As the "expert" in local anesthetics, you need to monitor the total doses being administered.
- Almost any local anesthetic can be used for infiltration.
- Onset is quick.
- Epinephrine will prolong the duration of action for most local anesthetics. Caution should be used when epinephrine containing local anesthetics are injected during

halothane anesthesia. Never allow a local anesthetic solution containing epinephrine to be injected in end organs such as the nose, penis, ears, fingers, or toes. The action of epinephrine may cause vasoconstriction and subsequent necrosis of these anatomical areas.

- Pain with injection will be noted in the conscious patient due to the acidic nature of local anesthetics.

Pediatric Doses for Local Anesthetics

Local Anesthetic	Usual Concentration	Usual Dose (mg/kg)	Maximum Dose Plain (mg/kg)	Maximum Dose with 1:200,000 Epinephrine (mg/kg)	Duration of Action
Procaine	1-2%	7	10	10	30 minutes to 1 hour
Lidocaine	0.5-2%	5	4.5	7	1-2 hours
Bupivacaine	0.25-0.5%	2	2.5	3	2.5-6 hours

Regional Anesthetic Techniques

There are several regional anesthesia techniques that are beneficial for postoperative analgesia. It is important to be skilled in these techniques to prevent injury and provide for effective postoperative analgesia. Regional anesthesia techniques include caudal, penile, inguinal, and brachial plexus blocks.

Non Opioid Analgesics

Non steroidal Anti-inflammatory Medications (NSAIDS)

NSAIDS, combined with local anesthesia or alone, can be effective for minor to moderate postoperative pain. Advantages over opioids include the avoidance of side effects such as nausea and vomiting, respiratory depression, and decreased level of consciousness. NSAIDS should not be administered to children less than 1 year of age due to the risk of toxicity and renal failure. Children less than 1 have immature renal and hepatic function. For children over 1 year of age, knowledge of the maximum single and daily doses are important to prevent an overdose.

NSAID Dosages Based on Weight

NSAID	Single Dose (mg/kg)	Maximum Daily (24 hour period) Dose (mg/kg/day)
Ibuprofen	10	40
Dicolfenac	1	3
Naproxen	7.5	15
Acetaminophen	15	60 (for neonates) 90 (for older children)

Children who receive NSAIDS should have normal renal and hepatic function. NSAIDS should also be avoided in children that have been hospitalized recently with asthma. NSAIDS are versatile medications. They can be administered preoperatively to decrease the inflammatory response of surgery and reduce postoperative discomfort. They can be administered in a liquid or suppository form.

Opioid Analgesics

For the management of moderate to severe pain, opioid analgesics should be used. Monitor the patient for side effects. Monitor the patient for effectiveness in reducing pain. Blood pressure, heart rate, pulse oximetry (if available), and respiratory rate should be monitored after administration. The use of short acting opioids, such as fentanyl, should be considered. Longer acting opioids, such as morphine and meperidine, should be considered for severe pain. Please refer to the Medication chapter for a more in-depth review.

Common and Uncommon Medical Conditions

Respiratory Infections

The presence of an upper respiratory infection increases the risk of complications related to the administration of general anesthesia. Complications include laryngospasm, bronchospasm, and hypoxia. Consider the current symptoms that the patient is experiencing. For example, it is common for children to have clear nasal discharge (runny nose) but no fever, abnormal breath sounds, or other symptoms that would indicate the presence of an upper airway infection. The patient that presents for an elective surgical procedure with symptoms that include purulent nasal discharge, a productive cough, fever, fatigue, and abnormal breath sounds should be postponed. A child with a recent history of an upper respiratory infection may be at risk for developing respiratory complications for 2-4 weeks after resolution of symptoms. Patients presenting for emergency surgery will not be able to be postponed. Preoperative aerosolized respiratory treatments with beta adrenergic medications (i.e. albuterol) may reduce airway reactivity. The anesthesia provider should consider preoperative hydration, corticosteroids, and anticholinergic medications. Preoperative

hydration will help to loosen secretions. Corticosteroids reduce inflammation and airway reactivity. Anticholinergics contribute to bronchodilation and dry secretions. Instrumentation of the airway should not occur until the patient is under an adequate level of anesthesia. Vigilance for respiratory complications should be maintained during the perioperative period. Induction and emergence are two phases of anesthesia that the patient is at increased risk for respiratory complications.

Asthma

Asthma is a common medical problem. A child may not be diagnosed with asthma, but may exhibit symptoms during the preoperative evaluation. Asthma related symptoms may be common when children are exposed to high levels of airway irritants (i.e. dust, cigarette smoke, open cooking in the home). The main symptom is wheezing, but the patient may also experience shortness of breath. Asthma causes the bronchial airways to become constricted, obstructing airflow. Decreases in lung volumes cause the patient to breathe differently. This results in a change in the patient's chest wall mechanics. In an attempt to breathe easier, the patient will demonstrate an increased respiratory effort. Changes in lung volumes may result in ventilation and perfusion mismatching, resulting in hypoxemia and hypercarbia.

The sympathetic nervous system is largely responsible for maintaining normal patency of the bronchials. Treatment of asthma involves the use of beta-adrenergic agonists, anticholinergics, theophylline or aminophylline, and steroids. Beta-adrenergic agonists counteract constriction of the bronchioles, resulting in bronchodilatation. Beta-adrenergic agonists are administered by inhalers or nebulizers. Anticholinergics produce bronchodilatation through their antimuscarinic action and dry secretions. Theophylline and aminophylline inhibit phosphdiesterase, an enzyme that breaks down cyclic AMP. This results in bronchodilation. Common side effects of theophylline or aminophylline include tachycardia, cardiac dysrhymias, anxiety, nausea, and vomiting. Steroids help stabilize membranes and have anti-inflammatory effects.

The patient with asthma, or asthma like symptoms, should be assessed in the preoperative period. Postponement of elective procedures should occur in the patient with active wheezing. Patients who are not wheezing may undergo elective procedures. Though not actively wheezing, the patient with asthma is at increased risk for airway complications. Preoperative treatment with beta-adrenergic agonists should be considered in patients with a history of asthma. The following are important considerations:

- Volatile anesthetics are bronchodilators.
- Use non-histamine releasing medications (i.e. avoid morphine and other medications that are known to release histamine). Histamine is a potent bronchoconstrictor.
- Ketamine is an excellent bronchodilator to use in the asthmatic. Atropine or glycopyrrolate should always be administered to decrease salivation.

Induction is a critical time for the patient with asthma. Ensure that the patient is under an adequate level of anesthesia before stimulation or airway manipulation. Stimulation may result in severe bronchospasm. During surgery, treat wheezing with a beta-adrenergic agonist (albuterol/salbutamol/terbutaline). Severe bronchospasm should be treated with intravenous aminophylline. A loading dose of 6 mg/kg is used to achieve an adequate blood concentration. A continuous infusion of aminophylline should be started at a rate of 0.5-0.9 mg/kg/hour. Monitoring the patients' heart rhythm is important during aminophylline administration, since it may cause dysrhymias. If the bronchospasm does not resolve and is severe, epinephrine may be required. The dose for pediatrics is 0.01 mg/kg subcutaneously or an intramuscular injection of 0.01 ml/kg of a 1:1000 solution. The total dose should not exceed 0.5 mg. Subcutaneous doses may be repeated at 20 minute to 4 hour intervals. Hydrocortisone administration may be considered; dosing is 3 mg/kg intravenously. Emergence is another critical period. A deep extubation may be considered to avoid coughing, resulting in bronchospasm and/or laryngospasm.

Malnutrition

Malnutrition is a problem in many countries. The patient who is malnourished should begin a period of gradual, but intensive feeding, prior to an elective procedure. This is important for a couple of reasons. First, the patient may not be able to meet the metabolic demands of surgery. Second, the malnourished patient may not be able to heal appropriately. This can lead to wound dehiscence and infection with serious consequences.

The following are signs of malnutrition:

- Lack of subcutaneous fat
- Poor muscle tone
- Poor skin turgor
- Bleeds easily, due to vitamin K deficiency
- Reddened and greasy nasal area
- Sores at the corners of the mouth
- Anatomical abnormalities such as a square shaped head, enlarged wrists, and ribs.
- Examination of the mouth may reveal serious dental abnormalities, thrush (white patches), and necrotizing ulcerative gingivitis (Vincent's angina).
- Examination of the eyes may reveal corneal and conjunctival changes.

Malnutrition may lead to deficiencies in key vitamins and minerals, including iron, folate, and vitamin B12, resulting in anemia. Hemoglobin levels may be higher than expected due to dehydration but, once the patient is hydrated, a more accurate hemoglobin level may be drawn.

Beriberi is a nutritional deficiency related to thiamine deficiency. Beriberi is a common problem in Asia, the Philippines, and the islands of the Pacific. (Thiamine content is low to absent in highly polished rice.) Early symptoms of beriberi include fatigue, irritability, poor memory, sleep loss,

chest and abdominal pain, and constipation. Continued thiamine deficit can lead to muscle weakness, respiratory, and cardiac failure.

The effects of malnutrition has several consequences. Malnutrition affects the liver, depressing its function. The liver is responsible for metabolizing, through the action of enzymes, many of the medications administered during anesthesia. The result is a prolonged duration of action. Malnutrition results in low levels of protein. When intravenous fluids are administered edema can occur in the limbs and/or lungs, leading to pulmonary edema. Elective procedures should be delayed until the patient is nourished back to health. If emergency surgery is necessary, a local or regional anesthetic may be better tolerated than a general anesthetic.

Epiglottitis

Epiglottitis is caused by the bacteria haemophilus influenza. The patient will exhibit symptoms such as difficulty in swallowing, high fever and inspiratory stridor. Epiglottis is defined by the four "d's"- dysphagia, drooling, dysphonia, distress, and stridor. Symptoms are due to swelling of the epiglottis and tissue above the epiglottis (supraglottic). Epiglottis may be confused with croup. Croup generally occurs in children less than 2 years of age, is caused by a virus, and its onset is gradual over 1-3 days. The patient will exhibit a low grade fever less than 39 degrees centigrade. Airway obstruction is less severe than epiglottis. Epiglottis, on the other hand, occurs in children 2-6 years of age, is caused by bacteria, and progresses rapidly within a 24 hour period. The patient will exhibit a high fever of 39 degrees centigrade or greater. The patient will demonstrate a severe airway obstruction that can progress to total airway obstruction. Patients that have suspected epiglottitis should be admitted to the hospital and treated with antibiotics (i.e. ampicillin). Anesthesia providers may be asked to participate in the care of the patient since intubation is often required. Intubation should occur only in the operation room and with preparations made for an emergency tracheostomy. The following are anesthetic considerations related to epiglottitis:

- The ability to perform a skilled inhalational induction is essential for the child with epiglottis.
- It is important not to upset the child. Attempt to establish a relationship with the child. Do not perform procedures that are uncomfortable such as starting an IV. This can wait until the airway has been secured.
- The patient may feel the need to sit up due to their respiratory distress. Allow them to sit up or assume any position that helps them feel better during anesthetic induction.
- There should be no attempts at intubation until the child is in the operating room, airway equipment is assembled and ready for use, and there is staff and equipment available for an emergency tracheostomy. A smaller than normal endotracheal tube will be required due to swelling. An intubating stylet should be available.

- Induction of anesthesia should be with oxygen and a volatile anesthetic agent. No nitrous oxide should be used. The induction should be slow and deliberate. Try not to upset the child.
- No muscle relaxants should be used. This may lead to total collapse of tissue and a complete airway obstruction.
- No attempt should be made at intubation until the patient is under a deep level of general anesthesia. Be prepared for an emergency tracheostomy if intubation is unsuccessful.

Monitoring of the patient usually occurs in the intensive care unit. After a couple days of antibiotic therapy, the swelling usually subsides enough for extubation. The presence of an air leak around the endotracheal tube is usually a sign that the swelling has decreased enough to allow the patient to breathe on their own. Extubation occurs in the operating room after direct laryngoscopy to confirm that the swelling has subsided.

Tuberculosis

Tuberculosis is an infectious disease caused by mycobacterium tuberculosis. Tuberculosis causes inflammation, formation of tubercles, tissue necrosis, abscesses, fibrosis, and calcification of tissue. The respiratory system is primarily affected; however, this disease has systemic effects. It can affect the gastrointestinal, genitourinary systems, bones, joints, the nervous system, lymph nodes, and skin. Up to 1.7 billion people around the world have tuberculosis, and up to 3% of the cases of tuberculosis are resistant to medications. Patients with tuberculosis may have HIV, and patients with HIV may have tuberculosis. It has been estimated that 25% of patients with one of these diseases has the other. The following list contains anesthetic considerations regarding tuberculosis patients:

- The patient with tuberculosis may have severe systemic involvement that can affect many organ systems. They may be malnourished, dehydrated due to poor intake of fluids and fever, and have electrolyte abnormalities. If they are suffering from a fever, they will have a higher metabolic rate and require a greater concentration of oxygen.
- The respiratory system will be affected. They patient may have a chronic cough and produce sputum that may be bloody. This may lead to collapsed sections of the lung, leading to a ventilation/perfusion mismatch and hypoxia. Sputum is generally thick and may block endotracheal tubes. Frequent suctioning is required. For acutely ill patients, consideration should be given to performing a nasotracheal intubation and leaving it in position for postoperative ventilation and suctioning.
- A big concern is contamination of anesthesia equipment with infected secretions. Use disposable endotracheal tubes. If using a reusable endotracheal tube, it should be thoroughly cleansed with a disinfectant and autoclaved. A disposable breathing system should be used if possible. If not, then it should be thoroughly cleaned and sterilized.

- If you cannot adequately clean anesthetic equipment, consideration should be given to a ketamine anesthetic, or the use of a local or regional anesthetic technique.
- Protect yourself by wearing gloves and a mask. Change your clothes after coming into contact with a patient with tuberculosis.

Prematurity

Prematurity is defined as being born before 37 weeks. The third trimester (last 3 months) of pregnancy is important for developing organs. Preterm infants have problems maintaining normal body temperature, do not eat well, and may have problems breathing. As a result of hypoxia, they can develop central nervous system damage, retinopathy, and respiratory problems such as respiratory distress syndrome, apnea, and bronchopulmonary dysplasia. In addition, the patient may suffer from anemia, patent ductus arteriosis, and necrotizing enterocolitis. The premature neonate or infant presents a challenge to the anesthesia provider, warranting the following anesthetic considerations:

- Preoperative information should include birth history, medical problems, and laboratory data including coagulation status, hydration, and nutrition.
- Consider a second anesthesia provider to help with management.
- The patient should be kept warm. If possible an infant warmer should be used, exposed areas should be covered, the operating room should be between 35-37 degrees centigrade, and warm fluids should be administered.
- Do not administer more oxygen than what is required. The premature neonate is at risk for development of retinopathy related to excessive oxygen administration.

Pediatric Table

	Neonate <30 days	Infant 1-12 months	Child (i.e. 5 year old)	Adult
Oxygen Consumption (ml/kg/min)	6	5	4	3
Functional Reserve Capacity	25 ml/kg	25 ml/kg	35 ml/kg	40 ml/kg
Glomerular Filtration Rate	30-35 ml/min	60-90 ml/min	95-125 ml/min	95-125 ml/min
Hemoglobin Level (g/dl)	17	11-12	13	14
Hematocrit %	55	30-35	38	
Blood Volume (ml/kg)	85	80	75	65
Heart Rate (beats per minute)	130	120	90	80
Systolic Blood Pressure (mmHg)	65	90-95	95	120
Respiratory Rate	35	25	20	15

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Appendices to Basic Guide to Anesthesia for Developing Countries

Appendix A: Medical Math

Guidelines for Parenteral Medication Administration

Subcutaneous volume to be injected is 1.0 ml or less

Intramuscular volume injected depends on the size of the patient.

Healthy Adult	Up to 3.0 ml in large muscles
Elderly, thin adults, and older children	Up to 2.0 ml in large muscles
Toddler or infants	Up to 1.0 ml in large muscles

Formula Method for Calculating Medication Dosages

The **formula method's** equation is $\frac{D}{H} = X$

- D – dosage desired
- H – what is available
- X – is the unknown dosage that you want to administer
-

Example: The patient is to receive 10 mg of succinylcholine. The concentration of the vial is 20 mg per ml. So how much should be administered?

The formula method's equation is $\frac{D}{H} = X$.

D = 10 mg H = 20 mg

$$\frac{10\ mg}{20\ mg} = X$$

Divide the ratio $\frac{10}{20} = 0.5$

Multiply 0.5 x 1 ml = 0.5 ml

X = 0.5 ml…would be prepared for administration.

Calculation for Administration of Intravenous Fluids

Step 1:

$$\frac{Total\ amount\ of\ fluid\ to\ be\ infused}{Number\ of\ hours\ to\ be\ infused\ over} = ml\ per\ hour$$

Step 2:

$$\frac{ml\ per\ hour\ \ X\ gtts\ per\ ml\ (drop\ factor)}{60\ minutes} = \text{gtts per minute}$$

The formula used for calculating intravenous fluid flow rate is a two step process.

STEP 1: Calculate the amount of fluid to be administered by the number of hours that the infusion will be administered over.

Example: 450 ml of lactated ringers is to be infused over 3 hours. The drop factor of your intravenous tubing is 20 gtts per ml of solution.

$$\frac{450\ ml}{3\ hours} = 150 \text{ ml per hour}$$

STEP 2: Multiply the ml per hour by the drop factor on the package (number of drops per ml). Divide it by 60 minutes. The calculated answer to the equation will determine the number of gtts per minute that should be infused.

$$\frac{150\ ml\ per\ hour\ \ X\ 20\ gtts\ per\ ml}{60\ minutes} = \frac{3000\ gtts}{60\ minutes} = 50 \text{ gtts per minute}$$

Round the answer up or down to the nearest 10^{th}.

Appendix B: Anesthesia Record

Date of Surgery _____ Patient Name _____
Surgical Procedure _____ Age _____
Surgeons _____ Father/Husband's Name _____
Anesthesia Provider _____ City/Village _____
Height _____ Ward/Bed _____
Weight _____
Pre-op Vital Signs: BP _____ HR _____ RR _____

ANESTHESIA RECORD

PRE ANESTHESIA EVALUATION

NONE

Cardiovascular ECG _____ Heart Sounds _____ ☐
Chest Pain ❑ Hypertension ❑ Rheumatic Fever ❑
Heart Disease ❑ Heart Murmur ❑ Coronary Artery Disease ❑
Congestive Heart Failure ❑ Valvular Disease ❑
Other _____

Respiration CXR _____ Lung Sounds _____ ☐
Asthma ❑ COPD ❑ Pneumonia ❑
Bronchitis ❑ Shortness of Breath ❑ Productive Cough ❑
Tuberculosis ❑ Recent Upper Airway Infection ❑
Other _____

Endocrine ☐
Diabetes ❑ Thyroid Disease ❑
Other _____

Urinary / Renal ☐
Renal Failure ❑ Patient Dehydrated ❑
Urinary Tract Infection ❑
Other _____

Gastrointestinal ☐
Diarrhea ❑ Reflux Disease ❑ Bowel Obstruction ❑
Nausea & Vomiting ❑ Hepatitis/Cirrhosis ❑
Other _____

Neurological Level of Consciousness _____ ☐
Dizziness/Fainting ❑ Stroke ❑
Neuromuscular Disease ❑ Seizures ❑
Paralysis ❑ Muscle Weakness ❑
Other _____

Allergies ☐

Current Medications

Airway ☐
Teeth
Cervical Spine Mobility _____
Temporomandibular Movement _____

With mouth opening able to visualize:
Hard Palate ❑
Soft Palate ❑
Uvula Base ❑
Uvula ❑

Previous Anesthesia Problems ☐

Anesthetic Plan _____

_____ DATE AND TIME

_____ SIGNATURE OF EVALUATING ANESTHESIA PROVIDER

LABORATORY VALUES

CBC
Hb _____ Hct _____
WBC _____ Plts _____
Other _____

Electrolytes/Kidney Function
Na^+ _____ K^+ _____ Mg^+ _____
BUN _____ Creatinine _____
Other _____

Coagulation
Bleeding time _____ Coagulation time _____
Petechia _____ Bruising _____

Urinalysis:

Other Lab:

ASA Classification

❑ ASA Class I: Normal Healthy Patient
❑ ASA Class II: Mild Systematic Disease
❑ ASA Class III: Moderate to Severe Disease
❑ ASA Class IV: Severe Systemic Disease
❑ ASA Class V: Moribund Patient Not Expected to Survive

Mallampati/Samsoon-Young Classification

❑ Class I: Uvula, faucial pillars, and soft palate
❑ Class II: Faucial pillars and soft palate
❑ Class III: Soft and hard palate
❑ Class IV: Hard palate

☐ Anesthetic options, with risks and benefits, have been discussed with the patient and/or legal guardian.

☐ Anesthetic apparatus checked, airway equipment checked, medications assembled and prepared for anesthetic case.

ANESTHESIA RECORD

Intravenous Access: Site _____ Gauge of Needle _____

TIME																	TOTALS
Gasses	O2 L/min.																
	N_2O/Air L/min.																
IV Medications																	
End Tidal CO_2																	
Pulse Oximetry																	
ECG Rhythm																	
Inspired O_2																	
TEMP C°																	
Tidal Volume																	
Respiratory Rate																	

Symbols

X Anesthesia
⊙ Operation
V Blood Pressure
Λ Heart Rate
• Spontaneous Respiration
S Assisted Respiration
A Controlled Respiration
C

200 180 160 140 120 100 80 60 40 20 S A C

REMARKS

Fluids																	
Estimated Blood Loss mls																	
Urine Output mls																	
POSITION																	

Immediate pre anesthesia assessment completed ❑

Monitors:
Blood Pressure ❑ EKG ❑
Esophageal/Precordial Stethescope ❑
Pulse Oximeter ❑
Peripheral Nerve Stimulator ❑
End Tidal CO_2 ❑

❑ Blankets on Patient

Induction: ❑ Rapid Sequence Cricoid Pressure
Pre O_2 ____ IV ____ IM ___ IH ___
Airway: ❑ Oral ❑ Nasal

❑ Mask ❑ Oral ETT ❑ LMA
❑ Nasal ETT ❑ Laser
❑ Nasal Cannula ❑ O_2 MASK
ETT Size: _____ mm
Taped @ _____ cm
Blade: Size: _____ Type: _____
❑ Breath Sounds Bilat ❑ Cricoid Pressure
❑ Difficult Intubation ❑ Atraumatic Intubation
(See Remarks)

Eyes: ❑ Taped ❑ Lube

INTAKE & OUTPUT:
Crystalloids: _____ mls
Colloid: _____ mls
Packed Red Blood Cells: _____ mls
Platelets: _____ mls
Other: _____ mls
Estimated Blood Loss: _____ mls
Urine Output: _____ mls

CIRCUIT:
Circle ❑ Draw Over ❑
Semi-Open ❑ T-Piece ❑
Non Rebreathing ❑

RECOVERY: _____ hrs
BP ____ / ____ P ____ R ____
Airway: _____ SaO_2 _____
Temp _____
❑ No apparent complications
❑ Complications (See Remarks)

_____
ANESTHESIA PROVIDER

Date _____
ASA _____
Anesthesia:
Start: _____
Finish: _____
Surgery:
Start: _____
Finish: _____
Premedications:
_____
_____
_____

Pressure points checked and padded ❑

REGIONAL - Type
Position _____
Interspace _____
Needle _____
Paresthesia _____
CSF _____
Agent _____
_____
Dose _____
Diluent _____
Volume _____
_____
_____
Prep. Solution _____
Level _____

TOURNIQUET SITE
_____
Pressure: _____ mmHg
Times: _____ - _____
Times: _____ - _____

Surgeon: _____
Operation: _____

_____ _____
ANESTHESIA PROVIDER

Appendix C: Fluid Management and Fluid Replacement

Signs and Symptoms of Dehydration

- Dry tongue
- Sunken eyes
- Loss of skin turgor
- Cool and cyanotic extremities
- Absence of veins by sight
- Hypotension (low blood pressure)
- Tachycardia (fast heart rate)
- Low urine output
- High specific gravity on urinalysis
- Sunken fontanel on infants

Fluid Management and Fluid Replacement Calculations

Fasting Fluid Deficit:	4 cc per kg per hour for 1-10 kg 2 cc per kg per hour for 11-20 kg 1 cc per kg per hour for 21 kg on up
Maintenance Fluids:	4 cc per kg per hour for 1-10 kg 2 cc per kg per hour for 11-20 kg 1 cc per kg per hour for 21 kg on up
Insensible Fluid Loss:	2 cc per kg per hour
Fluid Requirements Based on Surgical Trauma	minimal trauma = 3-4 cc per kg per hour moderate trauma= 5-6 cc per kg per hour severe trauma = 7-8 cc per kg per hour

Appendix D: Medication Dosages

Anesthesia Medication Dosages

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Acetaminophen (non-opioid analgesic)	325-1000 mg every 4-6 hours. Maximum dose is 4,000 mg in a 24 hour period.	10-15 mg/kg every 4-6 hours	Can be toxic to the liver. Avoid in patients with impaired liver function or renal function.
Atracurium (nondepolarizing muscle relaxant)	Intubation: 0.3-0.5 mg/kg Maintenance: 0.1-0.2 mg/kg	Intubation: 0.3-0.5 mg/kg Maintenance: 0.1-0.2 mg/kg	Use with caution in patients with asthma.
Atropine (to decrease secretions)	0.4 mg	0.02 mg/kg	Minimum dose for child is 100 mcg. Max dose for teen aged child is 1 mg.
Atropine (for low heart rate)	0.5 -1 mg max dose 3 mg	0.02 mg/kg max dose child is 0.5 mg	Minimum dose for child is 100 mcg. Max dose for teen aged child is 1 mg.
Atropine (combined with neostigmine pyridostigmine or edrophonium)	0.015 mg/kg of atropine given before or with neostigmine, pyridostigmine or edrophonium IV.	Same	
Butorphanol (non-opioid agonist/antagonist)	0.5-2 mg IV or 1-4 mg IM every 3-4 hours	Not recommended	Do not use in patients with coronary artery disease. Do not use in patients with opioid dependence.
Codeine (opioid analgesic)	15-60 mg orally	0.5 – 1 mg/kg for patients > 1 year old (max dose is 60 mg)	Can be given every 4-6 hours
Diazepam (sedation/anti-anxiety)	2-10 mg	0.12-0.15 mg/kg for a child aged 6 months to 11 years of age.	Decrease the dose for the elderly.
Diphenhydramine (anti-emetic)	25-50 mg or 0.3-0.5 mg/kg intravenously	0.5 mg/kg with a maximum dose of 6.25 mg in children 2-6 years; maximum dose of 12.5-25 mg in children 6-12 years.	Use cautiously in children. Never use in premature infants or newborns.

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Droperidol (anti-emetic)	0.625 mg IVP	Not recommended	May cause abnormal movements or feelings of impending doom. Treat with 25 mg diphenhydramine. Do not use in patients with Parkinson's disease. May cause a serious abnormal heart rhythm.
Edrophonium (reversal of nondepolarizing muscle relaxants)	0.5-1 mg/kg of edrophonium (maximum dose is 40 mg of edrophonium) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate	Same	Maximum dose is 40 mg. Must be mixed with atropine or glycopyrrolate. Short duration of action may allow the non depolarizing muscle relaxant re-paralyze the patient.
Ephedrine (vasopressor)	5-20 mg intravenously. Titrate to effect. Ephedrine may be given intramuscularly in a dose of 25-50 mg.	Not recommended	Never use as a replacement for volume resuscitation.
Epinephrine (cardiac arrest)	0.5-1 mg	0.01 mg/kg	
Fentanyl (opioid analgesic)	2-10 mcg/kg IV	1-5 mcg/kg IV	
Flumazenil (reversal/antagonist for benzodiazepines)	0.2 – 1 mg. 1 mg is the maximum dose. Titrate slowly at a rate of 0.2 mg per minute until the desired effect is noted	Not recommended	Use with great caution in patients that have a history of seizures or dependent on benzodiazepines.
Gallamine (muscle relaxant)	Intubation 1-1.5 mg/kg Maintenance: 0.1-0.75 mg/kg	Same as adults	Do not use in patients with decreased renal function.
Glycopyrrolate (to decrease secretions)	0.1-0.2 mg	4-6 mcg/kg	
Glycopyrrolate (reversal of nondepolarizing muscle relaxants)	0.01 mg/kg of glycopyrrolate given before or with muscle relaxant reversal.	0.01 mg/kg of glycopyrrolate given before or with muscle relaxant reversal.	

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Ibuprofen (non-opioid analgesic)	400 mg orally	5-10 mg/kg orally	Can be given every 6 hours
Ketamine (anesthetic)	2 mg/kg	0.5-2 mg/kg	Use atropine to decrease secretions
Meperidine/Pethidine (opioid analgesic)	50-100 mg IV 50-150 mg IM every 3 to 4 hours	1 – 1.5 mg/kg IM or IV every 3-4 hours	Decrease dose by half if patient has been given promethazine. Decrease dose in elderly and those that weigh less than 60 kg.
Methohexital (anesthetic induction)	Sedation: 0.25-1 mg/kg IV Induction: 1-1.5 mg/kg IV	Same	
Metoclopramide (anti-emetic)	5-10 mg	0.1 mg/kg less than 6 years old. 2.5-5 mg 6 years to 14 years.	Given every 6-8 hours as needed.
Midazolam (sedation/ to reduce anxiety/ amnesia)	Sedation: 1 mg IV every 2-3 minutes, titrated to effect	IV route: 6 months to 5 years a dose of 0.05-0.1 mg/kg titrated to effect. (Max 6 mg) 6-12 years a dose of 0.05-0.1 mg/kg (Max 10 mg) Oral Route: 6 months and older 0.25- 0.5 mg/kg with max dose of 15-20 mg.	Oral dose should be mixed with a small amount (3-5 ml) of sweet clear juice or analgesic syrup to cover up bitter taste. Oral dose takes up to 30 minutes to be fully effective. Potent sedative, monitor patients for respiratory depression and hypotension.
Morphine (opioid analgesic)	2.5-10 mg IM or IV every 2-6 hours	0.03-0.05 mg/kg IM or IV every 3-8 hours. For children 6 months to 12 years.	Decrease dose by half if patient has been given promethazine. Decrease dose in elderly and those that weigh less than 60 kg.
Nalbuphine (opioid agonist-antagonist)	5-10 mg IV, IM, or subcutaneously.	10-100 mcg/kg IV, IM, or subcutaneously.	Do not use in patients with a history of opioid dependence.

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Naloxone (opioid antidote)	0.1-.04 mg IV, IM, or SC	10-100 mcg/kg IV, IM, or SC	Antidote for opioids. May be given by IV, IM, or SC (subcutaneous) routes. Repeat every 3-5 minutes until the patient is responding and breathing.
Neostigmine (reversal for nondepolarizing muscle relaxants)	0.05 mg/kg neostigmine (maximum of 5 mg) must be given with atropine or glycopyrrolate	Same dose as adult	Reversal agent for nondepolarizing muscle relaxants. Mix or give the atropine or glycopyrrolate first. Neostigmine can cause severe bradycardia if given alone.
Odansetron (anti-emetic)	4 mg intravenously	0.15 mg/kg	
Pancuronium (muscle relaxant)	Intubation: 0.04-0.08 mg/kg Maintenance: 0.01 mg/kg every 60 minutes	Same dose as adult	If you need to repeat the dose give 0.01 mg/kg in adults and children.
Pentazocine (opioid agonist-antagoinist)	20 mg IM or IV	Not used in children	Give every 2-4 hours as needed.
Phenylephrine (vasopressor)	50-100 mcg IV	Not routinely used in children	Never use as a replacement for volume replacement. May cause bradycardia in patients who are hypovolemic.
Promethazine (anti-emetic)	12.5-25 mg	0.25-0.50 mg/kg. Must be greater than 2 years. Max dose is 25 mg.	If given IV, give slowly over 5 minutes. Same dose can be given IM. Should be given every 4-6 hours as needed.

MEDICATION	ADULT DOSE	CHILD DOSE	REMARKS
Propofol (anesthetic induction)	2-2.5 mg/kg slowly over 30 seconds for induction of anesthesia. For maintenance of anesthesia a continuous infusion of 0.1-0.2 mg/kg/min or alternatively intermittent bolus of 20-50 mg.	2.5-3.5 mg/kg slowly over 30 seconds for induction of anesthesia. For maintenance of anesthesia a continuous infusion of0.125-0.3 mg/kg/min.	Give slowly over 30 seconds. May cause pain with injection.
Pyridostigmine (nondepolarizing muscle relaxant reversal)	0.25 mg/kg of pyridostigmine (maximum dose is 30 mg of pyridostigmine) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate.	0.25 mg/kg of pyridostigmine (maximum dose is 30 mg of pyridostigmine) mixed with 0.015 mg/kg of atropine or 0.01 mg/kg of glycopyrrolate.	Antidote for nondepolarizing muscle relaxants. Mix or give the atropine or glycopyrrolate first. Pyridostigmine can cause severe bradycardia if given alone.
Rocuronium (muscle relaxant)	Intubation dose in adults: 0.6-1.2 mg/kg. Maintenance of blockade in adults and children: 0.06-0.6 mg/kg.	Intubation dose in children: 0.4-1 mg/kg. Maintenance of blockade children: 0.06-0.6 mg/kg.	
Succinylcholine (depolarizing muscle relaxant)	Intubation dose: 0.6-1.2 mg/kg IV 2.5-4 mg IM dose.	Intubation dose: 1-1.5 mg/kg IV 2.5-4 mg IM dose.	Should not use more than 150 mg. Many contraindications…review carefully. Repeated doses close together may cause bradycardia or cardiac arrest.
Thiopental Sodium (anesthetic induction)	3-5 mg/kg	Children: 5-6 mg/kg Infants: 7-8 mg/kg	Use with caution in the elderly and dehydrated or bleeding patients.
Vecuronium (muscle relaxant)	Intubation: 0.08-0.1 mg/kg Maintenance: 0.01-0.05 mg/kg	Same as adult dose	

Appendix E: Fasting Guidelines

Elective cases

- Adults: no solid food for 8 hours; clear liquids or water up to 2 hours preoperatively.
- Children: no solid food for 8 hours; non-human milk up to 6 hours; breast milk up to 4 hours; water up to 2 hours preoperatively.

Emergency cases

- If possible, delay surgery for 8 hours since the last solid food intake; these patients should have a rapid sequence induction for anesthesia. If the surgery cannot be delayed for 8 hours, then still proceed with a rapid sequence induction for anesthesia.

Appendix F: Airway Management

Indications for Tracheal Intubation

To provide a patent airway for the patient during surgery.
Prevent aspiration (inhalation) of gastric contents.
To facilitate frequent suctioning of the patients lungs.
To facilitate positive pressure ventilation and avoid gastric distention from mask ventilation.
Operative site involving the face or airway. The position of the patient is not supine.
Difficulty in maintaining mask ventilation despite repositioning of the head and/or the use of an airway.
Diseases that involve the upper airway of the patient.

Physical Features that May Make Intubation Difficult

Large protruding jaw or a small receding jaw
Large tongue
Protruding 'buck' teeth, loose and missing teeth
Cleft palate
Small mouth or the inability to open the mouth wide
Pain with opening of the mouth
Short muscular neck
Deviated trachea
Any condition that limits the movement of the neck (neck mobility)
Obesity
Burns, scars, or tumors under the chin or on the neck

Mallampati/Samsoon-Young Class

Classification	Anatomical View	Potential Difficulty of Intubation
1	Uvula, faucial pillars, and soft palate	Should be easy
2	Faucial pillars and soft palate	Should be easy
3	Soft and hard palate	Potentially difficult
4	Hard palate	Most likely difficult

Recommendations for Pediatric Endotracheal Tube Size

- Uncuffed endotracheal tube used for children under 8 years old to decrease pressure on the cricoid cartilage and reduce the incidence of post extubation croup. The exception to this rule is if the child has a full stomach.
- Endotracheal should have a leak at 15-20 cm H2O, if there is no way to measure the air leak then there should be a slight air leak around the endotracheal tube.

Estimation of Endotracheal Tube Size and Depth of Insertion

Estimation of endotracheal tube size:

- Diameter of little finger of child usually correlates well with the correct sized diameter of the endotracheal tube.
- Children older than 2 years: endotracheal tube can be estimated by: age/4 + 4. For example, if the child is 4 years old divide 4 into 4 and add 4. 4 divided into 4 = 1 + 4 = 5.0 sized endotracheal tube.

Length of endotracheal tube insertion at the mouth can be estimated by:

- Under 1: 6 + weight(in kg). For example, if you have a 4 kg infant you would take 6 and add 4 to = 10 cm.
- Over 2 years: 12 + age/2. For example, if you have a 8 year old child you would divide the age by 2 which = 4 plus 12 = 16 cm.
- multiply internal diameter of ETT by 3 to give insertion (cm)

Endotracheal Tube Size by Age

6 months – 1 year	**3.5-4.0**
2 years	**4.5**
4 years	**5.0**
6 years	**5.5**
8 years	**6.0**
10 years	**6.5**
12 years	**7.0**

General Guidelines for Adult Endotracheal Tube Size

Adult or adolescent female	7.0-7.5
Adult or adolescent male	7.5-8.0

Treatment of Post Extubation Croup

1. Symptoms occur within 1 hour of extubation. The maximum intensity of symptoms occurs within 4 hours post extubation. Symptoms should resolve in 24 hours.
2. Treatment should include humidified oxygen and hydration (take into account the amount of IV fluids given to the patient during surgery.) Racemic epinephrine should be given if available, (0.5 ml of 2.25% and 2.5 cc of NS). Alternatively Nebulized epinephrine 0.5% in a dose of 0.5 ml, diluted in 1.5 ml of normal saline should be administered.
3. Corticosteroids should be given to decrease swelling (i.e. dexamethasone 4-8 mg IV).
4. Patient should be closely monitored for 2-4 hours after treatment and if concerns remain about the patient, he/she should be closely monitored overnight.

Treatment of Laryngospasm

1. Continuous positive pressure with 100% oxygen.
2. Suctioning of secretions and placement of oral airway. If the obstruction continues then administer:
3. Atropine 0.01-0.020 mg/kg and succinylcholine 2 mg/kg IV (4 mg/kg IM). atropine should be given first by the IV or IM route. Some clinicians don't routinely use atropine when administering succinylcholine for the first time. If the clinician does not administer atropine, then atropine should be drawn up and readied for administration. The patient should be monitored closely for bradycardia. Succinylcholine and atropine can be administered by intramuscular injection.
4. Reintubation if necessary.

Rapid Sequence Induction

- Assemble medications and airway equipment. Start an IV.
- Pre-oxygenate the patient with 100% oxygen.
- Induce with thiopental or propofol. Once consciousness is lost, have your assistant increase the cricoid pressure to 3-4 kg as you give succinylcholine. A nondepolarizing muscle relaxant may be used if the patient has a contraindication to succinylcholine.

- Once the patient starts to fasciculate, intubate the patient.
- Once correct endotracheal tube placement has been confirmed, the assistant may release cricoid pressure.
- If possible place a gastric tube to suction out what may remain in the patient's stomach.
- Prior to extubation make sure the patient is fully awake, the muscle relaxant has been reversed, and the patient is able to follow commands before endotracheal tube removal.

Confirmation of Correct Endotracheal Tube Placement (Trachea vs. Esophagus)

Test	Result	How Reliable is it?
End tidal carbon dioxide testing	**Correct**: positive wave form **Incorrect position**: no waveform	Certain- is the best test
Esophageal detection device (i.e. 50 ml syringe with self inflating bulb)	**Correct**: air is easily aspirated **Incorrect:** the bulb does not aspirate air	Certain- unless the patient has a lot of air in the stomach.
Watching the endotracheal tube pass between the vocal cords	**Correct:** easy view	Certain- unless visualization was poor.
Pulse oximetry	**Correct:** the reading easily comes up and reads within the normal range for the patient. **Incorrect:** the reading declines and continues to decline despite ventilation.	Certain
Listen with stethoscope	**Correct**: bilateral and equal breath sounds are noted. **Incorrect:** no breath sounds are noted and a gurgling sound is noted in the stomach.	Probable- sounds can radiate and fool the anesthesia provider.
Ventilate the patient	**Correct:** easy to ventilate, chest rises. **Incorrect:** difficult to ventilate, stomach gurgles, chest does not rise.	Probable- the anesthesia provider can sometimes find it hard to distinguish between esophageal and tracheal placement of the endotracheal tube.
Observe the patient	**Correct**: the patient remains pink. **Incorrect:** the patient becomes cyanotic.	Certain/probable- by the time the patient becomes cyanotic the patient is very hypoxic.
Pushing on the patient's chest/condensation in the endotracheal tube	**Correct:** air comes back/condensation occurs. **Incorrect:** air does not come back/no condensation noted.	Probable- other techniques are more accurate.

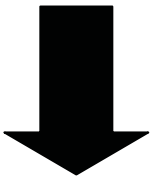
Appendix G: Basic CPR

The A, B, C's
Basic Assessment

Stimulate the victim.
Gently shake the victim's shoulder and ask "Are you all right?"

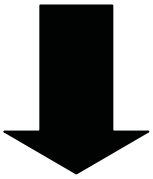
A- Airway

Look, listen, and feel.
Is the airway patent or obstructed?
You may need to clear & open the airway.



B- Breathing

Is the victim breathing? Is it adequate? If not breathing you may need to perform rescue breathing. Give 2 breathes.



C- Circulation

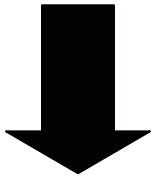
Does the victim have a pulse?
You may need to perform chest compressions.

Adult Respiratory Arrest

Stimulate the victim.
Gently shake the victim's shoulder and ask "Are you all right?"

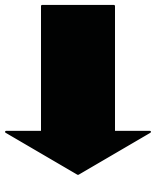
A- Airway

Look, listen, and feel.
Is the airway patent or obstructed?
You may need to clear & open the airway.



B- Breathing

Is the victim breathing? Is it adequate? If not breathing you may need to perform rescue breathing. Give 2 breathes.



C- Circulation

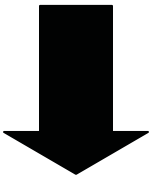
Does the victim have a carotid pulse? If the victim has a pulse, but is not breathing, perform rescue breathing at a rate of 10-12 breathes per minute or 1 breath every 5 seconds.

Adult CPR

Stimulate the victim.
Gently shake the victim's shoulder and ask "Are you all right?"

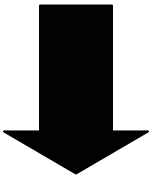
A- Airway

Look, listen, and feel.
Is the airway patent or obstructed?
You may need to clear & open the airway.



B- Breathing

Is the victim breathing? Is it adequate? If not breathing give 2 breathes.



C- Circulation

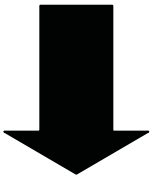
Does the victim have a carotid pulse? If no pulse, start chest compressions. Push hard, push fast at a rate of 100 compressions per minute. The compression to ventilation ratio is 30:2. Check the carotid pulse after 5 cycles or 2 minutes.

Pediatric Respiratory Arrest

Stimulate the victim.
Gently shake the victim's shoulder and ask "Are you all right?"

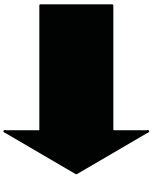
A- Airway

Look, listen, and feel.
Is the airway patent or obstructed?
You may need to clear & open the airway.



B- Breathing

Is the victim breathing? Is it adequate? If not breathing you may need to perform rescue breathing. Give 2 slow breathes, just enough to make the chest rise.



C- Circulation

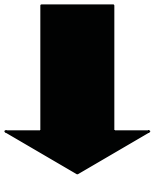
Does the victim have a carotid pulse (child) or brachial pulse (infant)? If the victim has a pulse that is greater than 60, but is not breathing, perform rescue breathing at a rate of 12-20 breathes per minute or 1 breath every 3-5 seconds.

Pediatric CPR

Stimulate the victim.
Gently shake the victim's shoulder and ask "Are you all right?"

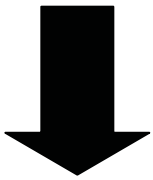
A- Airway

Look, listen, and feel.
Is the airway patent or obstructed?
You may need to clear & open the airway.



B- Breathing

Is the victim breathing? Is it adequate? If not breathing you may need to perform rescue breathing. Give 2 slow breathes, just enough to make the chest rise.



C- Circulation

Does the victim have a carotid pulse (child) or brachial pulse (infant)? If the victim has a pulse that is less than 60 or absent perform chest compressions and ventilations at a rate of 30:2 for 1 rescuer and 15:2 for 2 rescuers. Check the pulse after every 5 cycles of CPR.

Appendix H: Cardiac Arrest in the Operating Room

Adult Resuscitation

Cardiac Arrest without an ECG in Adults

A. Call for help
B. Shut off anesthetics, 100% oxygen, rapidly infuse intravenous fluids
C. A, B, C, s
D. Start CPR
E. Consider the causes
F. Epinephrine 1 mg IV. Repeat every 3-5 minutes. Vasopressin 40 u as a onetime dose may be given. Continue CPR.
G. Check for a pulse every few minutes
H. May try atropine at a dose of 1 mg IV. May repeat up to 3 mg (0.4 mg/kg).

Adult Symptomatic Bradycardia

A. Consult the surgeon about the problem.
B. Decrease or shut off anesthetics (if the bradycardia is severe).
C. Ensure that your airway is clear, that you are giving 100% oxygen. If due to surgical stimulation ask that it be stopped.
D. Give atropine 1 mg intravenously.
E. If this does not increase the heart rate repeat every 3-5 minutes for a total of 3 mg (0.04 mg/kg).
F. If this is not successful consider an epinephrine drip. Mix 1 mg in 500 ml of normal saline. This will give you 2 mcg per ml. Run the infusion at 1-5 ml per minute. Must be infused carefully if there is no infusion pump available.
G. If bradycardia persists consider stopping the surgical procedure and waking the patient up. Consult with the surgeon about further management of the patient.

Adult Pulseless Ventricular Tachycardia or Ventricular Fibrillation

Without a defibrillator:

A. Call for additional assistance.
B. Shut off all anesthetics, give 100% oxygen, and open up the IV fluids.
C. ABC's, CPR, and ventilation of the patient.
D. Give 1mg epinephrine every three to five minutes or give 40u vasopressin IV (a onetime dose). If the single dose of vasopressin does not help in the resumption of a pulse, then continue the resuscitation with epinephrine
E. Continue the resuscitation until the resumption of a pulse or the physician has stopped the code.

With a defibrillator:

A. Call for additional assistance.
B. Shut off all anesthetics, give 100% oxygen, and open up the IV fluids.
C. ABC's, CPR, and ventilation of the patient.
D. Prepare for non-synchronized defibrillation.
E. Start at 200 joules. If this does not return the patient to a normal rhythm defibrillate at 200-300 joules. If this has no effect defibrillate at 360 joules.
F. If defibrillation does not return the patient to a normal rhythm with a pulse and blood pressure, continue CPR and ventilation.
G. Give 1mg epinephrine every three to five minutes or give 40u vasopressin IV (a onetime dose). If the single dose of vasopressin does not help in the resumption of a pulse, then continue the resuscitation with epinephrine.
H. Repeat defibrillation at 360 joules 60 seconds after every dose of epinephrine.
I. After two or three does of epinephrine and not pulse, give 1 to 1.5mg/kg lidocaine IV. Lidocaine is acceptable for ventricular tachycardia and/or ventricular fibrillation that do not respond to defibrillation.
J. If the patient does not return to a normal rhythm then continue with CPR, epinephrine, and defibrillation.
K. Continue the resuscitation until the resumption of a pulse or the physician has stopped the code.

Adult Asystole

A. Call for additional help.
B. Shut off all anesthetics, give 100% oxygen, and rapidly infuse the IV fluids.
C. ABC's, CPR, and ventilations.
D. Consider the possible causes.
E. Give 1mg epinephrine IV. Repeat the dose every three to five minutes while continuing chest compressions and ventilation. If there is no IV access, dilute 2mg of epinephrine in 10ml of saline and squirt it down the endotracheal tube.
F. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR.
G. After two to four doses of epinephrine you may want to give 1mg atropine IV. Atropine is recommended for a slow conduction rate PEA. You can repeat the atropine dose every three to five minutes for a total of 3mg of atropine or a 0.04 mg/kg.
H. Continue CPR until resumption of a pulse or a physician stops the code.

Pediatric Resuscitation

Cardiac Resuscitation without an ECG

A. Call for additional help.
B. Shut off all anesthetics, give 100% oxygen, and open up the intravenous fluids.

C. A, B, C's, CPR, and ventilation.
D. Consider the possible causes.
E. Give epinephrine at a dose of 0.01 mg/kg intravenously for the first dose. Additional doses of epinephrine should be given every 3-5 minutes at a dose of 0.l-0.2 mg/kg while continuing chest compressions and ventilation.
F. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR. This should take no longer than 10 seconds.
F. Continue CPR until resumption of a pulse or the resuscitation effort is called off by a physician.

Pediatric Symptomatic Bradycardia

A. Stop surgical stimulation. Decrease or shut off the anesthetic.
B. Give 100% oxygen. Secure the airway if not already done. Rapidly infuse intravenous fluids.
C. If the blood pressure is not low give a fluid bolus of 10 ml per kg intravenously and give atropine by one of the three following methods:
   a. Intravenous: 0.01-0.02mg/kg (10-20 mcg per kg). The minimum dose of atropine is 0.1mg or 100mcg in the pediatric patient
   b. Intramuscular injection:0.02mg/kg
   c. Endotracheal tube: Mix the 0.1mg/kg epinephrine with 5ml of normal saline and squirt down the endotracheal tube. Follow this with five ventilations.
D. Monitor the heart rate.
E. If blood pressure is low give 0.01mg/kg epinephrine IV. If no intravenous line then give 0.1mg/kg epinephrine via the endotracheal tube. Mix the dose of epinephrine with 5ml of normal saline and squirt down the endotracheal tube. Follow this by five ventilations.
F. Repeat the epinephrine dose every three to five minutes.
G. Consider additional doses of atropine at 0.02mg/kg intravenously. The maximum dose of atropine for a child is 0.5mg and for a teen-aged child is 1mg,
H. Watch for resumption of a normal pulse.

Pediatric Pulseless Ventricular Tachycardia/Ventricular Fibrillation

Without a defibrillator

A. Call for additional assistance.
B. Shut off all anesthetics, give 100% oxygen, and infuse IV fluids rapidly.
C. ABC's, CPR, and ventilation.
D. Give 0.01mg/kg epinephrine IV. Subsequent does of epinephrine are given in doses of 0.1mg/kg. You may use alternative routes such as the endotracheal tube or intra-osseous if IV access is not available. The endotracheal tube dose is 0.1mg/kg epinephrine, first mixed with 5ml normal saline and followed by five ventilations.

E. Continue the resuscitation until the resumption of a pulse or a physician stops the code.

With a defibrillator

A. Call for additional assistance.
B. Shut off all anesthetics, give 100% oxygen, and infuse IV fluids rapidly.
C. ABC's, CPR, and ventilation.
D. Prepare for non-synchronized defibrillation.
E. Start at 2 joules per kg. If not effective follow with 3 joules per kg. If not effective then follow with 4 joules per kg.
F. If defibrillation does not return the patient to a normal rhythm with a pulse and blood pressure, then continue CPR and ventilation.
G. Give 0.01mg/kg epinephrine IV. Subsequent does of epinephrine are given in doses of 0.1mg/kg. You may use alternative routes such as the endotracheal tube or intra-osseous if IV access is not available. The endotracheal tube dose is 0.1mg/kg epinephrine, first mixed with 5ml normal saline and followed by five ventilations.
H. Repeat defibrillation at 4 joules per kg 30 to 60 seconds after every dose of epinephrine.
I. If not successful, continue CPR and ventilation and give 1mg/kg lidocaine, wait 30 seconds, and defibrillate at 4 joules per kg.
J. If not successful, continue CPR and ventilation. Subsequent doses of epinephrine are given in doses of 0.1mg/kg. Defibrillate 30 seconds after each dose of epinephrine. May repeat after three to five minutes.
K. You may consider repeating the lidocaine again.
L. If not successful, continue CPR, epinephrine, and defibrillation.
M. Continue the resuscitation until the resumption of a pulse or a physician stops the code.

Pediatric Asystole/PEA

A. Call for additional help.
B. Shut off all anesthetics, give 100% oxygen, and rapidly infuse intravenous fluids.
C. ABC's, CPR, and check the airway.
D. Consider the possible causes. Identify and treat the cause.
E. Give 0.01mg/kg epinephrine IV initially. Additional doses of epinephrine should be given every three to five minutes at a dose of 0.lmg/kg while continuing chest compressions and ventilation. If no IV access is available the endotracheal tube is an option. Mix the dose of epinephrine with 5ml of normal saline and squirt down the endotracheal tube. Follow this with five ventilations.
F. Stop CPR every few minutes and check for a pulse, if no pulse, continue CPR.
G. Continue CPR until resumption of a pulse or the code is called stopped by a physician.

Appendix H: Pediatric Table

	Neonate <30 days	Infant 1-12 months	Child (i.e. 5 year old)	Adult
Oxygen Consumption (ml/kg/min)	6	5	4	3
Functional Reserve Capacity	25 ml/kg	25 ml/kg	35 ml/kg	40 ml/kg
Glomerular Filtration Rate	30-35 ml/min	60-90 ml/min	95-125 ml/min	95-125 ml/min
Hemoglobin Level (g/dl)	17	11-12	13	14
Hematocrit %	17	30-35	38	
Blood Volume (ml/kg)	85	80	75	65
Heart Rate (beats per minute)	130	120	90	80
Systolic Blood Pressure (mmHg)	65	90-95	95	120
Respiratory Rate	35	25	20	15

Glossary of Common Terms

Glossary of Common Terms

-A-

Acetylcholinesterase (Pseudocholinesterase)- Enzyme found in red blood cells and nerve endings. It is responsible for metabolism of acetylcholine. Succinylcholine has a short duration of action due to the action of this enzyme. Patients with abnormally low levels of pseudocholinesterase may have a prolonged neuromuscular block when succinylcholine is administered.

Agonist- A medication that binds to a specific receptor, resulting in stimulation. For example, opioids stimulate mu receptors resulting in analgesia.

Allergin- A substance/medication that causes an allergic reaction.

Allergic Reaction- Signs and symptoms resulting from exposure to an allergin. Signs and symptoms may range from minor itching/rash to a life threatening anaphylactic reaction. An anaphylactic reaction must be treated rapidly to prevent cardiovascular collapse.

Alveoli- The portion of the lung responsible for the exchange of oxygen and carbon dioxide .

Ambu-Bag- Also known as a bag-mask device. Contains a mask, self inflating bellows, a one way valve to prevent re-breathing, and oxygen tubing for supplemental oxygen. Often used for the resuscitation of patients outside the operating room. An ambu-bag should be available in the operating room in the event that the anesthesia machine fails.

Anemia- Abnormally low hemoglobin level, impacting the patient's oxygen carrying capacity. May be caused by excessive blood loss, diminished red blood cell production, and/or red blood cell destruction. May be related to disease processes and malnutrition.

Angina- Chest pain related to decreased oxygen delivery to the heart muscle. Treated with oxygen, morphine, and nitroglycerin. Angina may progress to a myocardial infarction.

Antacid- A medication that reduces the acidity of stomach contents making the contents more alkaline. An example of an antacid is sodium citrate.

Antagonist- A medication that binds to a specific receptor, preventing stimulation. For example, naloxone is an antagonist to the mu receptors. The administration of naloxone will result in the reversal of the respiratory depression and analgesia associated with opioids.

Antiemetic- A medication used to prevent or decrease the incidence of nausea and vomiting.

Antihistamine- A medication that is an antagonist to histamine receptors. There are two types of histamine receptors. H-1 receptors are found in the intestines, blood vessels, and lungs. An allergic reaction will stimulate these receptors resulting in wheezing or bronchospasm. Diphenhydramine is a specific antagonist to H-1 receptors. H-2 receptors are found in the stomach. Cimetidine is a specific antagonist to H-2 receptors.

Antisialagogue- A medication that reduces salivation/secretions. Atropine and glycopyrrolate are traditional "drying" agents used prior to anesthesia. Glycopyrrolate is two times more potent than atropine when used as an antisialogogue. An antisialagogue is important to administer prior to a ketamine anesthetic.

Anxiety- A feeling of being uneasy or scared. The patient may experience tachycardia, sweating, increased blood pressure, and tremors. Patients often experience anxiety prior to surgery. Anti-anxiety agents such as diazepam or midazolam help to decrease anxiety.

Aortic Stenosis- A narrowing of the aortic valve, obstructing the outflow of blood from the left ventricle. The goal of an anesthetic in these patients include: maintaining the heart rate while avoiding tachycardia, maintaining a normal sinus rhythm, increasing/maintaining preload, maintaining afterload, and blood pressure. This valvular condition increases the risk of mortality during anesthesia. Spinal anesthesia should be avoided.

Apnea- Absence of breathing.

Arrhythmia- Any change in the patient's heart rhythm from normal sinus rhythm.

Aspiration- Any liquid or solid matter that enters the trachea and bronchioles. It is one of the most feared complications during anesthetic induction in patients that require emergent surgery who have eaten recently; pregnant patients; diabetic patients; obese patients; and any medical condition that may increase gastric contents or weaken sphincter control. Aspiration of stomach contents can result in life threatening bronchospasm and pneumonia. Medications to help reduce the risk of aspiration include: metoclopramide, to help empty the stomach; an antacid and histamine 2 antagonists, to reduce the acidity of contents. The application of cricoid pressure may reduce the incidence of aspiration.

Asthma- A chronic disease that results in narrowing of the bronchioles, increased secretions, wheezing, and an increase in the work of breathing. Life threatening status asthmaticus must be treated rapidly with inhaled bronchodilators, epinephrine, and possibly steroids. Patients experiencing acute asthma attacks should not have anesthesia due to the risk of life threatening complications related to endotracheal tube placement/manipulation of the airway.

Asystole- The heart stops contracting. The electrocardiogram will show a straight line. This must be rapidly treated by finding the cause. Common causes of asystole include: lack of oxygen, an abnormally high or low potassium, abnormally low body temperature, low blood pH, or a medication overdose. CPR, epinephrine, and atropine should be administered during resuscitation.

Atelectasis- A collapse of portions of the patients alveoli (where oxygen exchange occurs) due to bronchial obstruction. This may impair the patient's ability to remain oxygenated.

-B-

Barbiturate- A medication that results in generalized depression of consciousness and other vital bodily functions. An example of a barbiturate is sodium thiopental. Barbiturates should not be used in any patient who is hemorrhaging, hypovolemic, or has a history of porphyria.
Benzodiazepine- A medication that reduces anxiety, resulting in the inability to recall events. Examples of benzodiazepines include diazepam and midazolam.

Bleeding Disorder- Any condition that results in the inability to clot blood normally. It may be the result of excessive blood loss, medications, herbs, or a disease process.

Bleeding Time- A laboratory test that determines how well the patient's platelets work. The platelets are responsible for forming the initial clot. Bleeding times are not very accurate.

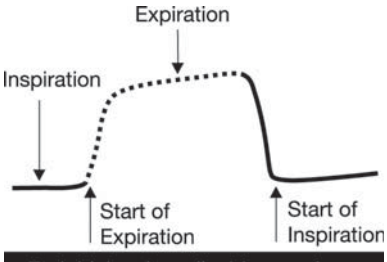
Bronchospasm- A narrowing or contraction of the patient's bronchioles. This may be a natural response to irritating inhaled anesthetics and airway manipulation, including intubation. A bronchospasm may impair oxygen exchange. It is often noted by an increase in the amount of pressure it takes to ventilate the patient and wheezing. Often treated by deepening the anesthetic, positive pressure ventilation, and bronchodilating medications. Severe cases may require epinephrine.

Bronchus- Just below the trachea, the airway will divide into a right and left bronchus. From the right and left bronchus the airway will divide into several smaller bronchi. The right bronchus is straighter than the left. It is easy to insert an endotracheal too far and ventilate only the right side of the lung. It is important to listen to bilateral breath sounds after intubation. In addition, if the patient aspirates the right side of the lung is the most likely site to accumulate the contents.

-C-

Calcium Channel Blocker- A cardiac medication that blocks the movement of calcium to heart cells. Calcium channel blockers should not be used to treat arrhythmias during the treatment of malignant hyperthermia.

Capnograph- A device used to monitor the expired carbon dioxide during anesthesia.



Carbon Dioxide- A gas product produced by the body and exhaled during respiration.

Catecholamine- A term used to describe norepinephrine, epinephrine, and dopamine. These substances are naturally produced by the body, as well as pharmacologically produced.

Cholinesterase- An enzyme that metabolizes succinylcholine, as well as other medications. An abnormally low level of this enzyme may result in a prolonged block for patients that have received succinylcholine.

Chronic Obstructive Pulmonary Disease- A chronic lung disease resulting in alteration of normal gas exchange. Includes chronic bronchitis or emphysema. Patients with chronic bronchitis have an irreversible narrowing of the bronchioles, decreasing the amount of air that reaches the alveoli. Patients with emphysema have an irreversible destruction of the alveoli, reducing the amount of air exchange that occurs at the alveoli.

Colloid- An intravenous fluid that expands the intravascular space. Colloids remain in the intravascular space longer than crystalloid solutions. Examples include hetastarch, dextran, and albumin.

Creatine Phosphokinase- An enzyme found in skeletal muscle, heart, brain, and gastrointestinal tract tissue. Measured by laboratory tests and may indicate damage or injury. Elevated levels are found in patients that have triggered a malignant hyperthermia event.

Creatinine- A laboratory value that indicates kidney function. Elevated levels may indicate kidney dysfunction (i.e. renal failure or insufficiency).

Crystalloid- An intravenous solution used to replace fluid loss. Examples include normal saline and lactated ringers.

-D-

Defibrillator- A device that delivers energy to the heart. Used during life threatening arrhythmias such as ventricular fibrillation and ventricular tachycardia. The energy will "stun" or depolarize the heart and hopefully allow for a normal conduction pattern to resume. The energy that is delivered is measured in joules.

Dehydration- Loss of body fluids due to fasting, vomiting, diarrhea, or a disease process. Replacement of body fluids prior to and during anesthesia is important in maintaining vital bodily function.

Denitrogenation- Pre-oxygenation of a patient prior to the induction of anesthesia with 100% oxygen for at least 3 minutes is important to remove nitrogen. This allows for a reservoir of oxygen during an anesthetic induction.

Depth of Anesthesia- A term that refers to the patient's response or lack of response to stimuli. For example, a patient that responds to an incision may be considered to be under "light" anesthesia.

Diastolic Pressure- Measurement of the patient's arterial pressure when the ventricles of the heart are at rest and filling with blood. This is the "bottom" number of the blood pressure.

Diffusion Hypoxia- A condition that can occur when nitrous oxide is used during an anesthetic. This will occur if the patient is allowed to breathe only room air at the end of the procedure. The oxygen concentration will be less since nitrous oxide leaves the blood faster than oxygen can get into the blood. It is important to use 100% oxygen when waking up a patient from an anesthetic.

Dyspnea- Any condition in which the patient feels that they cannot breathe adequately. This may be noted by an increase in the work of breathing and the inability for the patient to "catch" their breath.

-E-

Electrocardiogram (EKG/ECG)- A monitor that records the electrical activity of the heart. This monitor helps diagnose changes in the patient's rhythm.

Emergence- Occurs from the termination of the anesthetic until the patient is able to respond to verbal stimuli. It is important to ensure that the patient has adequate muscle relaxant reversal, can maintain a patent airway, responds to verbal stimuli, and vital signs are stable before turning the care over to the recovery nurse.

Emesis- Any stomach contents that are forcefully ejected (vomiting).

Emphysema- A form of chronic obstructive pulmonary disease.

Endobronchial Intubation- May be the result of mistakenly inserting an endotracheal tube too deep. Lung sounds are generally present only on the right side of the lungs. Alternatively, some surgical procedures require endobronchial intubation for one lung ventilation.

Endotracheal Tube- An artificial airway placed during anesthesia. The size of the endotracheal tube is based on the size of the patient. Adult patients should have a cuffed tube used while pediatric patients should have an uncuffed endotracheal tube inserted. The purpose of the endotracheal tube is to precisely administer volatile anesthetics and oxygen to the lungs; protect the patient from aspiration and laryngospasm; and allow the patient to be positioned for surgery while ensuring a secure and patent airway.

End Tidal Carbon Dioxide- The measurement of expired carbon dioxide by capnography. Helps detect successful endotracheal intubation and the adequacy of ventilation.

Esophageal Reflux- The flow of stomach contents into the esophagus. May result in aspiration.

Expiration- The elastic recoil of the lung and chest wall results in the elimination of air from the lungs.

Extubation- The removal of an endotracheal tube from the patient.

Eye Signs During Anesthesia- An imprecise measure of the depth of anesthesia. Includes the use of eyelid reflex, papillary size, response to light, and eye movement.

-F-

Fasciculation- The random, uncoordinated contraction of muscles. Associated with the administration of succinylcholine.

-G-

Gamma-Aminobutyric Acid (GABA) - A chemical found in the brain that results in sedation. Benzodiazepines increase the action of GABA in the brain resulting in sedation.

Gas Cylinder- A metal container that holds compressed gas. It is important to know the contents of gas cylinders to avoid the administration of gases other than oxygen to your patient. To help prevent catastrophic mistakes in delivering the incorrect gas to patients an international color code has been applied to gas cylinders to indicate the contents. It is important to check if your particular country has a system in place. In the absence of a reliable system it is important to ensure that you have the correct gas prior to administration to the patient. This may be accomplished by sniffing the gas, checking with the supplier, and checking the contents with gas/oxygen analyzers, if available.

International Color Codes

Gas	Symbol	Color
Oxygen	O2	White
Carbon Dioxide	CO2	Gray
Nitrous Oxide	N2O	Blue
Nitrogen	N2	Black
Air		White & Black

General Anesthesia- Mediations administered to render a patient insensible to pain (analgesia); make the patient unaware of the procedure (amnesia); and muscle relaxation for surgical purposes. Anesthetics may be administered by the inhalational route, intravenous route, or intramuscular route. Vigilance is essential during the administration of general anesthesia. During general anesthesia the patient is reliant upon the anesthetist to maintain a patent airway, provide adequate oxygenation, and support of adequate heart function.

Glottis- A term to describe the opening to the larynx between the vocal cords.

-H-

Hallucination- A patient may experience a dream like state that includes things that are not real but experienced by sight, hearing, or feeling. Often seen with ketamine anesthesia.

Hematocrit- A laboratory test that indicates the volume of mature red blood cells. Used to determine blood loss, the need for blood replacement, and oxygen carrying capacity.

Hemoglobin- The specific portion of the red blood cell that carries oxygen. Used to help determine blood loss, the need for blood replacement, and oxygen carrying capacity.

Hemorrhage- Excessive or uncontrollable bleeding.

Hepatitis- Inflammation of the liver caused by a virus or medications. May affect the livers ability to metabolize medications. Halothane has been implicated in causing hepatitis.

Hepatotoxicity- A medication or substance that can damage or cause inflammation of the liver. Halothane, in some individuals, may be hepatotoxic.

Histamine- A substance found throughout the body. There are two types of histamine. Histamine 1 (H1) receptors are found in the intestines, blood vessels, and lungs. An allergic reaction will stimulate these receptors resulting in wheezing or bronchospasm. Diphenhydramine is a specific antagonist to H-1 receptors. Histamine 2 (H-2) receptors are found in the stomach. Cimetidine is a specific antagonist to H-2 receptors.

Hoffman Elimination- A metabolic pathway for the medication atracurium. Breakdown of atracurium occurs by Hoffman Elimination and is pH and temperature dependent. The metabolism of atracurium is not dependent upon the liver or kidneys.

Hypercapnia- Abnormally high carbon dioxide level.

Hypertension- Abnormally high arterial blood pressure. Defined in adults as greater than 180 for systolic pressure and 100 for diastolic pressure.

Hyperventilation- An increase in respiratory rate and/or volume that decreases carbon dioxide levels to lower than normal levels.

Hypocapnia- Abnormally low carbon dioxide level.

Hypotension- An arterial blood pressure that is lower than normal for a patient. Significant hypotension may result in decreased tissue perfusion and potential cardiovascular/neurological impairment. Hypotension can be treated during anesthesia by decreasing the amount of anesthetic that a patient is receiving, increasing fluid administration, a head down position, and the administration of vasopressors.

Hypothermia- A lower than normal body temperature. Patients should be protected from hypothermia by keeping them covered.

Hypoventilation- A decrease in respiratory rate and/or volume that increases carbon dioxide levels to higher than normal levels.

Hypovolemia- A decrease in intravenous fluid volumes that can lead to hypotension and decreased tissue perfusion.

Hypoxia- A decrease in oxygen delivered to tissue. Hypoxia can be caused by anemia related to a decrease in oxygen transport to tissue; from a lack of oxygen delivery to the patient; toxicity that does not allow oxygen to be used by tissue; and severe hypotension which does not allow the oxygen to be delivered to the tissue in enough quantity.

-I-

Informed Consent- The explanation and acceptance of the risks and benefits associated with any procedure/anesthetic.

Inhalation Anesthesia- The administration of volatile anesthetics through a mask to induce general anesthesia. Often used in the pediatric population.

Insensible Water Loss- Body fluids that are lost due to evaporation and ventilation.

Intra-ocular Pressure- The inner pressure of the eye. Normal intra-ocular pressure is 10-30 mmHg. Most anesthetics will decrease intra-ocular pressure. Ketamine, topical atropine, and succinylcholine are the exceptions. Succinylcholine should not be administered to patients with an injury to the globe of the eye since an increase in intra-ocular pressure may cause the loss of the inner contents resulting in blindness.

Intravenous Anesthesia- The use of intravenous agents to induce general anesthesia.

Intubation- The placement of an endotracheal tube through the nose or mouth into the trachea.

-J-

Joule- Is a measurement of energy. The energy used in defibrillation is measured in joules.

-K-L-

Laryngoscopy- The use of a laryngoscope to view the glottic opening to place an endotracheal tube.

Laryngospasm- A contraction of muscles in the larynx resulting in the inability/increased difficulty in the ventilation of the patient. This complication occurs when an endotracheal tube is not in place in the glottis. It is often related to light anesthesia and can be life threatening. Avoiding the manipulation of the airway when the patient is "light" will decrease this complication. Treatment includes the use of positive pressure to overcome the obstruction and the use of succinylcholine to stop the obstruction. The use of a nondepolarizing muscle relaxant should be used if succinylcholine is contraindicated.

Larynx- The portion of the airway that contains cartilage rings. It is the space between the pharynx and trachea. In the adult the larynx is found between the 4th and 6th cervical vertebrae.

-M-

Malignant Hyperthermia- A genetic condition caused by volatile anesthetics and succinylcholine. It results in a high fever, tachycardia, arrhythmias, hypoxia, increased carbon dioxide production, and muscle stiffness. It must be treated rapidly with dantrolene sodium along with symptomatic treatment. Death can ensue rapidly without appropriate treatment.

Metabolic Acidosis- A condition that results in a decrease in normal body pH. This can be caused by such conditions as diarrhea and kidney dysfunction.

Metabolic Alkalosis- A condition that results in an increase in normal body pH. This can be caused by such conditions as vomiting and endocrine abnormalities.

Micrognathia- A condition in which the jaw of a patient is abnormally small and short. This may lead to a difficult intubation and the ability to maintain a patent airway during mask ventilation.

Minimum Alveolar Concentration- This is the concentration of a volatile anesthetic that is required to prevent 50% of the patients from moving during surgical incision. It is a rough guide to dosing the volatile anesthetic. Age and numerous other variables can impact this.

Mitral Regurgitation- A condition in which the mitral valve does not close, resulting in blood being ejected back into the left atrium. Goals of anesthesia include maintaining or slightly increasing heart rate, maintaining preload, reducing afterload, and maintaining blood pressure.

Muscular Dystrophy- A group of diseases that result in atrophy of muscles. Succinylcholine is contraindicated in patients with muscular dystrophy.

Myocardial Infarction- A condition that is the result of a decrease in oxygen supply to the heart muscle. This may be caused by any obstruction or decrease of blood flow to the heart muscle. Death can occur from myocardial infarction.

-N-

Nasotracheal Tube- An endotracheal tube that is placed through the nose into the trachea, securing the airway. This approach to a patent airway occurs commonly for oral surgical procedures.

Normocapnia- A normal level of carbon dioxide.

Normothermia- A normal temperature.

-O-

Opiate- A group of medications that are used to treat pain. An example of an opiate includes fentanyl, morphine, and meperidine.
Oximeter- A monitoring device that uses two different wavelengths of light to estimate the oxygen saturation of blood. This monitor, along with the capnograph, greatly reduces the mortality and morbidity associated with anesthesia.

-P-

Peripheral Nerve Stimulator- A monitor that uses an electrical stimulus to stimulate muscles, assessing the degree of neuromuscular blockade. This is an important monitor to use prior to emergence to ensure the patient has adequate recovery prior to extubation.

Pharynx- The area between the mouth and larynx. The pharynx can be divided into the nasopharynx, which is area in the mouth that contain the nasal passages; the oropharynx which includes the back of the mouth down to the epiglottis; and the laryngopharynx, which includes the epiglottis to the larynx.

Physical Status- Is a classification system that is used for anesthesia to address the overall health of the patient.

ASA Class	Overall Health and Examples of Systemic Conditions
I	Healthy patient.
II	Mild to moderate disease such as controlled hypertension, controlled diabetes, and/or obesity.
III	Severe disease such as angina, COPD, and prior myocardial infarction.
IV	A severe disease that is a constant threat to life such as congestive heart failure, renal failure, and liver disease.
V	A patient not expected to live more than 24 hours.

Porphyria- This is a genetic condition. There are several types of porphyria. The hepatic porphyria's can result in abdominal pain, neurological abnormalities, seizures, and cardiovascular collapse, when barbiturates such as sodium thiopental are administered.

-Q-R-S-T-U-V-W-X-Y-Z-

Systolic Blood Pressure- Measurement of the arterial pressure when blood is ejected from the ventricles. This is the "top" number of the blood pressure.

INTERNATIONAL FEDERATION OF NURSE ANESTHETISTS

MONITORING GUIDELINES

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INTERNATIONAL FEDERATION OF NURSE ANESTHETISTS

PATIENT MONITORING GUIDELINES

Anesthesia safety is the goal of anesthesia delivery worldwide. Parameters that enhance safety include professional knowledge, vigilance, constant monitoring and changes in the anesthetic plan based upon patient responses to the anesthetic.

Included in the International Federation of Nurse Anesthetists Standards of Practice is a standard (IV) that addresses monitoring. It states, "the nurse anesthetist **will monitor** psychological and physiological responses, interpret and utilize data obtained from the use of invasive and noninvasive monitoring modalities and take corrective action to maintain or stabilize the patient's condition, and provide resuscitative care." The nurse anesthetist **will monitor**, record and report the patient's physiological and psychological signs and provide resuscitative care that includes fluid therapy, maintenance of airway and provision of assisted or controlled ventilation.

Patient monitoring guidelines are intended to assist the nurse anesthetist in providing consistent, safe anesthesia care. While these guidelines are intended to apply to patients undergoing general, regional or monitored anesthesia care, they do not apply to epidural analgesia or labor or pain management. These guidelines may be exceeded in any or all respects at any time at the discretion of the anesthetist. In extenuating circumstances, the nurse anesthetist must use clinical judgement in prioritizing and implementing these guidelines. If there is reason to omit a monitored parameter, the reason for the omission should be documented on the record.

Monitoring Guidelines

Ventilation

Purpose: To assess adequate ventilation of the patient.

Guideline: Ventilatory adequacy shall be assessed by palpation or observation of the reservoir breathing bag, chest movement, and auscultation of breath sounds. Ventilation should be continuously assessed by the use of a precordial or esophageal stethoscope. Correct placement of an endotracheal tube must be verified by auscultation and chest excursion. When available, spirometry, ventilatory pressure monitors and end-tidal CO_2 monitoring should be used. When a patient is ventilated by mechanical ventilator, the integrity of the breathing circuit must be monitored by a device that is capable of detecting disconnection.

Oxygenation

Purpose: To assess adequate oxygenation of the patient

Guideline: Adequacy of oxygenation shall be monitored by observation of skin color, color of the blood in the surgical field and arterial blood gas analysis as indicated. The use of pulse oximetry is encouraged on all patients. During general anesthesia, the oxygen concentration delivered by the anesthesia machine shall be continuously monitored with an oxygen analyzer with a low oxygen concentration limit alarm. An oxygen supply failure alarm system shall be used to warn of low oxygen pressure in the anesthesia machine.

Circulation

Purpose: To assess adequacy of the patient's cardiovascular system.

Guideline: Circulation shall be assessed by **at least one** of the following measures: ; digital palpation of pulse, auscultation of heart sounds, continuous intra-arterial pressure monitoring, or pulse oximetry. Skin color and capillary refill should be monitored. Blood pressure and heart rate shall be determined and recorded at least every 5 minutes. An electrocardiogram (ECG/EKG) continuously displayed from induction through emergence is highly encouraged.

Body Temperature

Purpose: To assess changes in body temperature.

Guideline: During every anesthetic, there shall be readily available a means to measure body temperature. When changes in temperature are anticipated, the temperature shall be measured.

Neuromuscular Function

Purpose: To assess neuromuscular function.

Guideline: When neuromuscular blocking drugs are used, neuromuscular function shall be assessed by respiratory strength, hand grip, sustained head lift, and negative inspiratory force. Assessment of neuromuscular function by a nerve stimulator is strongly recommended.

Anesthesia Equipment

Anesthesia equipment should be selected to ensure appropriate delivery of available anesthetics and maintenance of physiological parameters adequate for organ preservation. Equipment should be checked thoroughly each day and an abbreviated check of all equipment shall be completed before each anesthetic.

Nurse Anesthetist

Continuous clinical observation and vigilance are the cornerstone for anesthesia safety. The nurse anesthetist shall be in constant attendance of the patient until care has been accepted by another qualified individual.