A Minimalist Introduction to Anesthesiology

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This document can be freely downloaded from anesthesiamicrotext.homestead.com
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ABBREVIATIONS USED

ASA – American Society of Anesthesiologists
BID – twice daily
BP – blood pressure
CNS – central nervous system
CO – cardiac output
COPD – chronic obstructive pulmonary disease
CO2 – carbon dioxide
CPR – cardiopulmonary resuscitation
CVS – cardiovascular system
ECG- electrocardiogram
EEG – electroencephalogram
EMLA – eutectic mixture of local anesthetics
ETT – endotracheal tube
FIO2 – fraction of inspired oxygen
HR – heart rate
ICP – intracranial pressure
ICU – intensive care unit
IVC – inferior vena cava
kg – kilogram
LA – local anesthetic
MAC – minimum alveolar concentration
mcg - micrograms
mg – milligrams
ml – milliliter (1 ml = 1 cc = 1/1000 liter)
N2O – nitrous oxide
NPO – nothing by mouth ("nil per os")
OR – operating room
PA – pulmonary artery
PCA – patient controlled analgesia
PCO2 - carbon dioxide partial pressure
PEEP – positive end-expiratory pressure
PRN – as needed
SVC - superior vena cava
TEE – transesophageal echocardiogram
VT/VF – ventricular tachycardia / ventricular fibrillation

ASA Physical Status Classification

Class 1. A healthy patient.
Class 2. A patient with mild systemic disease.
Class 3. A patient with severe systemic disease that limits activity but is not incapacitating.
Class 4. A patient with an incapacitating systemic disease that is a constant threat to life.
Class 5. A moribund patient not expected to survive 24 hours with or without operation.
Class 6. Brain dead patient for organ harvesting

Note: An "E" is assigned if the surgery is done under emergent conditions. For example, an emergency cholecystectomy on an otherwise healthy patient would be Class 1E. If the patient were hypertensive, he would be assigned a 2E classification.

DISCLAIMER – These notes are very abbreviated and by their nature are incomplete. Consult standard references (e.g., Miller's Anesthesia, 6th Ed) for complete information, especially for drug doses. These notes have not yet been peer-reviewed.

Kinds of Anesthesia

Surgery can be carried out using a variety of anesthetic methods:

General Anesthesia

- using inhaled agents (e.g., isoflurane, desflurane)
- using intravenous agents (e.g., propofol, thiopental)
- combinations of inhaled and intravenous agents

Regional Anesthesia

- using epidurally administered drugs (epidural)
- using spinally administered drugs (intrathecal)
- using nerve plexus blocks (e.g. brachial plexus block)
- blocking individual nerves (e.g. femoral nerve block)

Local Anesthesia

- by needle infiltration of local anesthetic agents
- application of local anesthesia to mucous membranes (topical)
- application of EMLA cream to regular skin

Regional Anesthesia involves the selective application of local anesthetics such as lidocaine, bupivacaine or ropivacaine to appropriate neural structures. It offers many potential advantages over general anesthesia: good postoperative analgesia, blunting of surgically induced endocrine and metabolic changes, fewer cardiovascular alterations, and (sometimes) reduced intraoperative blood loss. On the down side, however, regional anesthesia has a higher failure rate compared to general anesthesia, and few patients enjoy having needles inserted into them.

FIGURE 1. Patient receiving an epidural in preparation for childbirth. In obstetrics, the epidural needle is frequently inserted between the L3 and L4 lumbar vertebrae. Thoracic epidurals are commonly used for thoracic and upper abdominal surgery (e.g. with a catheter placed near the T8 level).

General Anesthesia usually aims to achieve six distinct conditions despite powerful noxious stimuli:

- Loss of consciousness ("hypnosis")
- Analgesia - loss of pain
- Amnesia - loss of memory
- Motionlessness – may involve muscle relaxation
- Obtundation / attenuation of autonomic reflexes (tachycardia, hypertension, gag reflex, etc.).
- Homeostasis (otherwise normal physiological state)

Minimum Alveolar Concentration (MAC)

(MAC=alveolar concentration needed to prevent movement in 50% of patients getting a surgical cut). Use 1.3 MAC or more to ensure better patient protection against movement from painful stimuli.

Halothane	0.8 %
Isoflurane	1.3 %
Sevoflurane	2.3 %
Desflurane	7 %
Nitrous oxide	105 %

ANESTHESIA MACHINE CHECK

(HIGHLIGHTS ONLY – SEE FULL CHECKLIST)

Oxygen Line Pressure	Oxygen Flowmeter
Nitrous Line Pressure	Nitrous Flowmeter
Oxygen Tank Check	Check for Leaks
Vaporizer Check	Check Ventilator

AIRWAY & EMERGENCY STUFF

Suction	Resuscitator Bag
Oxygen	Defibrillator
Laryngoscope	Crash Cart
Endotracheal Tube (ETT)	Emergency Drugs
Stylette (in ETT)	Fire Extinguisher

Mnemonic - "SOLES"

COMMON ANESTHETIC DRUGS

DRUG	USUAL CONC	USE	DOSE / kg
Thiopental	25 mg/ml	Induction	3 – 5 mg
Propofol	10 mg/ml	Induction	1.5 – 3 mg
Fentanyl	50 mcg/ml	Analgesia	2-5 mcg
Morphine	varies	Analgesia	20-60 mcg
Midazolam	1 mg/ml	Hypnosis	20 mcg
Succinylcholine	20 mg/ml	Intubation	1 – 2 mg
Rocuronium	10 mg/ml	Musc Relax	0.5 – 1 mg
Dolacetron	25 mg/ml	Antiemetic	0.2– 0.4 mg

TABLE 1: Intravenous drugs frequently used in general anesthesia (adults). Note that some drugs are often given by infusion, such as propofol 50-150 mcg/kg/min or remifentanil (0.1 – 0.2 mcg/kg/min), often with 70% N20 used in addition.

MAXIMUM DOSES OF SOME LOCAL ANESTHETICS

AMIDES		ESTERS	
Lidocaine with epi	7mg/kg	Cocaine (topical)	3mg/kg
Lidocaine plain	5mg/kg	Procaine	14mg/kg
Bupivacaine with epi	3mg/kg	Chloroprocaine	14mg/kg
Bupivacaine plain	2mg/kg		
Mepivacaine	7mg/kg		
Ropivacaine	3mg/kg		

Table 2

LOCAL ANESTHETIC (LA) TOXICITY

CNS toxicity

a) Excitation Phase: tinnitus, confusion, restlessness, perioral numbness or tingling, metallic taste, lightheadedness, sense of dread and impending doom.
b) Convulsive Phase: grand-mal clonic-tonic seizure
c) Depression Phase: CNS depression with drowsiness and unconsciousness.
d) Respiratory depression and apnea.

CVS Toxicity

a) Excitation Phase:
(i) hypertension, tachycardia (with convulsions)
b) Depression Phase:
(i) Negative inotropic effect with decreased blood pressure, cardiac output and stroke volume.
(ii) Peripheral vasodilation with further hypotension.
c) Cardiovascular Collapse

BE SURE TO CALL FOR HELP!

MANAGEMENT OF LA TOXICITY

(a) Prevention (e.g. pretreatment with benzodiazepines [when appropriate], aspirate before injection)
(b) Early recognition (converse with patient)
(c) Prevent progression (e.g., thiopental 50-75mg IV or diazepam 5-10 mg IV)
(d) Airway management (may need succinylcholine, cricoid pressure and ETT). Must provide oxygen and ensure ventilation.
(e) Remember the fetus in the pregnant patient. (Fetal monitoring. Stat Cesarean section if CPR needed.)

Sample Emergency Drugs

Atropine 1 ml syringe	0.6 mg /ml	Raise heart rate (HR)
Ephedrine 10 ml syringe	5 mg /ml	Raise BP (and HR)
Phenylephrine 20 ml syringe	50 mcg / ml	Raise BP
Nitroglycerine 10 ml syringe	0.2 mg / ml	Lower BP / treat heart ischemia
Esmolol 10 ml syringe	10 mg /ml	Lower HR (and BP)

PHARMACOKINETICS AND PHARMACODYNAMICS

All drugs undergo distribution and elimination following their administration (pharmacokinetics - "What the body does to the drug"). Related to this is the field of pharmacodynamics ("What the drug does to the body") a science often based on understanding how drug molecules bind to (occupy) receptors at various sites in the body.

Ventilators are used in operating rooms and intensive care units (ICU) for respiratory support of patients who cannot breathe on their own. ICU ventilators are more complicated and more flexible than OR ventilators. There are 5 main ventilator parameters.

- Tidal Volume (e.g. 700 ml) [Volume of gas injected into trachea with each breath]
- Respiratory Rate (e.g. 12 breaths / minute)
- FiO2 (Fraction of Inspired Oxygen) (e.g. 60% oxygen)
- PEEP (Positive End Expiratory Pressure) (e.g. 5 cm H2O)
- I:E ratio (e.g. 1:3) Time for inspiration in relation to time for expiration

When ventilating a patient, aim for an arterial PCO2 around 35 - 40 mmHg in normal cases, and 28-32 mmHg in patients with increased ICP. Ensure that all ventilation-related alarms (apnea, high airway pressure, etc.) are enabled.

Perioperative Fluid management

Ensure adequate hematocrit, coagulation, intravascular volume and urine output by giving adequate IV fluids and blood products. For most cases run an IV of normal saline (NS) or Ringer's (RL) at 250 ml/hr to start, then adjust to meet the following goals:
[1] In first two hours of case, replace any preoperative fluid deficit (e.g. NPO for 8 hours x 125 ml maintenance fluid needed per hour kept NPO = 1000 ml to give in first 2 hrs)
[2] Meanwhile, for entirety of case replace "third space" surgical losses at 2 - 10 ml/kg/hr (e.g., 2 for carpal tunnel repair, 5 for laparoscopic cholecystectomy, 10 for bowel surgery.)
[3] Maintain urine output over 50 ml / hr or 0.5 to 1.0 ml/kg/hr
[4] Replace blood loses 4-to-1 with crystalloid (e.g., RL or NS) or 1-to-1 with colloid (e.g., hespan, hextend, albumin 5%, FFP)
[5] Maintain hematocrit in safe range (above 0.24 in everyone; at or above 0.3 in selected patients at risk – e.g. patients with coronary artery disease) by transfusing packed cells as needed.
[6] Monitor indices of coagulation (PT, PTT, INR, ACT, platelets).

Perioperative Oxygen Delivery

Oxygen may be given by one of five routes: face mask (of which there are a variety of types), nasal prongs, endotracheal tube, oxygen tent, and transtracheal catheter. The last two methods are used only occasionally. For more information visit http://www.lhsc.on.ca/resptherapy /rtequip/oxygen/index.htm (source of images below)

SIMPLE FACE MASK

NASAL PRONGS

Patient Monitors

- Noninvasive Blood Pressure (manual or automatic)
- Electrocardiogram (ECG)
- Pulse Oximeter
- Airway Gas Monitor (CO2 = capnography, N2O, agents)
- Airway Pressure Monitor
- Airway Gas Flows (Spirometry)
- Airway Disconnect Alarm
- Nerve Stimulator
- Urometer (urine output)
- Body Temperature
- Special Cardiac Monitors (CVP, PA line, CO, TEE)
- Special Neurological Monitors (ICP, EEG, evoked potentials)

In addition: visually monitor breathing pattern, signs of distress, patient color, etc.

Pulse Oximetry

Pulse oximetry is a simple non-invasive method of monitoring arterial oxygen saturation, the percentage of hemoglobin (Hb) with oxygen molecules attached. The pulse oximeter consists of a probe attached to the patient's finger, toe or ear lobe which is in turn attached to the main unit. In some units an audible tone occurs with each heart beat and changes pitch with the saturation reading. A pulse oximeter detects hypoxia well before the patient becomes clinically cyanosed and is required in ALL patients undergoing anesthesia. Note that pulse oximeters give no information about the level of arterial CO2 and are therefore useless in assessing the CO2 in patients at risk of developing hypercarbic respiratory failure. Units are now available for well under $1000.

Bag and Mask Ventilation

Bag and mask ventilation is an important clinical skill to master. In most resuscitation settings a self-reinflating bag with nonrebreathing valves (such as that shown below) is used to provide positive pressure ventilation, usually using 100% oxygen. This bag fills spontaneously after being squeezed and can be used even when oxygen is unavailable. Ventilation is often made much easier when the "jaw thrust maneuver" is carried out. Oropharyngeal or nasopharyngeal airways can also be helpful. During prolonged bag and mask ventilation, a nasogastric tube may be used to vent air forced into the stomach.

Oropharyngeal Airways **Nasopharyngeal Airway**

Difficult mask ventilation is said to occur when "it is not possible for the unassisted anesthesiologist to maintain the oxygen saturation above 90 percent using 100 percent oxygen and positive pressure mask ventilation in a patient whose oxygen saturation was above 90 percent before anesthetic intervention" or when "it is not possible for the unassisted anesthesiologist to prevent or reverse signs of inadequate ventilation during positive pressure mask ventilation" (ASA definitions).

TABLE 3 - Predictors of Difficult Mask Ventilation

- Age over 55 years
- Body mass index exceeding 26 kg/m^2
- Presence of a beard
- Lack of teeth (edentulous)
- History of snoring

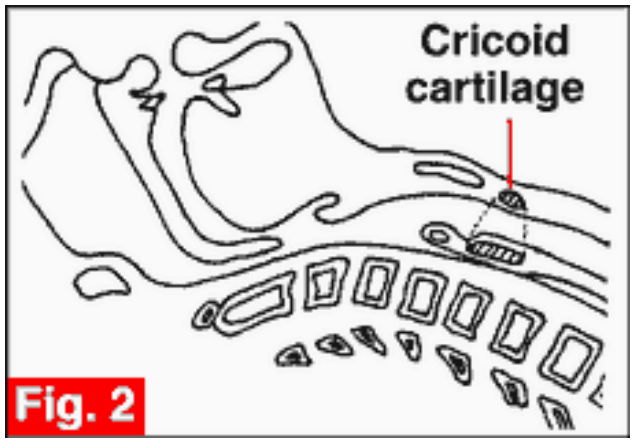
Source: Anesthesiology 2000; 92: 1229
AVAILABLE FREE ONLINE AT **www.anesthesiology.org**

TABLE 4 - Factors Leading to Increased Risk of Pulmonary Aspiration with General Anesthesia

- Recent food or fluid ingestion
- Severe obesity
- Symptoms of gastroesophageal reflux
- Advanced pregnancy
- Severe ascites
- Opioid administration or other condition resulting in delayed gastric emptying (but OK to give for premedication)
- History of gastroparesis or other motility disorder
- Bowel ileus or bowel obstruction

TABLE 5 - Steps in a Rapid Sequence Induction

- Performed in patients at risk of regurgitation / aspiration
- Ensure that drugs, equipment and assistants are ready and that all patient monitors are operational.
- Remember that a rapid sequence induction is inappropriate in patients suspected to be difficult to intubate - awake intubation is preferable.
- Generously preoxygenate the patient.
- Give induction (e.g. thiopental / succinylcholine) in predetermined dose (do not titrate to clinical effect). At the same time have your assistant apply cricoid pressure to compress the esophagus (44 Newtons force, 10 lbs) [This is known as the "Sellick maneuver"]. See Figure 2, below.
- Do not ventilate while waiting for the drugs to work. (Note: many authorities advocate gentle mask positive pressure ventilation to reduce the chance of hypoxemia.)
- Intubate when conditions are correct; inflate ETT cuff.
- Ensure ETT is in correct position (clinically, capnograph).
- Have assistant relieve cricoid pressure.
- Continue with the remainder of the anesthetic.



Source: http://www.nda.ox.ac.uk/wfsa/html/u02/u02_b03.htm

MUSCLE RELAXANTS Muscle relaxants are not anesthetics, they simply paralyze skeletal muscle (not cardiac muscle, for obvious reasons!) Relaxants should only be used with the patient asleep (general anesthesia) since it would be horrible to be awake and unable to move even your eyelids. Of course, all patients receiving relaxants must be ventilated, and should have their degree of relaxation monitored with a "blockade monitor". Nondepolarizing muscle relaxants work by competing with acetylcholine at the myoneural junction - "COMPETITIVE INHIBITION". Most muscle relaxants are of the "nondepolarizing" type and can be reversed; the exception is succinylcholine, which is a depolarizing muscle relaxant.

Reversal of nondepolarizing muscle relaxants is commonly done in adults using neostigmine 3-5 mg IV with glycopyrrolate 0.6 – 1.0 mg IV (Neostigmine inhibits the hydrolysis (breakdown) of acetylcholine by competing with acetylcholine for attachment to acetylcholinesterase at sites of cholinergic transmission.; the glycopyrrolate prevents the neostigmine from slowing down the heart rate to dangerous levels). Atropine 1.2 mg can be given instead of glycopyrrolate.

Doses of Some Popular Intermediate Duration Relaxants (40-50min)

- vecuronium 0.1-0.2 mg/kg
- atracurium 0.5-0.6 mg/kg
- cisatracurium 0.15-0.2 mg/kg
- rocuronium 0.5-1.0 mg/kg

SUCCINYLCHOLINE Succinylcholine is the only depolarizing muscle relaxant in clinical use. The usual dose for intubation is 1-2 mg/kg. It is cheap, fast acting and usually wears off quickly (5 minutes or so). It is still in common use for intubation (especially for rapid sequence inductions) or as an infusion for short procedures (e.g. laparoscopy). However, succinylcholine suffers from important limitations that have led many clinicians to abandon its use completely. First, the action of succinylcholine cannot be reversed; one must wait for its breakdown by plasma cholinesterase. Second, it triggers malignant hyperthermia in susceptible individuals. Third, it can produce a deadly hyperkalemic response in susceptible individuals, typically patients with burns, massive trauma, stroke, prolonged immobilization or spinal cord injury. (A common factor here may be either massive tissue destruction or CNS injury with muscle wasting.)

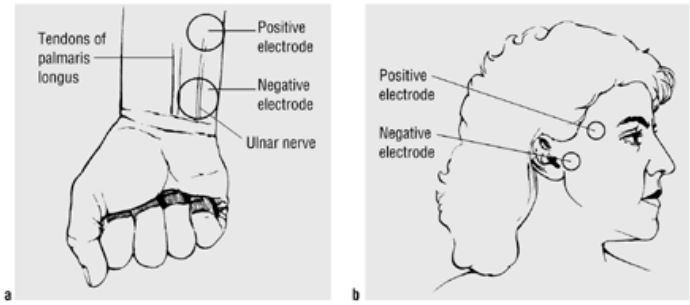
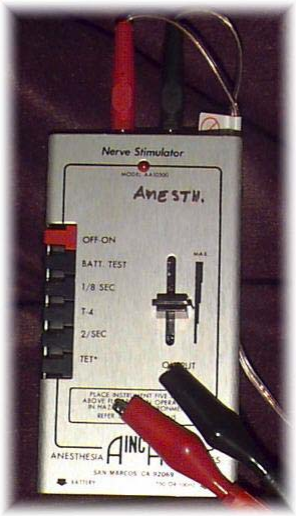


Figure 3. Neuromuscular blockade monitoring usually involves electrode placement at the ulnar nerve (left) or the facial nerve (right), with use of a high-voltage nerve stimulator (below). (http://www.postgradmed.com/issues/2002/02_02/blanchard1.gif)



Did you know ...

Curare was the first muscle relaxant used clinically. Known scientifically as Chondrodendron tomentosum, it is a South American vine native to the Amazon Basin. The main alkaloid responsible for the muscle relaxant actions (and why it works as an arrow poison) is d-tubocurarine. It was first isolated in 1897 and obtained in drug form in 1935. The first clinical use was in Montreal, Canada in 1942, by Dr. Harold Griffith.

Food for thought "General anesthesia is neither general nor is it anesthesia (the absence of sensation). Under general anesthesia, the nervous system continues to be bombarded by nociceptive input. Although central transmission may be diminished, the body is not rendered senseless. Nociceptive afferent stimuli reach the spinal cord and higher centers, and the nervous system responds - with reflex movement, autonomic response, and neurohumoral response, and by establishing a hyperexcitable state ("wind-up"). This is not anesthesia, the lack of feeling, because the nervous system is responding to pain. There is nothing general about it; it is rather limited. So what is "general anesthesia" if it is not the insensibility to pain? The truth is that we do not know exactly what we mean when we speak of general anesthesia. It is ambiguous. We have a much better idea what general anesthesia is not." Bruce Ben-David et al. A trap of our own making. Anesthesia and Analgesia. 82:1083, April 1995.

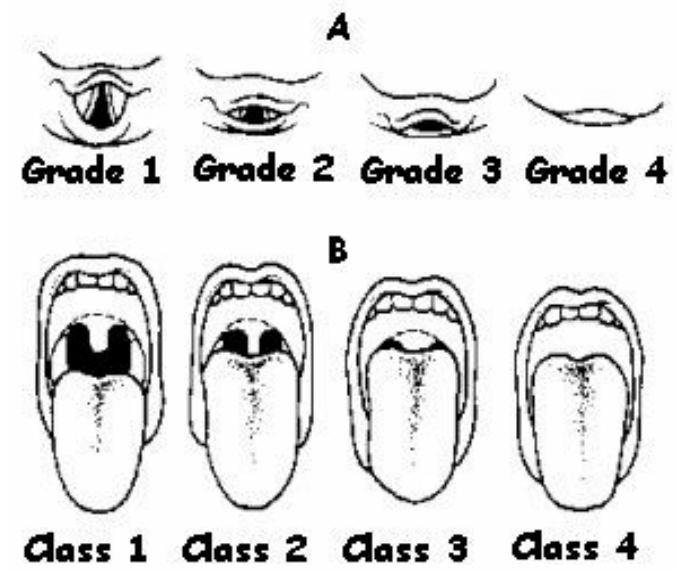


FIGURE 1 – Two Important Airway Classifications
[Source: www.pdh-odp.co.uk/ intubation_grades.htm]

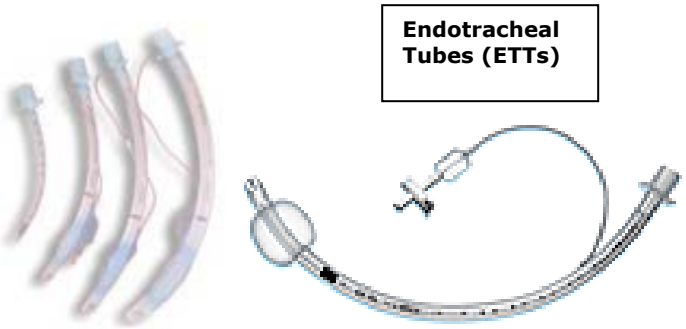
A Cormack and Lehane classification of the view at laryngoscopy. *(Cormack RS, Lehane J: Difficult tracheal intubation in obstetrics. Anaesthesia 39:1105, 1984)*

Grade I: most of the glottis is seen
Grade II: only posterior portion of glottis can be seen
Grade III: only epiglottis seen (none of glottis seen)
Grade IV: neither epiglottis nor glottis can be seen

B Mallampati classification of the oropharyngeal view. *(Mallampati SR, Gatti SP, Gugino LD: A clinical sign to predict difficult intubation: a prospective study. Can Anaesth Soc J 32:429-434, 1985)* Do with patient sitting, the head in the neutral position, the mouth wide open, and the tongue protruding to the maximum. The patient should not be phonating. The Mallampati classification is then assigned based upon the visible pharyngeal structures.

Class I: visualization of the soft palate, fauces, uvula, anterior and posterior pillars.
Class II: visualization of the soft palate, fauces and uvula.
Class III: visualization of the soft palate and base of uvula.
Class IV: soft palate is not visible.

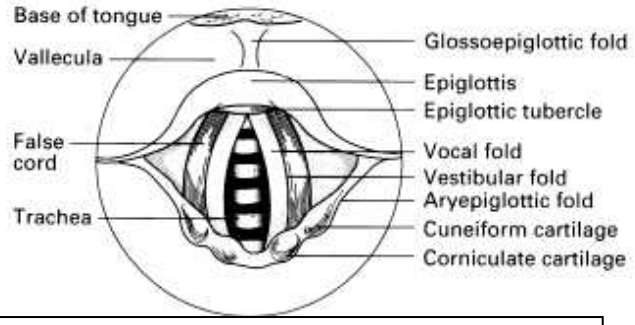
Endotracheal Tubes (ETTs)



Some Forms of Initial Empirical Treatment

1.	Dx:	Symptomatic bradycardia
	Rx:	IV atropine 0.6 - 1 mg
2.	Dx:	Sustained apnea
	Rx:	Positive pressure ventilation
3.	Dx:	Pulseless ventriculat tachycardia (VT)
	Rx:	CPR; cardioversion; drugs
4.	Dx:	Severe hypoxemia
	Rx:	100% oxygen

View of the larynx at laryngoscopy (below)



http://www.4um.com/tutorial/anaesth/rsi.htm

View of Glottis at Laryngoscopy
http://www.uniklinikum-giessen.de/anaesthesie/jpg/glottis.jpg

THE "CLINICAL CRISIS PROTOCOL" is an approach to dealing with urgent problems when a patient's life is in danger and there is limited time to act. Thus, diagnosis of the problem must be accompanied by initial empirical treatment, i.e. diagnosis and treatment must be carried out concurrently, even when it's far from clear what is going on. For example, severe bradycardia (heart rate < 40) may or may not be associated with symptoms such as syncope and can be due to many different causes, (e.g. third degree heart block, beta blocker overdose, use of an anti-cholinesterase without sufficient anticholinergic (e.g. neostigmine without glycopyrrolate or atropine), increased ICP, etc.

An approach to rapidly assess the patient the trouble is needed.
LOOK: Color (cyanosis, erythema, pallor), respirations (rate, pattern), diaphoresis, bleeding/dressings/drains, neck (jugular venous distenstion, tracheal deviation), restlessness, discomfort …
LISTEN: breath sounds (?equal), wheezes, crackles, stridor, heart sounds, patient's complaints, observations of bystanders…
FEEL: pulse (rate, intensity, pattern), grip strength (esp. after muscle relaxants given), forehead (temperature, diaphoresis)
GET: help, vital signs, old chart, crash cart, labs, chest x-ray...

Again, we emphasize that initial empirical treatment is essential while we are finding out what is going on. For example, in the case of symptomatic severe bradycardia, intravenous atropine (0.6 - 1 mg) should be given (among other things).

Urgent Clinical Problems Requiring Immediate Intervention
1. Ventricular tachycardia / ventricular fibrillation
2. Cyanosis / hypoxemia in recovery room
3. Grand-mal seizures / unresponsive patient / coma
4. Severe bradycardia or other rhythm disturbance
5. Stridor (noisy inspiration from partial upper airway obstruction)
6. Loss of pulse in an extremity (esp. following vascular surgery)
7. Severe hypotension or hypertension
8. Myocardial ischemia (with or without angina or ECG changes)

Capnography is the continuous analysis and recording of carbon dioxide CO2 concentrations in respiratory gases. A capnograph uses one of two types of analyzers: mainstream or sidestream. Mainstream units insert a sampling window into the breathing circuit for gas measurement while sidestream units aspirate gas from the circuit and the analysis occurs away from the circuit. Capnographs may utilize infrared techniques (most common), mass spectroscopy, Raman scattering, or photoacoustic technology. Capnography is especially useful to monitor for a number of important clinical situations:

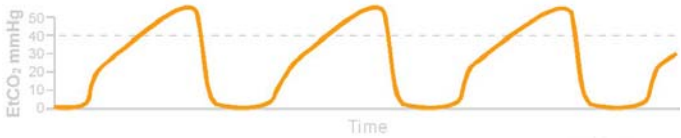
- Verification of endotracheal intubation (a normal capnogram is not obtained when the endotracheal tube ends up in the esophagus.)
- Monitoring CO2 elimination during cardiac arrest and CPR (the capnogram "improves" as pulmonary blood flow improves with adequate circulation).
- Detecting hypoventilation and hyperventilation
- Detecting rebreathing of CO2 (in which case the inspiratory CO2 level is nonzero).
- COPD patients (abnormal phase III capnogram)
- Inadequate seal of the endotracheal tube

Note: A **sudden severe decrease in end-tidal CO2** is often due to a potentially catastrophic cardiorespiratory event: Circulatory arrest. Pulmonary embolus. Hypotension from severe blood loss. Compression of the IVC or SVC.

Additional information at **http://www.capnography.com**

Normal Capnogram

Abnormal capnogram in a patient with severe COPD



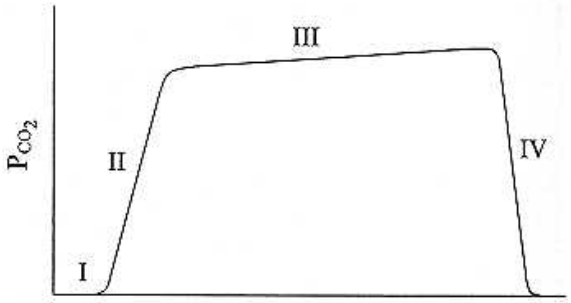
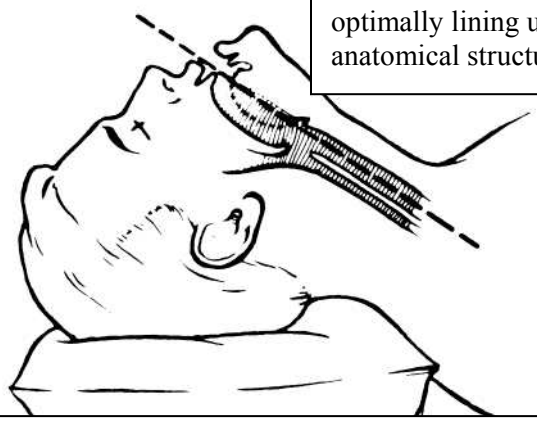


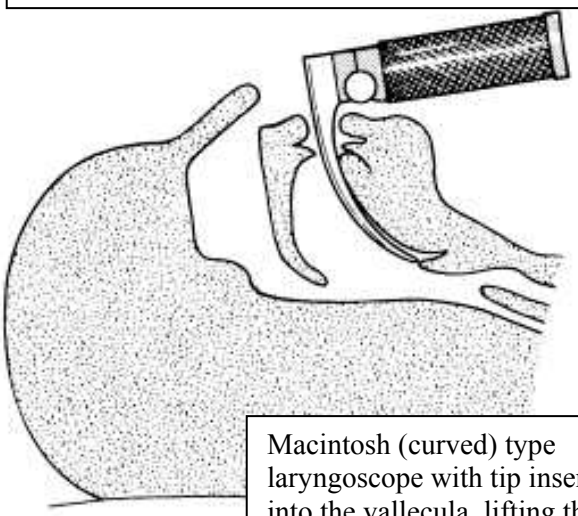
Fig. 3. A normal capnogram, with the labeled segments corresponding to the different phases of the respiratory cycle.

The capnogram has 4 segments that correspond to phases of the respiratory cycle. The first phase is a flat part, due to exhalation of dead space. The second is the ascending segment, from exhalation of mixed dead space and alveolar air. The third is the plateau portion that represents exhaled CO2 from the alveoli. The fourth phase represents the beginning of inspiration.
www.rcjournal.com/contents/10.99/ 10991207fig3.jpg

The "**sniffing position**" facilitates intubation by optimally lining up the anatomical structures.

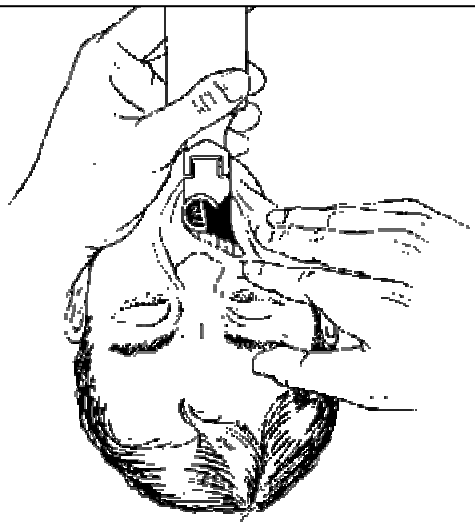


http://www.4um.com/tutorial/anaesth/rsi.htm



Macintosh (curved) type laryngoscope with tip inserted into the vallecula, lifting the epiglottis out of the way

Top – side view of intubation. **Bottom** – view of intubation from the perspective of the intubator. *Notice that the laryngoscope is held with the left hand, while the endotracheal tube is passed using the right hand.*



http://www.childrensmemorial.org/depts/anesthesia/images/intro2.jpg
Young patient receiving an "inhalation induction" (mask induction) for general anesthesia. An alternate method would be to give intravenous medications (IV induction), but many children are reluctant to receive needles. Many centers allow parents to be present at the induction of anesthesia; many others do not.

http://www.datex-ohmeda.com/products/anelifesupport_aestiva_B.htm
A typical modern anesthesia machine with patient monitoring accessories.

http://www.datex-ohmeda.com/products/monitoring_cam_B.htm
Typical compact patient monitor with ability to display a large variety of clinical parameters, such as heart rate (green), oxygen saturation (yellow), blood pressure (red) and airway gas parameters (white). The three waveforms shown are ECG (top), pulse oximeter plethysmograph waveform (middle) and capnogram (bottom). Waveforms and numbers are configurable as to position and color according to clinician preference and clinical circumstances.

Did you know … The word *anesthesia* is unusual because we know exactly when the term was formulated. Following a public demonstration of general anesthesia using ether by Dr. Morton at Massachusetts General Hospital, on October 16, 1846, Dr. Oliver Wendell Holmes was asked by him to name this valuable new process. Holmes (1809-1894) was a Boston doctor, an anatomist and an important poet. (Of interest, his son, Oliver Wendell Holmes, Jr., became be one of America's most important Supreme Court justices.).

BELOW: Morton delivering anesthesia via a special glass "inhaler" containing an ether-soaked sponge.

COURTESY OF THE NATIONAL LIBRARY OF MEDICINE

American Pain Society Guidelines

Mild pain - use non-prescription analgesics (note 1)

Moderate pain - use non-narcotic analgesics (eg. Ketorolac (Torodol) and other NSAIDS) (note 2)

Moderately severe pain - use non-narcotic analgesics with codeine or other weak opioid (note 3)

Severe pain - use non-narcotic analgesics with morphine or other strong opioid (note 4)

NOTE 1 NSAID = NonSteroidal AntiInflammatory Drug. NSAIDS and actominophen are popular non-narcotic analgesics; many are available without prescription and work well for mild to moderate pain.

NOTE 2 Ketorolac is an NSAID available in both oral and parenteral forms (eg. 10 mg po Q8h or 30 mg IM q8h [for limited periods only; be especially cautious in the frail and elderly]). In patients that are NPO, indomethacin 100 mg BID may be administered rectally alone or as an adjunct to opiates in patients meeting suitability criteria (see note 5 below).

NOTE 3 A sample script: Tylenol # 3 1 to 2 tabs q3h prn (Tylenol #3 tablet contains acetaminophen 325 mg with codeine 30 mg)

NOTE 4 Patient controlled analgesia (PCA) is often used for this purpose.

NOTE 5 REMEMBER: Many patients are potentially unsuitable for routine NSAID administration. These include the elderly, patients with a bleeding diathesis, patients with impaired renal performance and patients at increased risk of gastroduodenal ulcers.

Visit the American Pain Society at www.ampainsoc.org

More on Drugs and General Anesthesia

General anesthesia is generally achieved using either inhaled agents or intravenous agents (with the occasional use of intramuscular drugs). Inhaled drugs include nitrous oxide (too weak to use on its own) and potent volatile agents such as halothane, enflurane, isoflurane, sevoflurane, desflurane, and even old-fashioned ether (still used in the third world). *Inhaled agents* are used primarily for maintenance of anesthesia, although they can also be used to induce general anesthesia ("inhalation induction"). Intravenous agents are used primarily for the induction of anesthesia but in some cases (e.g., propofol) can be given by infusion for the maintenance of unconsciousness (for example, for airway procedures such as rigid bronchoscopy or tracheal reconstruction). *Intravenous agents* include thiopental, propofol, ketamine, benzodiazepines such as diazepam and midazolam and narcotic (opiate) analgesics such as fentanyl, sufentanil, remifentanil, alfentanil, morphine and meperidine (Demerol).

Some forms of regional and peripheral nerve anesthesia

- Single-shot spinal anesthesia
- Continuous spinal anesthesia (no longer in common use)
- Caudal anesthesia
- Single-shot epidural anesthesia (no longer in common use)
- Continuous epidural anesthesia
- Combined spinal / epidural techniques
- Brachial plexus anesthesia (several forms)
- Bier block (forearm)
- Intercostal nerve blocks
- Lower extremity blocks

PRACTICAL POINTS IN USING LOCAL ANESTHETICS

1. Added epinephrine (e.g., 1:200,000 to 1:100,000) can be particularly helpful both to increase the duration of local anesthetic effect and to reduce bleeding. For example, epinephrine added to lidocaine used in the repair of a scalp wound can help reduce blood loss in this highly vascular area. There is, however, a downside to using epinephrine. First, when absorbed systematically it can cause hypertension, tachycardia and even arrhythmias, and this is obviously a potential concern in hypertensive patients or patients with coronary artery disease. Secondly, using epinephrine may disguise bleeding sites that later become apparent once the epinephrine wears off and the patient has left the emergency room (e.g., scalp lacerations). Finally, epinephrine should not be used on digits, toes or on the penis because of concerns that ischemia may occur from the resulting vasoconstriction.

2. When using local anesthesia in large amounts, always ensure that the patient has an intravenous line in place in case of local anesthetic toxicity. Drugs to treat convulsions should be readily available (e.g., IV thiopental, midazolam or diazepam) as well as equipment and drugs for airway management.

3. Know the relationship between drug concentration in percent and concentration in mg/ml. Remember that a 1% solution has a concentration of 10 mg/ml. In a 70 kg person, for example, the maximum dose of lidocaine without epinephrine is 5 mg/kg = 350 mg = 35 ml of 1% lidocaine.

4. Poor anesthesia is frequently obtained when local anesthetics are injected into infected or inflamed areas (e.g., abscessed tooth). This has to do with the fact that although a normal tissue is around 7.4, it may drop to 5 or 6 with inflammation, rendering most of the anesthetic in the ionized form (which crosses cell membranes poorly), thereby reducing its effectiveness.

Did you know … nitrous oxide, N2O, is a colorless, odorless gas that was discovered in 1793 by the English scientist Joseph Priestley. It is sometimes known as "laughing gas" for its "disinhibiting" effects. It is often used clinically because of its analgesic effects.

FACTORS INFLUENCING LOCAL ANESTHETIC BLOOD LEVELS

(i) **Drug dose:** Obviously, blood levels are proportional to the amount given. Increasing the dose also increases the extent of the block and increases the risk of local anesthetic toxicity.
(ii) **Drug type:** Some drugs such as prilocaine are so rapidly metabolized (by plasma cholinesterase in this instance) that high blood levels are harder to achieve.
(iii) **Pattern of absorption** (Pharmacokinetics): Drugs injected intravascularly achieve a high peak level shortly after injection, while those injected into a peripheral compartment (e.g. infiltration into tissues) take a longer time to achieve a peak level.
(iv) **Site of administration:** Administration of local anesthetics in highly vascular areas increases the likelihood of encountering high drug levels.

The Geriatric Patient Geriatric patients have decreased reserve in all systems and are thus less forgiving of errors in clinical decision making. Many have lung disease, coronary artery disease, hypertension and may be on numerous medications. Decreases in muscle mass, renal function and hepatic function influence drug distribution and metabolism. Many geriatric patients are edentulous and it may thus be difficult to get a good seal when using a face mask in these patients. Increases in lung closing capacity with age leads to increases in alveolar-arterial oxygen tension difference and a need for higher inspired oxygen levels to maintain adequate oxygenation. Disorientation and confusion often follows general anesthesia in the elderly. Finally, spinal calcifications may make spinal or epidural methods difficult.

Trauma Patients Trauma patients often require immediate anesthesia and surgery with resuscitation, and assessment often occurring concurrently out of necessity. Practitioners of trauma anesthesia and surgery should be familiar with the Advanced Trauma Life Support (ATLS) protocol (see www.trauma.org). Here are some of the key issues:

- Limited time for patient assessment (e.g. allergies, medications)
- Patients have a "full stomach"
- May be hypovolemic from blood loss
- May have pulmonary and/or cardiac injuries from blunt or penetrating chest trauma
- Trauma to the face or airway may make intubation difficult
- May have closed head injuring resulting in increased ICP or C-spine injury, putting the brain and spinal cord at risk
- Patients are frequently combative and uncooperative, particularly if intoxicated from alcohol or street drugs
- Patients should be placed in a cervical collar (Philadelphia collar) if a C-spine injury is suspected clinically or radiologically.

Patients with Coronary Artery Disease may require anesthesia for bypass surgery or for noncardiac operations. Preoperatively these patients should be assessed to ensure that they are "optimized" with nitrates, beta blockers and/or calcium channel blockers. Ventricular performance can be determined clinically (signs/symptoms of CHF, exercise tolerance) and by specialized testing (e.g. echocardiography). Persantine-thallium testing (or related tests) will help identify myocardium at risk of infarction (reversible defects) or myocardium that is already scarred from infarction (fixed defects). The electrocardiogram may demonstrate previous infarction, ongoing ischemia, rhythm disturbances and more. Tachycardia is especially bad in these patients as it increases myocardial oxygen demand and reduces diastolic time (during which myocardial blood flow occurs). Many of these patients will need arterial lines (even for noncardiac surgery) so that vasodilators, vasopressors and/or inotropes can be given as needed. Pulmonary artery catheterization or CVP line placement may be needed to monitor left and right sided cardiac filling pressures as well as for other purposes. Careful attention to cardiac rate and other hemodynamic issues is essential, as is monitoring for ischemia in the ECG (ST segment depression).

30 Steps to Administering General Anesthesia

DRUG DOSAGE NOTE

Doses and volumes discussed here apply to normal adult patients. Adjustments for pediatric patients, frail patients, and patients with impaired renal, hepatic, respiratory or cardiac status will be needed. Drug interactions may also influence dosing needs. Remember that clinical drug dosing (and timing) is as much an art as a science.

1 Identify Clinical Considerations

Review the history, physical examination and laboratory results to identify the principal clinical considerations for the patient (e.g. limited mouth opening, hypertension, angina, asthma, anemia, etc.). Assign an ASA physical status to the patient.

Sometimes just one or two sentences will do the job: *Mr. Desai is an otherwise healthy ASA II 81 kg 46 year old man with chronic anemia (hematocrit = 0.29) and controlled hypertension (atenolol 25 mg BID) who is scheduled for a partial colectomy under general anesthesia. He has no allergies and his functional enquiry is negative.*

2 Consultations

Ensure that all required consultations have been done (e.g. diabetic patients may need an endocrinology consult; patients with myasthenia gravis will need a neurology consult). Here are some more random situations where formal or informal consultation may be appropriate:

- Recent myocardial infarction
- Poor left ventricular function (reduced ejection fraction)
- Pulmonary hypertension
- Metabolic derangements such as severe hyperkalemia
- Uncontrolled severe hypertension
- Mitral or aortic stenosis
- Pheochromocytoma
- Patients with coagulopathies
- Patients with a suspected difficult airway

3 Airway Assessment

Assess the patient's airway using the Mallampati system and examining the patient's oropharynx. Consider also other criteria (degree of mouth opening, head flexion /extension, jaw size, "mandibular space"). Take a good look for any loose, false or capped teeth. Warn patients with poor dentition that intubation carries a risk of chipped or loosened teeth. Determine if special airway management techniques (such as use of the GlideScope video larygnoscope, Bullard laryngoscope or awake intubation using a fiberoptic bronchoscope) are needed.

4 Consent

Ensure that the consent for the surgery has been obtained and that it is correctly signed and dated. Patients unable to give regular consent require special consideration: comatose patients, children, psychiatric patients etc. Some centers require separate consents for anesthesia and for blood transfusions. Central to proper consent is that the patient understands his or her options and their respective benefits and risks. It is not sufficient that the patient has merely and agreeably signed all papers placed before him.

5 Blood Product Planning

Ensure that any needed blood products (packed red cells, platelets, stored plasma, fresh frozen plasma, cryoprecipitate - depending on clinical circumstances) are available. Most smaller surgical cases have blood drawn for "**group and screen**" – determination of ABO / Rh blood grouping and screening for antibodies that might make crossmatching difficult. **Cross and Type**: Larger surgical cases often have a number of blood units (usually packed cells) specifically tested for the patient and more or less immediately available (e.g., 4 units of packed cells for cardiac bypass patients in the operating room refrigerator)

6 Aspiration Prevention

Ensure that the patient has been NPO ("nil per os" - nothing by mouth) for an appropriate length of time, i.e. ensure that the patient has an empty stomach.

(Patients without an empty stomach may need a rapid sequence induction, awake intubation, or management with local or regional anesthesia to reduce the chance of regurgitation and aspiration).

Pharmacologic means to reduce gastric volume and/or acidity may be appropriate preoperatively, such as a particulate-free oral antacid (sodium citrate 0.3 molar 30 ml po prior to induction of anesthesia) or agents such as cimetidine, ranitidine or famotidine (Pepcid).

7 Identify Routine Monitoring Needs

All patients undergoing surgery get the following routine monitors:

- Noninvasive Blood Pressure (manual or automatic)
- Airway Pressure Monitor / Disconnect Alarm
- Electrocardiogram
- Nerve Stimulator
- Pulse Oximeter
- Urometer (if a Foley catheter is placed)
- Airway Gas Monitor (incl. oxygen analyzer and capnogram)
- Body Temperature

In addition, spirometry (tidal volume / minute volume) and agent analyzers (% isoflurane % nitrous oxide etc.) are highly desirable. Body temperature may be measured in the axilla, the nasopharynx, the esophagus or the rectum.

8 Identify Special Monitoring Needs

CVP=central venous pressure PA=pulmonary artery
Determine whether special monitors (arterial line, CVP line, PA line etc.) are needed. Arterial lines allow beat-by-beat blood pressure monitoring, arterial blood gas monitoring and easy access to blood for tests. A CVP line is helpful to assess right-sided cardiac filling pressures. PA-lines are helpful when cardiac output must be measured or when right-sided cardiac pressure data would not be expected to reflect what is happening on the left side. PA catheters measure:

(1) CVP waveform
(2) PA waveform
(3) PCWP ("wedge pressure")
(4) Cardiac Output
(5) Right-sided resistance (PVR – pulmonary vascular resistance)
(6) Left-sided resistance (SVR – system vascular resistance)
(7) PA temperature

Evoked potential studies sometimes are useful to monitor the brain and spinal cord during neurosurgical and orthopedic procedures.

9 Premedication

Order preoperative sedation, drying agents, antacids, H2 blockers, or other drugs as appropriate. SAMPLE PREMEDICATION ORDERS:

Preoperative sedation
Diazepam 10 mg po with sip water 90 min preop
Midazolam 1 mg IV in holding area if requested by patient
Morphine 10 mg / Trilaphon 2.5 mg IM one hr preop *(heavier)*

Drying agent (e.g., prior to awake intubation)
Glycopyrrolate 0.4 mg IM one hr preop

Reduce gastric acidity (e.g., patients at aspiration risk)
Ranitidine 150 mg po evening before surgery and again in am

Cardiac prophylaxis (e.g., mitral stenosis)
Antibiotics as per AHA protocol

10 Intravenous Access

Start an intravenous (IV) of appropriate size in the hand or forearm (first using local anesthesia for larger IV sizes.)

In most cases, a size 20, 18 or 16 gauge IV catheter is hooked up to a bag of Normal Saline (0.9%) or Lactated Ringer's solution is usually used.

A large size 14 is often used in cardiac cases and other large cases, or where the patient is feared to be hypovolemic.

Some cases (e.g., trauma cases) will require more than one IV or will require a fluid warmer to avoid hypothermia. In other cases IV access will be via a central line, as in a line placed in the internal jugular vein, an external jugular vein or a subclavian vein.

11 Equipment Preparation

ANESTHESIA MACHINE CHECK
(HIGHLIGHTS ONLY – SEE FULL CHECKLIST)
Oxygen Line Pressure
Oxygen Flowmeter
Nitrous Line Pressure
Nitrous Flowmeter
Oxygen Tank Check
Check for Leaks
Vaporizer Check
Check Ventilator

AIRWAY EQUIPMENT
Suction
Oxygen
Laryngoscope
Endotracheal Tube
Stylet (in ETT)
"SOLES"

EMERGENCY STUFF

Airway Equipment

Resuscitator Bag

Defibrillator

Crash Cart

Emergency Drugs

Fire Extinguisher

12 Drug Preparation

Prepare drugs in labeled syringes. Examples:

Drug	Concentration	Use	Syringe
Thiopental	**25 mg/ml**	**Induction**	**20 ml**
Propofol	**10 mg/ml**	**Induction**	**20 ml**
Fentanyl	**50 mcg/ml**	**Analgesia**	**5 ml**
Midazolam	**1 mg/ml**	**Amnesia / Hypnosis**	**5 ml**
Succinylcholine	**20 mg/ml**	**Intubation**	**10 ml**
Curare	**3 mg/ml**	**Muscle Relaxation**	**5 ml**
Vecuronium	**1 mg/ml**	**Muscle Relaxation**	**5 ml**
Pancuronium	**2 mg/ml**	**Muscle Relaxation**	**5 ml**

Not all these drugs will be drawn up at one in any one case (e.g. usually need only one induction agent). Most patients will not need the full amount of any of these syringes at any one time.

13 Emergency Drug Preparation

Prepare emergency drugs for the case. Low risk cases may not need any of these drugs to be instantly ready. High risk cases may also require dopamine, epinephrine, norepinephrine and other agents.

Atropine 3 ml syringe 0.6 mg /ml Used to raise heart rate (HR)
Ephedrine 10 ml syringe 5 mg /ml Used to raise BP (and HR)
Phenylephrine 20 ml syringe 50 mcg / ml Used to raise BP
Nitroglycerine 10 ml syringe 0.2 mg / ml Used to lower BP / treat heart ischemia
Esmolol 10 ml syringe 10 mg /ml Used to lower HR (and BP)

14 Attach Patient Monitors

Prior to induction of general anesthesia the electrocardiogram, blood pressure cuff and pulse oximeter should be attached and baseline vital signs taken. The IV should also be rechecked before the induction drugs are given. After induction / intubation the capnograph, airway pressure monitor, neuromuscular blockade monitor and temperature probe should be attached. Special monitors (CVP, arterial line, evoked potentials, precordial Doppler) may also be needed.

15 Give Preinduction Drugs

Rocuronium 3 to 5 mg IV may be given to prevent fasciculation (with resulting myalgia) from succinylcholine (a rapid onset ultrashort acting intravenous depolarizing muscle relaxant used primarily for intubation). Small doses of midazolam (e.g. 1 - 2 mg IV) and/or fentanyl (e.g. 50 - 100 mcg IV) may be given to "smooth out" induction. Larger doses may be appropriate where less than usual doses of thiopental or propofol are planned (e.g. in cardiac patients). Preinduction hemodynamic "tuning" using nitroglycerine or esmolol may be needed in hypertensive patients or patients with coronary artery disease.

16 Induce General Anesthesia

- Tell the patient he / she will be going to sleep.
- Get baseline vital signs.
- Using thiopental (e.g. 3-5 mg / kg), propofol (e.g. 2-3 mg / kg) or other IV drugs, render the patient unconscious.
- Consider using etomidate or ketamine for hypovolemic patients.
- Consider using fentanyl or sufentanil as the main induction agent for cardiac cases.
- Use of an inhalation induction with a potent agent such as sevoflurane would also work, but is far less popular in adults.

17 Provide Muscle Relaxation

After the patient is unconscious, as evidenced by loss of a lid reflex, use a depolarizing muscle relaxant such as succinylcholine or a nondepolarizing agent such as rocuronium or vecuronium to paralyze the patient in order facilitate endotracheal intubation.

Succinylcholine is popular in this setting because of its rapid onset and offset (short duration of effect), but many clinicians never use succinylcholine routinely because of its occasionally lethal side effects related to hyperkalemia and because it is a trigger of malignant hyperthermia in susceptible individuals.

The effects of muscle relaxant drugs can be monitored using a nerve stimulator ("twitch monitor") as well as by observing the patient for unwanted movements.

(This step is not needed if a face mask or Laryngeal Mask Airway is used, or if the patient is intubated awake).

18 Intubate the Patient (Secure the Airway)

Using your gloved left hand insert a laryngoscope to visualize the epiglottis and cords and then pass an endotracheal tube (ETT) through the abducted vocal cords with your right hand. Ordinarily the ETT should be positioned with lips around 21 cm for women, 23 cm for men. Inflate the ETT cuff to 25 cm H2O pressure to establish a seal (about 5 ml air will usually suffice), then hook up ETT to patient breathing circuit. Check for equal air entry with stethoscope and check for correct-appearing capnogram. (If an LMA is used, it is inserted without a laryngoscope).

19 Ventilate the Patient

Although many cases can be done with the patient breathing on their own "breathing spontaneously", all cases using muscle relaxants need mechanical ventilation for a period. **USUAL VENTILATOR SETTINGS:**

- Tidal volume 10-12 ml/kg.
- Respiratory rate 8-12/min.
- Oxygen concentration 30%

NOTE Aim for a PCO2 of 35 - 40 mm Hg in normal cases, and 28-32 mm Hg in patients with increased intracranial pressure. Ensure that all ventilation-related alarms (apnea, high airway pressure, etc.) are enabled and appropriately set.

20 Look at Oxygenation

Room air is 21% oxygen. Under anesthesia patients are given a minimum 30 percent oxygen (Exception: cancer patients who have taken bleomycin get only 21% oxygen to reduce the chance of oxygen toxicity). 100 percent oxygen with aggressive PEEP (Positive End Expiratory Pressure) may be required in patients with severe respiratory failure (e.g., as in ARDS). Aim for a pulse oximeter reading (arterial oxygen saturation) above 95%. Drops in arterial oxygenation are often due to endotracheal tube displacement into the right bronchus – check for equal air entry in all such cases.

21 Dial in Inhaled Anesthetic

Provide maintenance anesthesia with nitrous oxide (N2O) 70%, oxygen 30% and a potent inhaled agent such as isoflurane (e.g. 1%). Using blood pressure, heart rate and other indices of anesthetic depth, adjust the inhaled agent concentration as needed (or give increments of IV agents such as fentanyl or propofol). Other volatile agents used in general anesthesia include sevoflurane, desflurane or halothane. Ether is still used in some parts of the world.

22 Add Intravenous Anesthetics

Add fentanyl, midazolam, propofol or other anesthetic agents as needed according to your clinical assessment of the anesthetic depth. Increments of fentanyl (50 – 100 mcg) will help maintain analgesia. Some clinicians prefer an all IV technique - Total Intravenous Anesthesia, or TIVA. This can be useful in patients with susceptibility to Malignant Hyperthermia (who cannot receive succinylcholine or potent inhaled agents such as desflurane, sevoflurane or isoflurane).

23 Add Muscle Relaxants

Muscle relaxation is needed for abdominal surgery and many other clinical situations. Using a neuromuscular blockade monitor add muscle relaxants as needed. (The degree of neuromuscular blockade is estimated by examining the finger movement patterns when the ulnar nerve is stimulated electrically with a series of four high-voltage shocks spaced 500 milliseconds apart.) Remember that not all cases require muscle relaxation and that all patients getting muscle relaxants must be ventilated mechanically.

24 Fluid Management

Ensure adequate hematocrit, coagulation, intravascular volume and urine output by giving adequate IV fluids and blood products. For most cases run an IV of Normal Saline or Ringer's solution at 250 ml/hr to start, then adjust to meet the following goals:

[1] In first two hours of case, replace any preoperative fluid deficit (e.g. NPO for 8 hours x 125 ml maintenance fluid needed per hour kept NPO = 1000 ml to give in first 2 hrs)

[2] Meanwhile, for entirety of case replace "third space" surgical losses at 2 - 10 ml/kg/hr (e.g., 2 for carpal tunnel repair, 5 for lap chole, 10 for bowel surgery.)

[3] Maintain urine output over 50 ml / hr or 0.5 to 1.0 ml/kg/hr

[4] Maintain hematocrit in safe range (above 0.24 in everyone; at or above 0.3 in selected patients at risk).

25 Monitor Depth of Anesthesia

Unintended intraoperative awareness during surgery, while rare, is a monumental tragedy to the patient and can trigger post-traumatic stress disorder. It may happen when a vaporizer inadvertently empties or other problem (e.g. infusion pump failure).occurs. Remember that awake surgical patients cannot signal their distress if they are paralyzed with muscle relaxants. Using clinical assessment, ensure that the patient is unconscious. This is more of an art than a science, but takes into account autonomic findings such as BP and HR and the amounts of drugs given to date. Use of a potent inhaled agent like isoflurane is especially likely to ensure unconsciousness. A BIS monitor (Bispectral Index Monitor) is frequently advocated as a monitor of anesthetic depth.

26 Prevent Hypothermia

Perioperative hypothermia can be a serious problem for some patients. For example, patients who shiver in the recovery room after surgery use excessive oxygen and may "put a strain on the heart" (induce myocardial ischemia in patients with coronary artery disease). Keep core temperature above 35 Celsius using fluid warmers, forced air heaters or just keeping the room warm. Measure axillary, rectal or oropharyngeal temperature to ascertain the degree of hypothermia. Temperature monitoring also helps detect the occurrence of an episode of Malignant Hyperthermia (a hypermetabolic syndrome).

27 Emergence

When the surgery is nearing completion, discontinue the anesthetic agents and reverse any neuromuscular blockade (e.g. neostigmine 2.5 - 5 mg IV with atropine 1.2 mg or glycopyrrolate 0.4 mg IV). Neostigmine is never given alone (or your patient will get severe bradycardia or cardiac arrest). Use a neuromuscular blockade monitor (nerve stimulator) to ensure that any muscle relaxation has been well-reversed. Allow spontaneous ventilation to resume. Check respiratory pattern visually and via capnograph. Wait for consciousness to return.

28 Extubation

Once the patient is awake and obeying commands, suction out the oropharynx with a large-bore mouth sucker, remove air from the ETT cuff with a 10 ml syringe, and pull out the ETT. Apply 100% oxygen by face mask after extubation. Supply jaw-thrust, oral airway, nasal airway or other airway interventions as needed to maintain good spontaneous breathing. Keep a close eye on the patient's breathing and on the pulse oximeter (keep above 95%).

29 Transport to PACU

(Recovery Room)

When the case is over and the paperwork done, bring the stretcher into the OR and put the patient on it without pulling out lines and disconnecting monitors.

Don't forget the oxygen tank and oxygen mask.

Monitor patients breathing visually. Keep a finger on a pulse while moving the patient (in appropriate cases), but use a transport monitor for sick patients or for big surgical cases (eg, cardiac surgery).

Give report to RNs in PACU as well as to the anesthesiologist managing the PACU (complex cases).

PACU = Post Anesthetic Care Unit

30 Arrange Postoperative Care

Before leaving, take care of any remaining paperwork. This includes analgesic orders (e.g. morphine 2 - 4mg IV prn), oxygen orders (e.g. nasal prongs 4 liters/min or face mask 35% oxygen), antibiotics, feeding orders, fluid orders and post-operative tests such as electrolytes and hematocrit.

Be sure to identify any special concerns you have about the patient.

Where appropriate, discuss current clinical situation with patient's family.