The Medical Student's Anesthesia Pocketbook

University of Texas Health Science Center Houston

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Anesthesia Overview

Adapted from "A Medical Student's Anesthesia Primer" by Roy G. Soto, MD (roysoto@ucla.edu)

Introduction

In many programs across the country, medical students are only exposed to two weeks of anesthesiology during their third or fourth year. The student often attends daily lectures and might be told to "read Miller's Basics of Anesthesia", but often by the time the student has finally figured out why we are doing what we're doing, the rotation is over, and he or she leaves with only a minimum of anesthesia knowledge.

This primer is intended to give a brief overview of what we do, when we do it, and why we do it for standard, uncomplicated cases ... the types that you are bound to see during your rotation. By no means is the information contained comprehensive, or intended to allow you to practice anesthesia solo, but it is intended to give an overview of the "big picture" in a format that can be quickly read in one sitting, and then referred to as needed. Keep in mind that there are many ways to accomplish the same thing in anesthesia, and you will undoubtedly see techniques that differ from what we've written here, but our goal again is to present you with a simple overview.

Anesthesia is a challenging and exciting specialty, but can also be extremely frustrating if not taught clearly during the short exposure that many medical students get to the field.

Preoperative History and Physical

Unlike the standard internal medicine H&P, ours is much more focused, with specific attention being paid to the airway and to organ systems at potential risk for anesthetic complications. The type of operation and the type of anesthetic will also help to focus the evaluation.

Of particular interest in the history portion of the evaluation are:

Coronary Artery Disease - What is the patient's exercise tolerance? How well will his or her heart sustain the stress of the operation and anesthetic? Asking a patient how he feels (i.e. SOB, CP) after climbing two or three flights of stairs can be very useful as a "poor man's stress test".

Hypertension - How well controlled is it? Intraoperative blood pressure management is affected by preoperative blood pressure control.

Asthma - How well controlled is it? What triggers it? Many of the stressors of surgery as well as intubation and ventilation can stimulate bronchospasm. Is there any history of being hospitalized, intubated, or prescribed steroids for asthma? This can help assess the severity of disease.

Kidney or Liver disease - Different anesthetic drugs have different modes of clearance and organ function can affect our choice of drugs.

Reflux Disease - Present or not? Anesthetized and relaxed patients are prone to regurgitation and aspiration, particularly if a history of reflux is present. This is usually an indication for rapid sequence intubation (succinylcholine + cricoid pressure).

Smoking - Currently smoking? Airway and secretion management can become more difficult in smokers.

Alcohol Consumption or Drug Abuse? - Drinkers have an increased tolerance to many sedative drugs (conversely they have a decreased requirement if drunk), and are at an increased risk of hepatic disease, which can impact the choice of anesthetic agents.

Endocrine:
Steroids – patients with recent steroid use may require preoperative steroids to cover secondary adrenal suppression.
Diabetes - Well controlled? The stress response to surgery and anesthesia can markedly increase blood glucose concentrations, especially in diabetics.
Thyroid – Hypo/Hyper metabolic states affect the cardiovascular system, renal clearance, and thermoregulation.

Medications - Many medications interact with anesthetic agents, and some should be taken on the morning of surgery (blood pressure medications) while others should probably not (diuretics, diabetes medications).

Allergies - We routinely give narcotics and antibiotics perioperatively, and it is important to know the types of reactions that a patient has had to medications in the past. The #1 anesthesia allergen is the non-depolarizing paralytics. The #2 class is antibiotics.

Family History - There is a rare, but serious disorder known as **malignant hyperthermia** that affects susceptible patients under anesthesia, and is heritable. Another heritable disorder is **pseudocholinesterase deficiency** which affects succinylcholine duration and may require extended postoperative ventilation.

Anesthesia history - Has the patient ever had anesthesia and surgery before? Did anything go wrong?

Last Meal - Whether the patient has an empty stomach or not impacts the choice of induction technique (another indication for rapid sequence intubation).

While a history of a difficult intubation may be the most reliable predictor of future difficult intubations, the physical exam is also important to help predict potential problems. For the physical exam, the specific areas which are of particular importance to the anesthesiologist include the cardiovascular system, lungs, head/neck/upper airway, signs of preexisting neurological dysfunction, and signs of coagulation dysfunction.

Many tests have been proposed to help predict difficulty with intubation, but no single factor, taken independently, has been able to accomplish this goal. However, when

multiple factors are taken together, the predictive value is increased. The following some specific aspects of the head/neck/upper airway exam which can be used to help predict difficulties that may be encountered.

Head/Neck/Upper Airway exam

Facial trauma or deformities- may make it difficult to perform laryngoscopy.

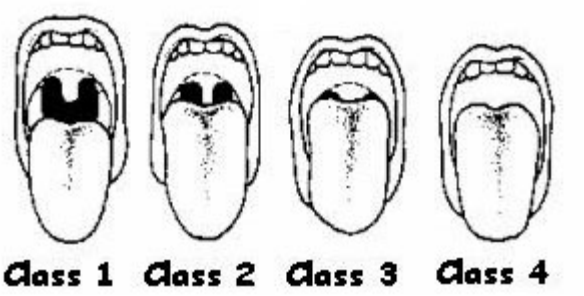
Deviated septum or nasal polyps- can pose difficulty with nasal intubation or with inserting a nasogastric tube, possibly resulting in bleeding.

Neck range of motion- the patient needs to be able to assume the sniffing position (cervical flexion and atlanto-occipital extension) so that the oral, pharyngeal, and laryngeal axes are aligned which will facilitate viewing the glottic opening. Normal patients should achieve 35 degrees or more of atlanto-occipital extension, which can assessed by observing the angle traversed by the occlusal surface of the maxillary teeth when the head is fully extended from the neutral position. Difficulty with intubation may be predicted by a significant reduction in the ability to achieve this degree of extension or if the patient experiences any pain, tingling, or numbness during this movement.

TMJ mobility and degree of mouth opening- this is important for determining the adequacy of space for manipulating the laryngoscope and endotracheal tube. Measure the inter-incisor distance. An opening of < 3 cm or 2 finger breadths will likely not provide adequate space and may result in a difficult intubation. In addition, ask the patient to move the lower incisors as high on the upper lip as possible (upper lip bite test). If the lower incisors do not reach the vermilion border of the upper lip, this may be a sign of inadequate translational movement of the TMJ, which is also necessary for successful laryngoscopy.

Dentition- It is important to note the presence of dentures, poor dentition, loose teeth, or caps, which may not tolerate digital manipulation or may be at risk of damage when the laryngoscopic blade is inserted into the mouth. Dentures should be removed before surgery. In addition, the presence of prominent maxillary incisors may result in obstruction of the view of the glottis. Conversely, edentulous patients are generally easy to intubate, but may pose difficulty with mask ventilation.

Tongue/Oropharynx- Direct laryngoscopy allows visualization of the larynx by displacing the tongue anteriorly into the mandibular space, which moves the tongue out of the line of sight. A normal sized tongue will generally fit easily into the space between the two mandibular rami. However, if the tongue is too large (macroglossia) or the mandible is too small (micrognathia), there will likely be difficulty with proper visualization of the glottis. The Mallampati classification is a method to assess the tongue size in relation to the size of the oropharynx. The test is performed by having the patient sit with their head in the neutral position, and then open their mouth as wide as possible and protrude the tongue as far as possible. They should not phonate, as this can elevate the soft palate and alter the view. A Class 3 or 4 view may be associated with difficult laryngoscopy.



The size of the mandible can be assessed by measuring the thyromental distance. This is the distance from the mentum of the mandible to the thyroid cartilage. A thyromental distance of 6 cm (approximately 3 finger breadths) or less, as often seen in patients with a receding mandible or a short neck, may indicate a possible difficult intubation. Alternatively, the sternomental distance (from mentum to sternal notch) can also be used, which assesses the size of the mandible and neck. A sternomental distance of < 13 cm may also point to difficulty with intubation.

Finally, a physical status classification is assigned, based on the criteria of the American Society of Anesthesiologists (ASA1-5), with ASA-1 being assigned to a healthy person without medical problems other than the current surgical concern, and ASA-5 being a moribund patient, not expected to survive for more than twenty four hours without surgical intervention. An "E" is added if the case is emergent. The full details of the classification scale are also detailed later.

IV's and Premedication

The two skills you should take the opportunity to practice while on your rotation are IV insertion and airway management/intubation. Every patient (with the exception of some children that can have their IV's inserted following inhalation induction) will require IV access prior to being brought to the operating room. The key to success with IV placement is preparation and patience. All of us have successfully found and cannulated a vein, only to find that we left the bag of IV fluid or the tape across the room. Normal saline, Lactated Ringer's solution, or other balanced electrolyte solutions (Plasmalyte, Isolyte) are all commonly used solutions intraoperatively.

Many patients are understandably nervous preoperatively, and we often premedicate them, usually with a rapid acting benzodiazepine such as intravenous midazolam (which is also fabulously effective in children orally or rectally). Metoclopramide, Bicitra, and/or an H2 blocker are also often used if there is a concern that the patient has a full stomach, and anticholinergics such as glycopyrrolate can be used to decrease secretions.

Room Setup and Monitors

Before bringing the patient to the room, the anesthesia machine, ventilator, monitors, and cart must be checked and set up. The anesthesia machine must be tested to ensure that the gauges and monitors are functioning properly, that there are no leaks in the gas delivery system, and that the backup systems and fail-safes are functioning properly.

The monitors that we use on most patients include the pulse oximeter, blood pressure monitor, and electrocardiogram, all of which are ASA requirements for patient safety. Each are checked and prepared to allow for easy placement when the patient enters the room. You may see some more complicated cases that require more invasive monitoring such as arterial or central lines.

In the operating room, the anesthesia machine can support non-invasive and invasive monitors. While in the majority of cases, non-invasive monitoring is sufficient, examples and indications of invasive monitors include:

- Arterial lines for continuous blood pressure monitoring – usually radial, but can be brachial, femoral, etc.
    - Used in any case where wide swings in blood pressure are expected, where tight control of blood pressure is needed, in cardiopulmonary bypass cases, or when there will be the need for multiple blood gas analyses.
- Central venous lines for measuring CVP- typically IJ or subclavian
    - Used in any case when there is the need to closely monitor the intravascular volume status or there is a need to evaluate right ventricular function.
- Pulmonary artery catheter for measuring Wedge pressure (LVEDP)
    - Used to determine RAP, PA, LVEDP, CO, and PvO_2. These measurements are helpful when faced with poor left ventricular function, valvular disease, recent MI, ARDS, massive trauma, major vascular surgeries, or when there is a critical need to accurately assess the intravascular fluid volume or the response to blood pressure interventions.
- Transesophageal echo (TEE) – used in many CV cases
    - Used to evaluate regional wall motion abnormalities indicative of myocardial ischemia, to evaluate stroke volume/ejection fraction, to evaluate cardiac valvular function, to look for intracardiac air, to monitor changes in cardiac function, or to evaluate adequacy of intravascular fluid volume.

The anesthesia cart is set up to allow easy access to intubation equipment including endotracheal tubes, laryngoscopes, stylets, oral/nasal airways and the myriad of drugs that we use daily. A properly functioning suction system is also vital during any type of anesthetic.

When it comes to drawing up the initial drugs, there are 4 categories of drugs that should be ready for each case: induction agents, sedation/analgesia drugs, reversal agents, and emergency drugs. At times, the specific drugs may vary depending on the case, but the following are most commonly used. The first 3 categories should be drawn up in preparation for the case, but the emergency drugs are often already prepared.

Induction Agents
Lidocaine (1%) (10mg/mL) – Draw up in a 5cc syringe
Propofol (10mg/mL) – Draw up in a 20cc syringe
Rocuronium (10mg/mL) – Draw up in a 5cc syringe

Sedation/Analgesia Drugs
Versed (1mg/mL) – Draw up in 3cc syringe
Fentanyl (50mcg/mL) – Draw up in 5cc syringe

Reversal Agents

Neostigmine (1mg/mL) – Draw up in 5cc syringe
Glycopyrrolate (0.2mg/mL) – Draw up in 5cc syringe

Emergency Drugs (*At Hermann, these drugs are already prepared and should be found in plastic bag)

*Phenylephrine (100mcg/mL) – In 10cc syringe
*Ephedrine (5mg/mL) – In 10cc syringe
*Succinylcholine (20mg/mL) – In 10cc syringe
Atropine 1mg/mL – In 3cc syringe

Other preparations that can be done before the case focus on patient positioning and comfort, since anesthesiologists ultimately are responsible for intraoperative positioning and resultant neurologic or skin injuries. Heel and ulnar protectors should be available, as should axillary rolls and other pads depending on the position of the patient.

Induction and Intubation

You now have your sedated patient in the room with his IV (gender selected at random ... you generally anesthetize men and women the same), and he's comfortably lying on the operating table with all of the aforementioned monitors in place and functioning. It is now time to stow your tray tables and bring your seats to the full upright position, because it's time for take-off. Indeed, many people compare anesthesia with flying an aircraft since the take-off and landing can be quite rocky at times whereas the actual flying can seem like smooth sailing.

The first part of induction of anesthesia should be pre-oxygenation with 100% oxygen delivered via a face mask. The goal should be an end-tidal oxygen concentration of more than 80%, a Sa02 of 100%, or lacking end tidal gas monitoring, at least four full tidal volume breaths with a tight fitting mask. Performing a "jaw thrust" or "chin lift" will optimize the patient's airway for bag mask ventilation.

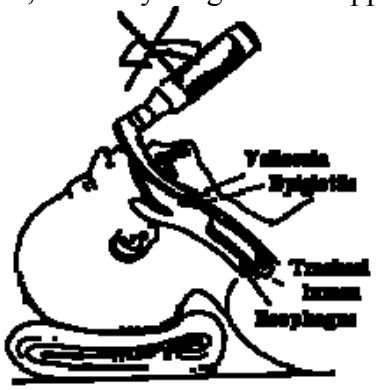
The reason we pre-oxygenate prior to induction and intubation is to maximize the amount of time a person can tolerate apnea without desaturating. This translates to more time available to secure the airway, which is very important if the patient turns out to have an unanticipated difficult airway. When breathing stops, the body's oxygen stores are limited to the oxygen in the blood and the oxygen in the lungs. A normal person uses approximately 250-300 mL of oxygen each minute and can desaturate in as little as 30 – 60 seconds of apnea. Within the lungs, the functional residual capacity (FRC) is approximately 3 liters in a normal person. When breathing room air (21% O_2), the FRC contains mostly nitrogen and a relatively small amount of oxygen. However, when breathing 100% O_2, this effectively replaces the nitrogen with oxygen within the FRC and creates a tremendous additional reserve of oxygen that can be used by the body. This pre-oxygenation can provide 3 – 6 additional minutes of apnea before significant O_2 desaturation occurs.

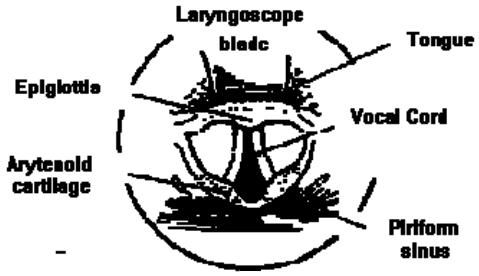
Again, using the example of a normal smooth induction in a healthy patient with an empty stomach, the next step is to administer an IV, anesthetic until the patient is unconscious. A useful guide to anesthetic induction is the loss of the lash reflex, which can be elicited by gently brushing the eyelashes and looking for eyelid motion. Patients frequently become apneic after induction and you may have to assist ventilation. The most common choices used for IV induction, probably in order of frequency, are Propofol, Thiopental, Etomidate, and Ketamine.

Assuming that you are now able to mask ventilate the patient, the next step is usually to administer a neuromuscular blocking agent such as succinylcholine (a depolarizing

relaxer) or vecuronium (or any of the other -oniums or -uriums, which are all non depolarizing relaxers). A twitch monitor is usually used to ascertain depth of relaxation, and when the twitch has sufficiently diminished, intubation can be attempted. Note that the above induction agents usually last for less than ten minutes, so many of us will turn on a volatile anesthetic agent while we are mask ventilating and waiting for the muscle relaxant to take effect. Try to keep a good mask seal so you don't anesthetize yourself ...

Once the patient is adequately anesthetized and relaxed, it's time to intubate, assuming you have all necessary supplies at the ready. Hold the laryngoscope in your left hand (whether you're right or left handed) then open the patient's mouth with your right hand, either with a head tilt, using your fingers in a scissors motion, or both. Insert the laryngoscope carefully and advance it until you can see the epiglottis, sweeping the tongue to the left. Advance the laryngoscope further into the vallecula (assuming you're using a curved Macintosh blade), then using your upper arm and NOT your wrist, lift the laryngoscope toward the juncture of the opposite wall and ceiling. There should be no rotational movement with your wrist, as this can cause dental damage. When properly done, the blade should never contact the upper teeth. Once you see the vocal cords, insert the endotracheal tube until the balloon is no longer visible, then remove the laryngoscope, hold the tube tightly, remove the stylet, inflate the cuff balloon, attach the tube to your circuit and listen for bilateral breath. If you have chest rise with ventilation, misting of the endotracheal tube, bilateral breath sounds and end tidal C02, you're in the right place and all is well! Tape the tube securely in place, place the patient on the ventilator, and set your gas flows appropriately.





Maintenance

As with flying an airplane, the maintenance portion of anesthesia can be very smooth, but when things go wrong, they can go very wrong very quickly. Therefore it is vital to continually monitor blood pressure, pulse, EKG, 02 saturation, temperature, end-tidal 02, C02, N20, and volatile agent levels, presence or absence of twitch, and patient position, as positioning changes can occur with table movement/tilt (or surgeon input).

It is also vital to pay attention to the case itself, since blood loss can occur very rapidly, and certain parts of the procedure can threaten the patient's airway, especially during oral surgery or ENT cases. It is also important to keep track of the progress of the case. It is a common beginner's mistake to give patients a muscle relaxant that lasts for an hour when the case only has 10 minutes to go. A good anesthesiologist has a "sixth sense." He or she

is always paying attention to the tone of the pulse oximeter or the slurping of blood into the suction canister. Vigilance is key to a good anesthetic.

One can also prepare for potential post-operative problems during the case, by treating the patient intraoperatively with long-acting anti-emetics and pain medications.

Emergence

Using our analogy of flying an airplane, a poor landing/emergence can be disastrous. Knowing when to turn down/ off your anesthetic agents comes with experience and attention to the progress of the surgical case. Emergence isn't as easy as it might at first seem, since very important steps have to take place before a patient can be safely extubated.

When using nondepolarizing neuromuscular blocking agents such as Rocuronium or Cisatracurium, a peripheral nerve stimulator is used to monitor the pharmacological effects of these drugs, and the dosage can be titrated to effect. Near the end of the case, the nerve stimulator is used to assess the degree of spontaneous recovery from these drugs. Neostigmine, an anticholinesterase drug, is typically used as a reversal agent when the spontaneous recovery is occurring, as determined by the presence of twitches induced by the nerve stimulator. When utilizing a train-of-four stimulation, the greater the number of visible muscle twitches, the greater the degree of spontaneous recovery that has occurred. A lack of muscle twitches indicates the blockade at the neuromuscular junction is still too intense and the administration of neostigmine is not likely to facilitate reversal. It is also important to note that even with 4 twitches and the return of spontaneous breathing, the patient may still have up to 75% of the NMJ receptors occupied by the blocking agent. The adequacy of recovery from the neuromuscular blocking drugs can be tested clinically by the ability of the patient to maintain a head lift, leg lift or handgrip strength for > 5 seconds.

Once a patient has adequately recovered from the effects of the neuromuscular blocking agents, is able to breathe on his own, is able to follow commands, demonstrates purposeful movements, and can protect his airway, he is most likely ready to be extubated. In addition, the following physiological parameters are also used to assess readiness for extubation.

- RR > 8 & < 30/min
- TV > 5 cc/kg
- TV/RR > 10
- PaO_2 > 65-70 mmHg on FiO_2 < 40%
- $PaCO_2$ < 50 mmHg
- Hemodynamic stability
- Temperature at least 35 C
- NIF > -20

Suction must always be close at hand, since many patients can become nauseous after extubation, or simply have copious oropharyngeal secretions. Once the patient is

reversed, awake, suctioned, and extubated, care must be taken in transferring him to the gurney and oxygen must be readily available for transportation to the recovery room/Post-Anesthesia Care Unit (PACU). Finally, remember that whenever extubating a patient, you must be fully prepared to reintubate if necessary, which means having drugs and equipment handy

PACU concerns

The anesthesiologist's job isn't over once the patient leaves the operating room. Concerns that are directly the responsibility of the anesthesiologist in the immediate postoperative period include nausea/vomiting, hemodynamic stability, and pain.

Other concerns include continuing awareness of the patient's airway and level of consciousness, as well as follow-up of intraoperative procedures such as central line placement and postoperative X-rays to rule out pneumothorax.

In summary, anesthesia is a specialty in which an extensive knowledge of physiology and pharmacology can be applied to the care of patients in a unique one-on-one intensive care setting. Challenge us to teach you what you don't understand, and get as much practice with airway management as possible. Also, remember that at the heart of anesthesiology are the ABC's - airway, breathing and circulation. No matter what field you may enter, basic knowledge of the ABC's is part, of any complete physician's repertoire. Enjoy!

Commonly Used Medications

Volatile Anesthetics

- *All are bronchodilators, except for desflurane which is irritating and may cause bronchospasm. Administered alone (i.e., without narcotics), inhaled anesthetics increase respiratory rate but decrease tidal volume.*
- *Except for halothane, inhaled anesthetics are not metabolized by the body and are eliminated by ventilation.*
- *All volatile anesthetics (but not nitrous oxide) are capable of triggering malignant hyperthermia (MH).*
- *While in many cases volatile anesthetics are used for maintenance of anesthesia, in some circumstances these drugs may be chosen to induce anesthesia such as in pediatrics cases in which the child may not tolerate IV placement awake.*

Halothane

Pro: Cheap, nonirritating so can be used for inhalation induction

Con: Long time to onset/offset, Significant Myocardial Depression, Sensitizes myocardium to catecholamines, Association with Hepatitis

Isoflurane

Pro: Cheap, excellent renal, hepatic, coronary, and cerebral blood flow preservation

Con: Long time to onset/offset, irritating so cannot be used for inhalation induction

Desflurane

Pro: Extremely rapid onset/offset

Con: Expensive, Stimulates catecholamine release, Possibly increases postoperative nausea and vomiting, Requires special active-temperature controlled vaporizer due to high vapor pressure, Irritating so cannot be used for inhalation induction

Sevoflurane

Pro: nonirritating so can be used for inhalation induction. Extremely rapid onset/offset.

Con: Expensive. Due to risk of "compound A" exposure must be used at flows > 2 L/min. Theoretical potential for renal toxicity from inorganic fluoride metabolites.

Nitrous Oxide

Pro: Decreases volatile anesthetic requirement, Dirt cheap, Less myocardial depression than volatile agents

Con: Diffuses freely into gas filled spaces (bowel, pneumothorax, middle ear, eye, Decreases Fi02, Increases pulmonary vascular resistance

IV Anesthetics

- *Most sedative hypnotics work through the inhibitory gamma-aminobutyric acid (GABA) neurotransmitter system in which increased chloride conductance leads to neuronal inhibition. Most IV induction agents bind to a specific site called $GABA_A$ for this inhibitory effect, and they have a rapid onset due to lipophilic properties which allow them to quickly partition into the highly perfused lipophilic brain and spinal cord. They also have short duration of action, with their termination of effect due to redistribution into less perfused tissues such as muscle and fat.*

Barbiturates (e.g., thiopental)

Decrease ICP by decrease in cerebral oxygen consumption. Since cerebral perfusion is preserved, desirable drug for neurosurgery cases. Causes respiratory and cardiac depression.

Pro: Excellent brain protection, Stops seizures, Cheap

Con: Myocardial depression, Vasodilation, Histamine release, Can precipitate porphyria in susceptible patients

Propofol

In adults, induction dose 1.5 to 2.5 mg/kg while continuous infusion of 100 to 200 micrograms/kg/min maintains unconsciousness. These values differ for children and for the elderly.

Pro: Prevents nausea/vomiting, Quick recovery if used as solo anesthetic agent

Con: Pain on injection, Expensive, Supports bacterial growth, Myocardial depression (the most of the four), Vasodilation, cross reactivity in patients with egg allergy.

Etomidate

Minimal depression of cardiovascular and pulmonary function. Ideal for patients with CVD or hemodynamic instability. Induction dose of 0.2 to 0.4 mg/kg that causes pain on injection and myoclonus. Suggested that it may suppress cortisol synthesis.

Pro: Least myocardial effect of IV anesthetics

Con: Pain on injection, Adrenal suppression (? significance if used only for induction), Myoclonus, Nausea/Vomiting

Ketamine

Works via antagonism of the N-methyl-D-aspartate receptor channel complex. Minimally depresses the cardiorespiratory system. Induction dose of 1 to 2 mg/kg in adults. Directly stimulates SNS and increases BP and heart rate. Increasing demand on the heart and is not a good choice for CAD patients.

Pro: Works IV, PO, PR, IM - good choice in uncooperative patient without IV, Stimulation of SNS $\rightarrow$ good for hypovolemic trauma patients, often preserves airway reflexes

Con: Dissociative anesthesia with postop dysphoria and hallucinations, Increases ICP/IOP and CMR02, Stimulation of SNS $\rightarrow$ bad for patients with compromised cardiac function, increases airway secretions

Dexmedetomidine

Selective alpha-2 adrenergic agonist, which is used in the operating room as an adjunct to general anesthesia, or to provide sedation for awake fiberoptic intubation or for regional anesthesia. It is generally given as a loading dose of 0.5-1 mcg/kg over 10 minutes, followed by an infusion of 0.2 to 0.7 mcg/kg/hr. It produces sedative-hypnotic and analgesic effects without causing respiratory depression.

Benzodiazepines (BDZ)

Usually provided as premedication for sedation and anxiolysis before general anesthesia. Properties include anxiolytic effects to sedation and unconsciousness at higher doses. Midazolam (Versed) induction dose of 0.1 to 0.2 mg/kg and infusion rates of 0.25 to 1 microgram/kg per minute. BDZs produce respiratory, cardiovascular, and upper airway reflex depression and in the presence of hypovolemia, may cause significant hypotension. Reversal of the sedative action of these compounds with the competitive antagonist, flumazenil.

Local Anesthetics

Esters - Metabolized by plasma esterases - one metabolite is PABA, which can cause allergic reactions. Patients with "allergy to novacaine" usually do well with amides for this reason. All have only one "i" in their name, eg. Procaine, Tetracaine, Chlorprocaine.

Amides - Metabolized by hepatic enzymes. All have at least two "i"s in their name, eg. Lidocaine, Ropivicaine, Bupivicaine

Opioids

Morphine – depresses breathing principally by impairing the medullary response to CO2. Also trigger the chemoreceptor trigger zone (CTZ) which may lead to nausea, and may in turn stimulate the vomiting center and produce emesis. Also, morphine decreases GI motility and propulsion, produces urinary retention, and releases histamine by stimulating basophils in the lungs and mast cells in the skin. In the CVS, morphine may produce vascular dilation, decrease SVR, and overall hypotension. It is long acting & renally excreted $\rightarrow$ active metabolite has opiate properties, therefore beware in renal failure

Demerol - euphoria, stimulates catecholamine release, so beware in patients using MAOI's, renally active metabolite associated with seizure activity, therefore beware in renal failure

Fentanyl/Alfentanil/Sufentanil/Remifentanil - More potent than morphine, with Sufentanil being the most potent (up to 1,000x as potent). In addition, all are shorter acting than morphine, with Remifentanil being the shortest. Often used to attenuate the stress response to surgical stimulation. Low doses produce brief effect, but larger doses are long acting, increased incidence of chest wall rigidity

vs. other opiates, no active metabolites, usually safe in patients with morphine allergies.

Muscle Relaxants

Depolarizing

Succinylcholine - inhibits the post-junctional receptor and passively diffuses off with increased ICP/IOP, muscle fasciculations and postop muscle aches, triggers MH, increases serum potassium especially in patients with burns, crush injury, spinal cord injury, muscular dystrophy or disuse syndromes. Rapid and short acting.

Nondepolarizing

Many different kinds, all ending in "onium" or "urium". Each has a different metabolism, onset, and duration making choice depend on specific patient and case. Some examples: *Pancuronium* - Slow onset, long duration, tachycardia due to vagolytic effect. *Cisatracurium*- Slow onset, intermediate duration, Hoffman (nonenzymatic) elimination so attractive choice in liver/renal disease. *Rocuronium* - Fastest onset of nondepolarizers making it useful for rapid sequence induction, intermediate duration.

Reversal Agents/ Anticholinergics

Reversal Agents

All are acetylcholinesterase inhibitors, thereby allowing more acetylcholine to be available to overcome the neuromuscular blocker effect at the nicotinic receptor, but also causing muscarinic stimulation.

(Cholinergic Crisis **SLUD CB2**: **S**alivation, **L**acrimation, **U**rination, **D**iarrhea, **C**iliary constriction(miosis), **B**ronchospasm, **B**radycardia.)

Neostigmine - shares duration of action with glycopyrrolate (see below)

Edrophonium - shares duration of action with atropine (see below)

Physostigmine - crosses the BBB, therefore useful for atropine overdose

Anticholinergics

Given with reversal agents to block the muscarinic effects of cholinergic stimulation, also excellent for treating bradycardia and excess secretions

Atropine - used in conjunction with Edrophonium, crosses the BBB causing drowsiness, so maybe bad at end of surgery for reversal, some use as premed for all children since they tend to become bradycardic with intubation and produce copious drool

Glycopyrrolate - used in conjunction with neostigmine, does not cross BBB

Central Anticholinergic Syndrome:
Blind as a bat (Blurred vision)
Red as a beet (Flushing)
Dry as a bone (Anhydrosis)
Fast as a hare (Tachycardia)
Mad as a hatter (Delerium)

Pharm Charts

Inhalational Anesthetics

Inhalation Anesthetics	Major Advantages	Primary Use	Toxicity/concerns
Nitrous Oxide	No odor Fast induction and recovery Minimal cardiopulmonary depression Good analgesic	Minor surgery Used in combination with general anesthetics for general anesthesia	Acute-N/V Chronic-inhibition of B12 metabolism and induction of B12 DEFICIENCY
***H*alothane**	Pleasant odor Slower induction and recovery	Most widely used pedi anesthetic world wide. Asthma patients (no bronchoconstriction)	Slow induction/recovery Sensitizes myocardium to catecholamines→Vent. Arrythmias ***H***epatotoxicity
Enflurane	Pleasant odor Less S.E. than Halothane	Adults	Hypotension Seizures @ high [ ] Nephrotoxicity
Isoflurane	Stable cardiac rhythm Rapid onset/recovery Minimal metabolism→low tox potential Excellent Muscle relaxant	Most widely used anesthetic in adults.	Pungent odor (not great for kids) Broncho-irritant
Desflurane	Rapid onset/recovery High potency (least soluble) Even less metabolism	Ambulatory surgery (for rapid recovery)	Very pungent Irritating to airways LARYNGOSPASM Expensive$$$
Sevoflurane	Fast induction/recovery High potency (least soluble) Nonirritating vapor	Outpatient anesthesia Inhalation Induction (especially children)	
Methoxyflurane			Renal Toxicity

Now Dont Stop Enjoying It, Have More!

Nitrous Oxide Desflurane, Sevoflurane, Enflurane Isoflurane Halothane Methylfurane

FASTEST ← Speed of Onset → SLOWEST

LOWEST ← Potency → HIGHEST

High MAC ← → Low MAC

(104) (6) (2.2) (1.5) (0.8)

MAC

Minimum Alveolar Concentration – defines the amount of anesthetic necessary to achieve no response to surgical stimulus. The numbers listed above are the concentrations necessary to achieve 1 MAC, or no response in 50% of the population. A MAC of 1.3 is 2 standard deviations up, or where 95% don't respond. A MAC of 1.5 is the MAC BAR, where sympathetic outflow is completely blocked. When using multiple agents, MAC's are additive, i.e. ½ MAC of nitrous (52%) + ½ MAC of Sevo (1.1%) is equal to 2.2% sevo alone.

Intravenous Anesthetics

Intravenous Anesthetics	Onset	Elimination	Pharmacokinetics	Advantages/ Use	Disadvantages
Barbituates (H&A) -Thiopental -Methohexital -Thiamylal	30-40 sec	 -10-12 hrs - 3-6 hrs	Redistribution	Rapid onset Fast recovery Anesthesia for short procedures.	No analgesia Alkaline/Tissue Irritant. Resp & CV depression Low TI OD risk
Benzodiazepines (H&A) -Diazepam -Midazolam -Lorazepam	3-5 min	 -20-40 hrs -2-6 hrs	Demethelated in the Liver. (prolonged t1/2 with cirrosis, etc)	Relative rapid onset Minimal resp and CV depression Preanesthetic	Not a good analgesic Can't produce surgical analgesia
Dissociative (H&A) -Ketamine		-2-3 hrs		Intense analgesia and amnesia Radiological procedures in children, Bronchodilator	Dissociative anesthesia (II) unpleasant recovery w/ hallucinations and nightmares
Miscellaneous (H&A) -Etomidate -Propofol	 ≈1 min 40-50 sec	 4-8hrs 3-6hrs	 Large volume of distribution, highly lipophilic	 Prevents N/V, quick recovery	 Hypotension, cv depression, requires mechanical ventilation, discoloration of urine (green)
Opioids **(A)** -Morphine -Fentanyl -Meperidine (Demerol) -Sufentanyl		 2-7 hrs 3-4 hrs 2-4 hrs		Minimal CV effects at normal dosages	Dose related cardiac depression. Meperidine-cardiac depression

IV Fluids

How Much?

Type \ HR	1	2	3	4
Maintenance per hour (4, 2, 1 rule, or kg +40 in anyone over 20 kg)	1	1	1	1
Deficit (Hrs NPO x Maintenance)	1/2	1/4	1/4	-
Insensible Loss (3-15 cc/hr : case dependent)				
Estimated blood loss (1:1 colloid, 3:1 crystalloid)				

Allowable Blood Loss

The allowable loss is calculated by multiplying the blood volume (BV) by the percent from starting hematocrit (HCTs) to threshold hematocrit (HCTt) for transfusion.

ABL = BV x ((HCTs-HCTt)/HCTs)

Blood volume is determined by multiplying the weight by a constant.
Neonates = 90 cc/kg
Infants = 80 cc/kg
Adult men = 60 cc/kg
Adult women = 50 cc/kg

Example

A 50 kg woman comes in after fasting for 12 hours for elective surgery. Her pre-op hematocrit was 35. You decide that in order to transfuse she must have a hematocrit less than 25. Over the course of the surgery she loses 250 cc's of blood each hour for 3 hours. She has only minimal blood loss during the last hour of her 4 hour surgery.

Type \ HR	1	2	3	4
Maintenance per hour (4, 2, 1 rule, OR kg +40 in anyone over 20 kg)	90	90	90	90
Deficit (Hrs NPO x Maintenance) 12 x 90 = 1080	540	270	270	-
Insensible Loss (3-15 cc/hr : case dependent)	8	8	8	8
Estimated blood loss (1:1 colloid, 3:1 crystalloid)	Col – 250 **Crys- 750**	Col – 250 **Crys- 750**	Col – 250 **Crys- 750**	-
Total crystalloid	1388	1110	1110	98

Additionally, she should be transfused as she passed her threshold for transfusion during the third hour. Since that point was close to the end of surgery, transfusion probably could be held off until arrival at PACU since transfusion reaction is not easily noticed while under general anesthesia.

ASA Classification

The purpose of the grading system is simply to assess the degree of a patient's "sickness" or "physical state" prior to selecting the anesthetic or prior to performing surgery. Describing patients' preoperative physical status is used for recordkeeping, for communicating between colleagues, and to create a uniform system for statistical analysis. The grading system is *not* intended for use as a measure to predict operative risk.

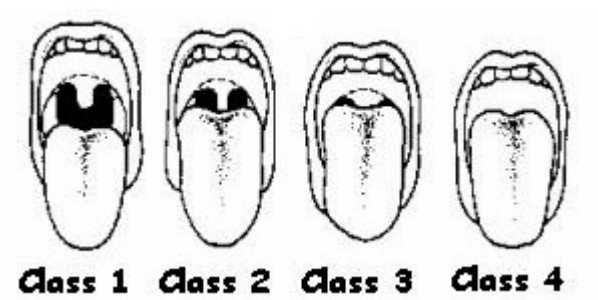
The modern classification system consists of six categories, as described below.

ASA Physical Status (PS) Classification System*		
ASA PS Category	**Preoperative Health Status**	**Comments, Examples**
ASA PS 1	Normal healthy patient	No organic, physiologic, or psychiatric disturbance; excludes the very young and very old; healthy with good exercise tolerance
ASA PS 2	Patients with mild systemic disease	No functional limitations; has a well-controlled disease of one body system; controlled hypertension or diabetes without systemic effects, cigarette smoking without chronic obstructive pulmonary disease (COPD); mild obesity, pregnancy
ASA PS 3	Patients with severe systemic disease	Some functional limitation; has a controlled disease of more than one body system or one major system; no immediate danger of death; controlled congestive heart failure (CHF), stable angina, old heart attack, poorly controlled hypertension, morbid obesity, chronic renal failure; bronchospastic disease with intermittent symptoms

ASA PS 4	Patients with severe systemic disease that is a constant threat to life	Has at least one severe disease that is poorly controlled or at end stage; possible risk of death; unstable angina, symptomatic COPD, symptomatic CHF, hepatorenal failure
ASA PS 5	Moribund patients who are not expected to survive without the operation	Not expected to survive > 24 hours without surgery; imminent risk of death; multiorgan failure, sepsis syndrome with hemodynamic instability, hypothermia, poorly controlled coagulopathy
ASA PS 6	A declared brain-dead patient who organs are being removed for donor purposes	
***ASA PS classifications from the American Society of Anesthesiologists**		

Mallampati Classification

The Mallampati Classification is based on the structures visualized with maximal mouth opening and tongue protrusion in the sitting position (originally described without phonation, but others have suggested minimum Mallampati Classification with or without phonation best correlates with intubation difficulty).



Class I: soft palate, fauces, uvula, pillars

Class II: soft palate, fauces, portion of uvula

Class III: soft palate, base of uvula

Class IV: hard palate only

Quick Reference/Review

- Pre-Anesthesia Evaluation
  - Cardiac Patient – decreased exercise tolerance important sign; if able to climb >2 flights of stairs, cardiac reserve probably intact
    - Post-MI – infarction risk stabilizes at 5-6% after 6 months
      - Perioperative MI mortality 20-50%
      - If no prior MI, perioperative risk 0.13%
      - Occur in 48-72 hrs post-op
      - No elective surgery within 6 months of MI
    - Prior Cardiac Surgery or PTCA is <u>not</u> contraindication to surgery
    - Contraindication to surgery = MI <1 month, uncompensated CHF, severe AS or MS
    - Evaluation
      - Major risk – unstable coronary syndrome
      - Intermediate risk – mild angina, prior MI, CHF, DM
      - Minor risk – age, abnormal EKG, arrhythmia, decreased functional capacity, stroke, uncontrolled HTN
    - Studies – EKG, Holter, stress test, technetium 99m, thallium imaging, coronary angiography
  - COPD
    - Explain obstruction
    - Determine severity and responsiveness to albuterol, get PFT's, CXR if highly symptomatic
    - Increased risk if pre-op PT's <50% predicted
    - Also helpful to determine home O2 requirement, hospitalization history, and which medicines used how often
  - DM
    - Watch for signs and symptoms of myocardial dysfunction, cerebral ischemia, HTN, renal disease
    - Correct hypoglycemia, DKA, and lytes before surgery
    - Maintain glucose between 120-180
    - Reglan + H2 blocker
    - Signs of autonomic neuropathy – impotence, HTN, neurogenic bladder, orthostasis
    - May also develop arthropathy leading to difficult cervical extension. If cannot put palms and fingers flat together, likely to have more difficult airway due to lack of extension.

- Malignant Hyperthermia – skeletal muscle hypermetabolic syndrome
    - Triggering anesthetics – halothane, esflurane, isoflurane, desflurane, sevflurane, succinylcholine
    - Gene – Ca channel of skeletal muscle sarcoplasmic reticulum with decreased reuptake of Ca
    - Symptoms – increased HR, increased breath rate, increased etCO2 (most sensitive), unstable BP, cyanosis, <u>coca-cola colored urine</u>
        - Late signs (6-24 hrs) – increased temperature, muscle swelling, heart failure, DIC, liver failure
    - Confirm diagnosis by large difference between venous CO2 and arterial CO2
    - Labs – Respiratory and metabolic acidosis, hypoxia, hyperkalemia, hypercalcemia, high myoglobin, high CPK, myoglobinuria
    - Incidence – 1:220,000; 1:40,000 with succinylcholine
    - Mortality – 10% overall, 70% without dantrolene
    - Future anesthesia – no pretreatment with dantrolene, flush anesthesia machine
    - TX

        1 - Call for help
        2 - Stop volatile anesthetic
        3 – 100% O2
        4 – Manually hyperventilate
        5 – Switch to a clean breathing circuit
        6 – Stop surgery, maintain on sedative-hypnotic anesthesia
        7 – Dantrolene 2.5mg/kg (mixed with sterile water) q 10 minutes to max dose of 10mg/kg. Maintenance dose at 1mg/kg q 6hrs for 72 hours.
        8 – Correct metabolic acidosis with NaCHO3 1-2mg/kg, Correct high K+
        9 – Cool patient with iced IV NS, and cold fluids in gastric lavage, in peritoneal or thoracic cavity if open, and PR
        10 – Maintain urine output with mannitol or lasix. Do not use CCB'
    - IV Fluids (LR, NS)
    - Maintenance (4+2+1) + NPO time (Maintenance * # hrs) + Evaporative loss (1-8cc/kg/hr)
- Local Anesthetics
    - Esters – **1** "i" in name (i.e. novocaine), metabolized by plasma pseudocholinesterases. One of its metabolites is PABA, which causes allergic reactions (i.e. with Procaine and Tetracaine). CSF has no esterases. Sulfa allergic patients.
    - Amides – **2+** "i"s in name (ie. Lidocaine, Bupivicaine), metabolized by liver enzymes, may cause methemeglobinemia (prilocaine, bupivicaine), allergic reaction rare, some bad hyperactivity reactions
    - Mechanism – decrease permeability to Na ions, binds to Na channel in inactivated state, no threshold potential reached, affects rapid firing nerves first, myelinated >>> unmyelinated

    - Contraindications – hypersensitivity, severe heart block, WPW syndrome
    - Toxicity – often follows predictable pattern of tinnitus, perioral numbness and tingling, sense of doom, seizure, coma.
        - Cardio – decreased phase IV depolarization, increased PR, wide QRS
        - Pulmonary – phrenic/intercostal nerve paralysis
        - CNS – dizziness, circumoral numbness, tinnitus, blurred vision, excitatory signs → CNS depression
        - Muscle – toxic injected IM
        - Lidocaine known to decrease coagulation
- Airway Management
    - LMA – sub for ET tube as long as inflation; may be used as guide for intubation
        - Propofol used for induction – relaxes jaw
        - Keep in place until patient opens mouth on arousal
        - Complications – aspiration, mucosa injury, laryngospasm/coughing
        - Contraindication – risks for gastric aspiration such as GERD, pregnancy, recent meal
- Mendelssohn's Syndrome
    - Aspiration pneumonia secondary to aspiration of gastric contents
    - TX – supportive admission to ICU, continued intubation, respiratory therapy, suctioning, O2, no antibiotics, questionable steroids
        - Antibiotics only used in presence of positive culture. Should not be given prior to this.
    - Pneumonia – delay surgery 8-12 hours, PO antacids, H2 blockers, Reglan, rapid sequence, on suction after intubation, suction of pharynx
    - Risk – anesthesia, muscle relaxants, trauma, full stomach, delayed gastric emptying, pregnancy, obesity, impaired LCS tone
    - Sx – dyspnea, tachypnea, increased HR, wheezing, CXR with lower lobe infiltrates, hypoxia
- Rapid Sequence Intubation – used in anyone at risk for aspiration. Major difference is that there is no bag-mask ventilation following induction, as this could introduce air into the GI track causing vomiting.
    1. Preparation – check **A**llergies, **M**edications, **P**ast med hx, **L**ast meal, **E**vents surrounding incident (**AMPLE**). Also check supplies and monitors.
    2. Preoxygenate – 100% for 3 minutes
    3. Pre-treat – opioids to reduce sympathetic response to intubation, raglan and bicitra to reduce risk of gastric aspiration syndrome
    4. Paralysis and anesthesia – IV induction followed immediately by succinylcholine, often use propofol due to its anti-emetic action
    5. Pass tube – immediately following fasiculations from succinylcholine
    6. Post-tube management – tape tube, opioids, etc, etc.

- Extubation Criteria
    - Tidal volume > 5cc/kg
    - Respirations spontaneous and >8/min
    - NIF of -10 to -15
    - Patient showing purposeful movement
    - Temperature of 35 C or greater
    - Hemodynamic stability
    - PaO2 ≥ 60 on FiO2 40, Pco2 ≤ 55 mmHg
- Laryngospasm
    - Children at especially high risk
    - Try to break first by giving high positive pressure
    - If cannot break, must use succinylcholine to paralyze patient to bag-mask or re-intubate.

<u>Pre-op Room Prep Checklist</u>
Machine – machine checkout, O2 calibration, gas level
Suction
Monitors – A line, central line, Pulse Ox, BP, EKG, BIS
Airway – laryngoscope, oral airway, mask, tube, OG, Temp probe
IV – alcohol, needle, flush on heplock, tape, IVF
Drugs – propofol, etomidate, paralytic, narcotic, versed, phenytoin, atropine, epinephrine, succinylcholine
Special, **S**eat

Labs – type and cross, H&H, coags

Procedure Checklist

The purpose of this section is to provide you with a list of procedures you may be required to perform or assist during the rotation. Due to the fact that these are more easily learned in a "see one, do one, teach one" fashion and that procedures may vary depending on available equipment, details on how to perform are intentionally left blank with ample room for you to take notes. Procedures you are more likely to perform and assist on are listed earlier. If you are looking to do them yourself, it may be helpful to read up on that procedure before hand and take notes here to help jog your memory when the opportunity arises.

Intubation

IV line placement

Bag Mask Ventilation

Ventilator Settings

Arterial Line Placement

Central Line Placement

Spinal

Epidural

Resources

The following are a short list of additional resources that you might find helpful during your anesthesia month in finding more in depth details about anesthesia.

Text

Morgan GE, Mikail MS, Murray MJ. "Clinical Anesthesiology" McGraw Hill Medical. 2005 (~$75)

Glidden RS. "NMS Anesthesiology". Lippincott Williams & Wilkins. 2003. (~$20)

Web

Virtual Anesthesia Text Book http://www.virtual-anesthesia-textbook.com/index.shtml

World Anaesthesia Online http://www.nda.ox.ac.uk/wfsa/index.htm

Notes