

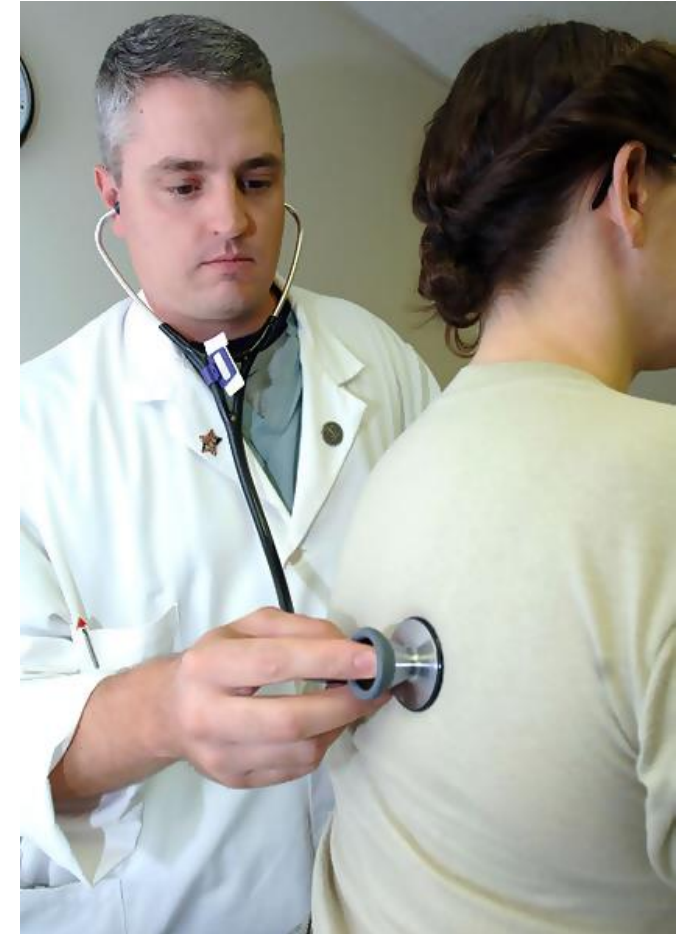
Preoperative Evaluation

Jason Ryan, MD, MPH



Preoperative Evaluation

- Detect unrecognized disease
- Evaluate factors that increase risk of surgery
- Propose strategies to reduce this risk
- Adverse outcomes of surgery:
 - Death
 - Myocardial infarction
 - Respiratory failure
 - Heart failure
 - Arrhythmias (atrial fibrillation)
 - Bleeding

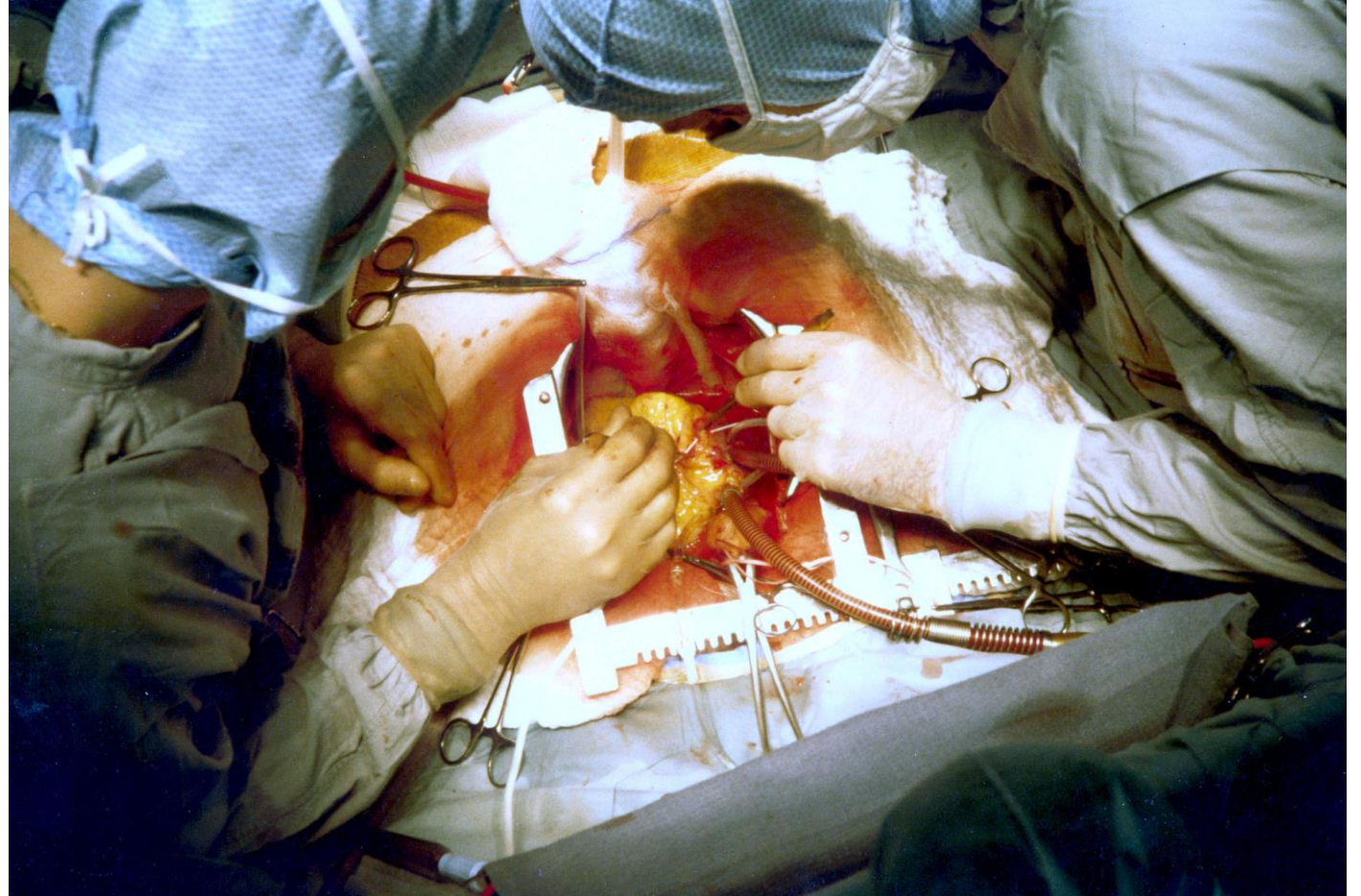


Wikipedia/Public Domain

Types of Surgery

- **Non-cardiac surgery**
- **Cardiac surgery**
 - CABG
 - Valve replacement

Open Heart Surgery



Preoperative Evaluation

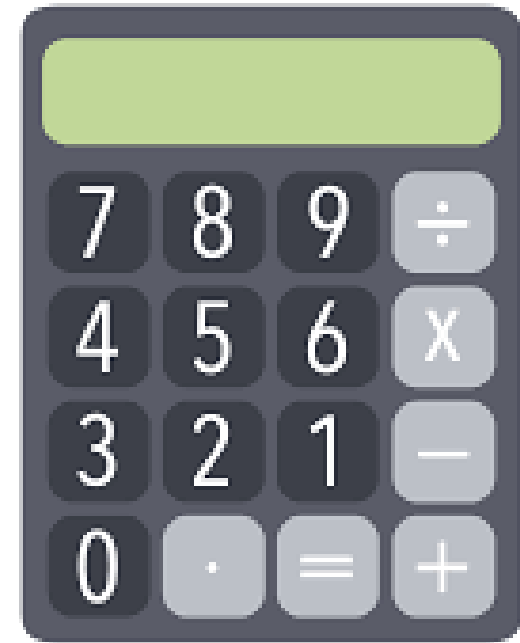
- History and physical exam
- Blood tests: CBC, chemistries
- EKG
- Cardiac stress test
- Chest x-ray
- Pulmonary function tests



Preoperative Evaluation

Cardiac Risk Evaluation

- Adverse cardiac outcomes of surgery
 - Myocardial infarction, arrhythmia, cardiac arrest
- Risk increased based on:
 - Patient factors
 - Surgical factors
- Calculators: estimate risk of cardiovascular complications
 - Based on procedure and patient factors
 - Gupta MICA NSQIP database risk model
 - Revised cardiac risk index
 - NSQIP universal surgical risk calculator

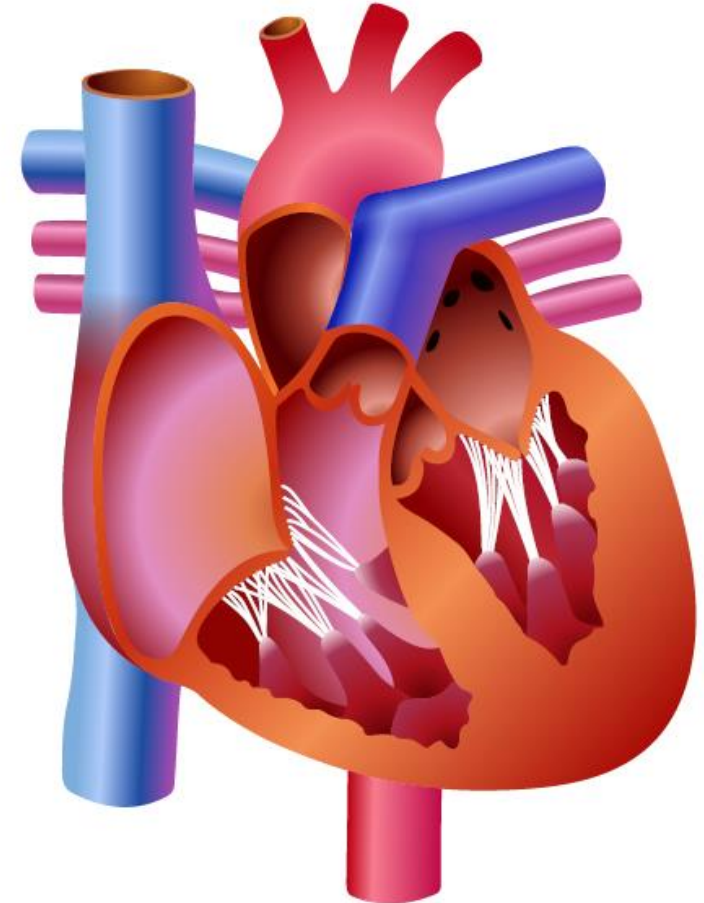


Needpix.com

Preoperative Evaluation

Cardiovascular Assessment

- History and physical exam
 - **Acute coronary syndrome** or **acute heart failure**
 - Treat or stabilize ACS or HF prior to surgery
- EKG
 - Usually done prior to surgery
 - Not absolutely necessary in completely healthy patients
- If no evidence of ACS or HF → proceed to surgery
 - No stress testing or other cardiac testing indicated
- One exception: **elective vascular surgery**



Preoperative Evaluation

Stress Test

- Major decision in elective surgery: **stress test?**
 - May identify critical coronary disease
 - In theory, revascularization may reduce risk of post-op MI
- Little data showing benefit of revascularization before surgery
- Stress test only indicated before **elective vascular surgery** in select patients



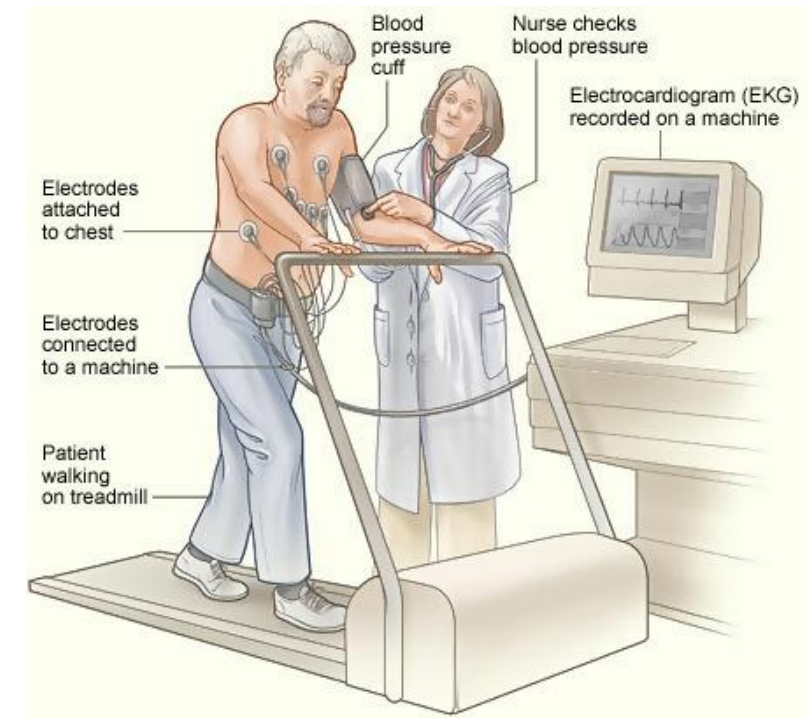
Shutterstock

Preoperative Evaluation

Elective Vascular Surgery

- AAA repair
- Femoral-popliteal bypass
- Carotid endarterectomy
- Surgery can be safely delayed
- Pre-operative **stress test** sometimes indicated
 - Only if patient functionally limited
 - Only if patient has risk factors
 - Only if abnormal result with **change management**

Stress Test



Preoperative Evaluation

Elective Vascular Surgery

- Unable to perform **4 METs of activity**
 - Climb stairs
 - Walk up an incline
- Patient must be **high-risk** (3 or more risk factors)
- Indications for pre-op stress test
 - Elective vascular surgery
 - Patient unable to perform 4 METs
 - High risk patient
 - Abnormal result with **change management**

Major Risk Factors

CAD

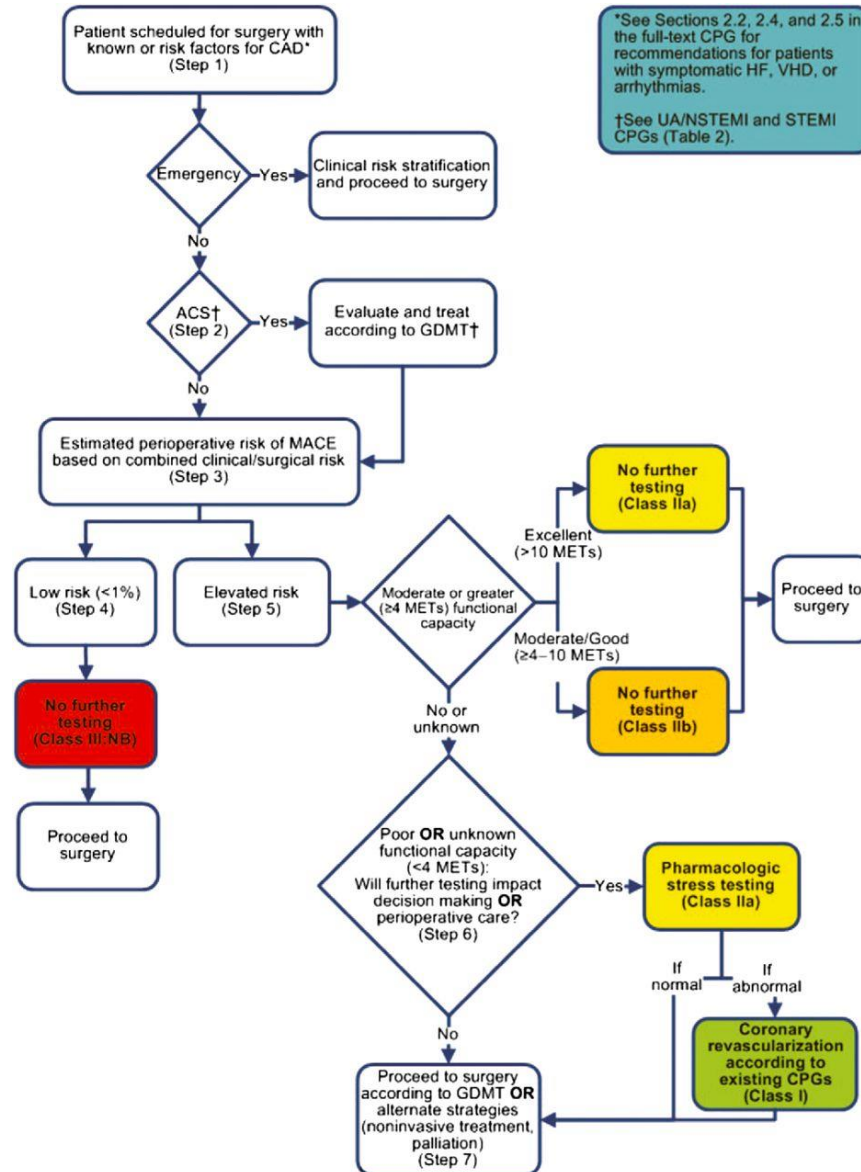
HF

CVA

Diabetes

Cr > 2.0

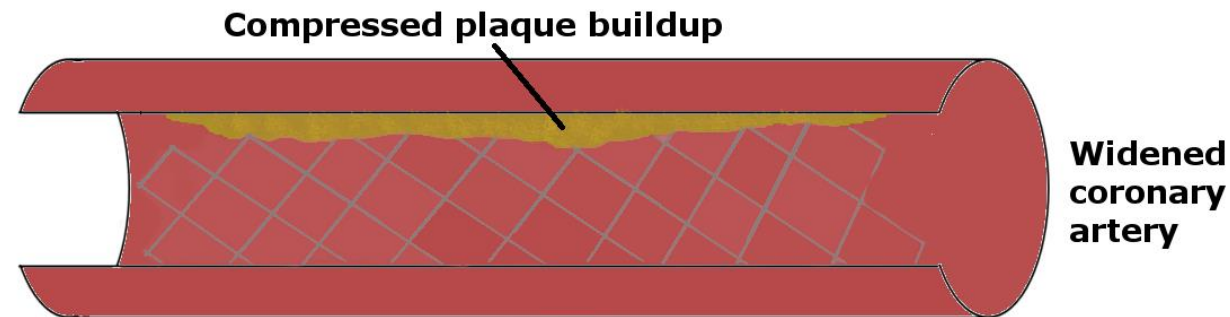
Age > 70



2014 ACC/AHA Guideline on Perioperative Cardiovascular Evaluation and Management of Patients Undergoing Noncardiac Surgery

Coronary Stents

- **Dual antiplatelet therapy (DAPT)** after implantation
 - Aspirin plus clopidogrel/ticagrelor/prasugrel
- Reduces risk of stent thrombosis
- Recommended DAPT duration: 6 to 12 months
- After 6 to 12 months: lifelong aspirin (81mg)



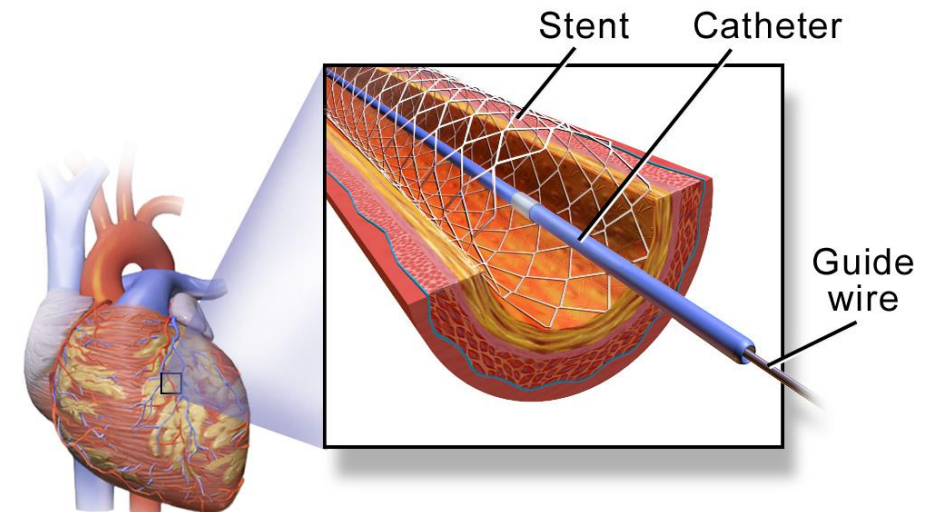
Coronary Stent

Preoperative Evaluation

Cardiovascular Assessment

- **Recent (< 6 months) coronary drug-eluting stent implantation**
 - Dual antiplatelet therapy recommended for 6 months
 - Discontinuation of DAPT associated with stent thrombosis
 - Consider delay surgery or perform on DAPT

Stent in Coronary Artery



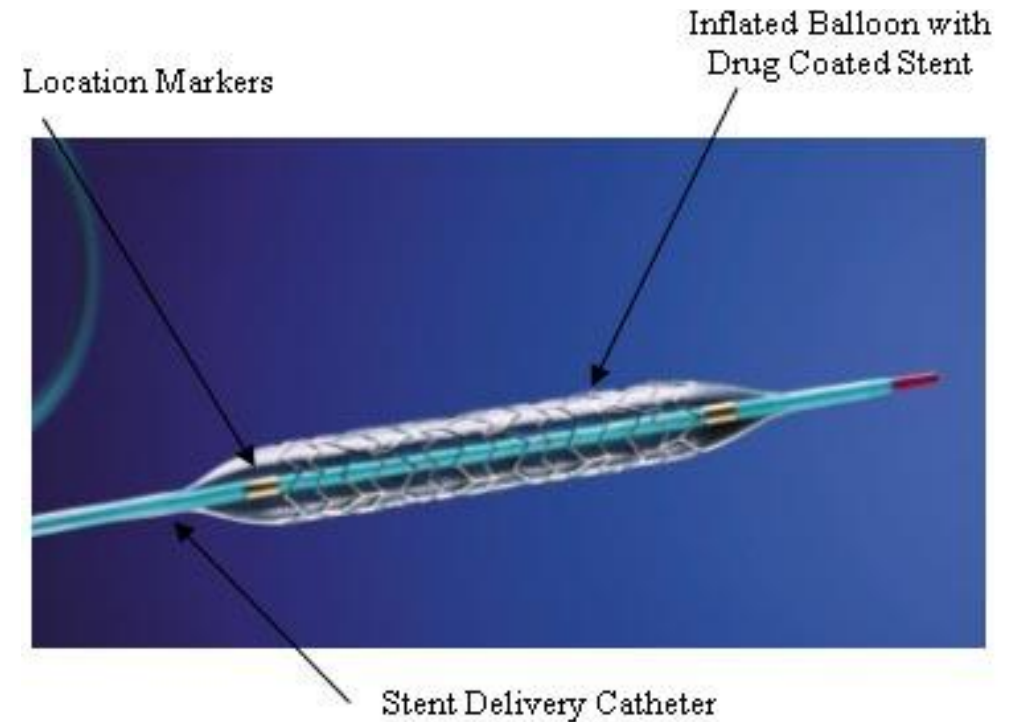
Wikipedia/Public Domain

Preoperative Evaluation

Cardiovascular Assessment

- Remote (> 6 months) coronary DES implantation
 - Discontinue antiplatelet therapy prior to surgery
 - Restart after surgery
- Special case: **bare metal stents**
 - Lower risk of stent thrombosis
 - May discontinue DAPT after 1 month

Coronary Stent

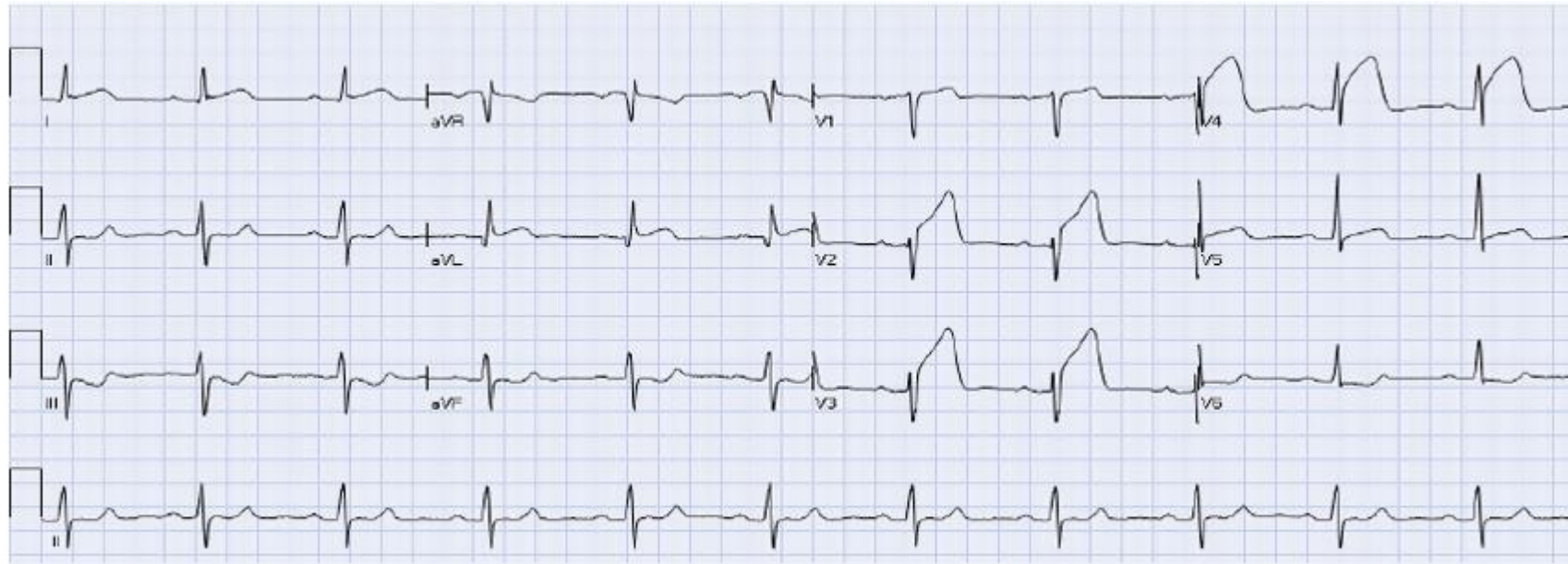


Preoperative Evaluation

Cardiovascular Assessment

- **Recent acute coronary syndrome**
 - Delay surgery until 60 days

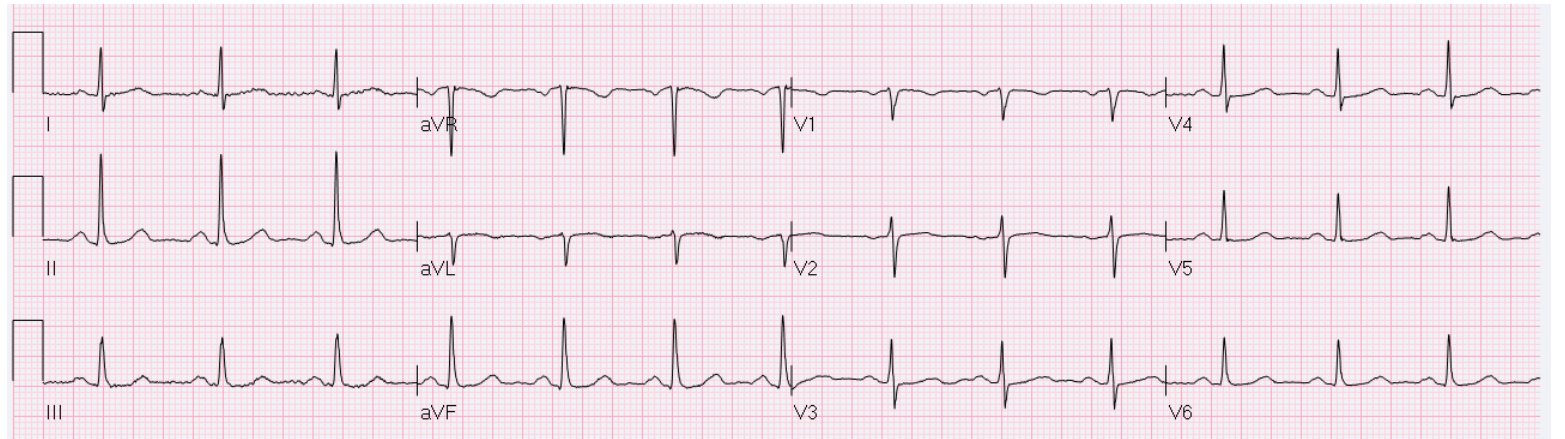
Anterior ST-elevation Myocardial Infraction



Preoperative Evaluation

Cardiovascular Assessment

- Most cardiac conditions do not prohibit surgery
 - Coronary artery disease
 - Cardiomyopathy
 - Heart failure
 - Prior cardiac arrest



Preoperative Evaluation

Pulmonary

- COPD
 - Optimize prior to surgery
 - No prohibitive level of pulmonary function
- Asthma, obstructive sleep apnea
 - Optimize prior to surgery

COPD

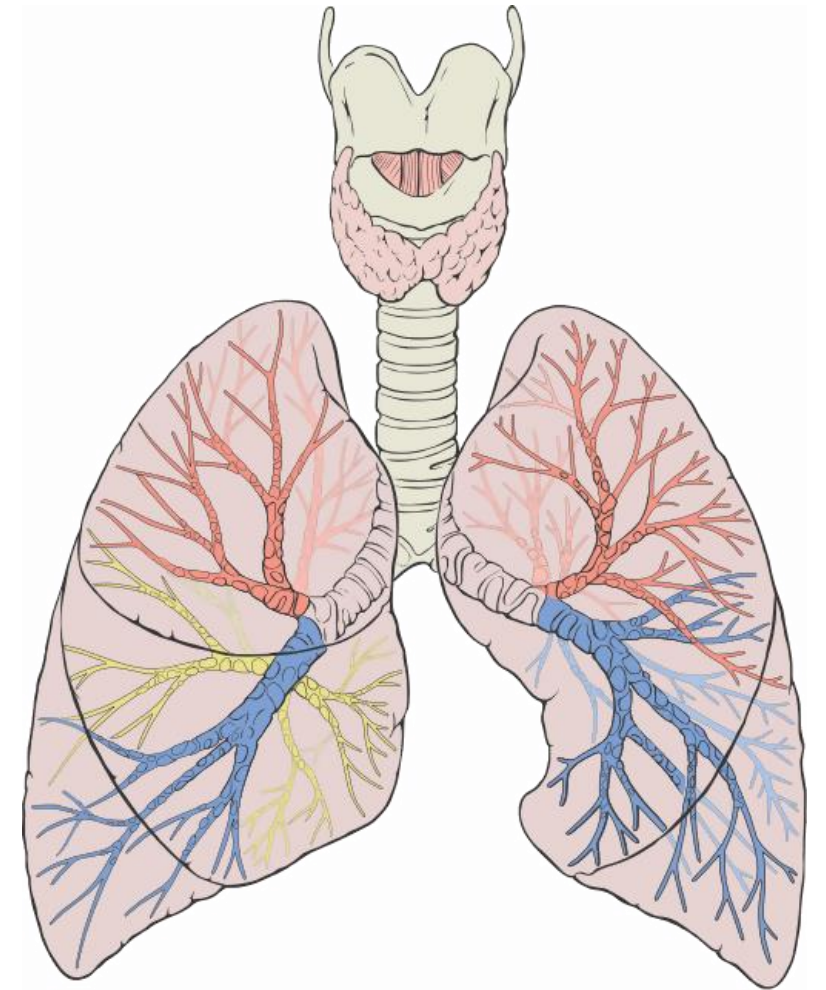


James Heilman, MD/Public Domain

Preoperative Evaluation

Pulmonary

- Cigarette smoking
 - Current smokers: increased risk post-op complications
 - Quitting before surgery may reduce risk
- Chest x-ray
 - Not routinely done unless specific indication
- Pulmonary function testing
 - Not routinely done unless specific indication

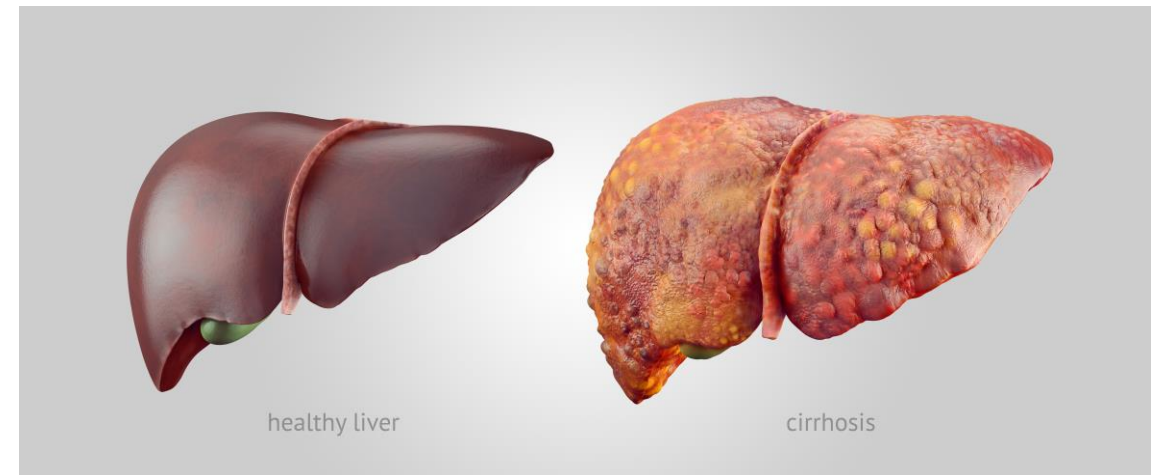


Patrick Lynch/Wikipedia

Preoperative Evaluation

Liver Disease

- Surgery usually acceptable for patients with cirrhosis
- **Child Pugh class**
 - Points for encephalopathy, ascites, bilirubin, albumin, PT
 - Class assigned based on points
 - Classes A and B = lower risk
 - Highest risk = class C
- **MELD score**
 - Point system using bilirubin, creatinine, INR
 - Estimates 3-month mortality
 - MELD Score > 15 = higher risk



Shutterstock

Preoperative Evaluation

Hematology

- High risk of bleeding with low platelets or coagulopathy
- **Goal platelets: > 50,000**
 - Normal platelet count: 150,000 to 450,000/ μ L
 - Bleeding risk usually not increased unless < 50,000
- **Goal INR < 1.5**
 - Normal INR = 1.0
 - Bleeding risk increased INR > 1.5
- **Goal Hgb > 7 g/dL (hct > 21)**
 - Adverse outcomes below this level



Public Domain

Preoperative Evaluation

Surgical Indications

- Emergency surgery
 - Risk of forgoing surgery extremely high
 - Very little role for preoperative evaluation
 - Classic example: **trauma**



Preoperative Evaluation

Surgical Indications

- Urgent surgery
 - Risk of *prolonged* delay is high
 - Hip fracture, malignancy
 - Brief delay only for urgent treatment (MI, HF)
- Elective surgery
 - Delay of surgery acceptable
 - Time to optimize patient
 - Extensive pre-operative testing possible



Preoperative Evaluation

Anticoagulants and antiplatelets

- Warfarin
 - Hold 4-5 days before surgery
 - Goal INR < 1.5
- Heparin drip
 - Half life 60 to 90 minutes
 - Discontinue hours before surgery
- LMWH
 - Last dose 24 hours before surgery
 - Last dose 50% normal dose
- Aspirin, clopidogrel, ticagrelor, prasugrel
 - Discontinue 5 to 7 days before surgery



Public Domain

Preoperative Evaluation

Other drugs

- ACE inhibitors and ARBs
 - May cause hypotension through ↓ RAAS activity
 - Usually held morning of surgery
- NSAIDs
 - Inhibit platelet function
 - Avoided 1 week prior to surgery
- Oral contraceptive pills
 - May increase risk of post-op thrombosis
 - Hold if surgery high risk for post-op DVT/PE
- Beta-blockers and statins: continue



Pixabay.com

Preoperative Evaluation

Other drugs

- Oral hypoglycemic agents
 - Sulfonylureas, thiazolidinediones
 - Hold morning of surgery
- Metformin
 - Associated with lactic acidosis with renal hypoperfusion
 - Hold morning of surgery
- Insulin
 - Continue, but decrease dose morning of surgery (NPO)

Postoperative Complications

Jason Ryan, MD, MPH



Postoperative Fever

- Immediate: within 24 hours
- Early: within the first 3 days after surgery
- Late: after postoperative day 3

Postoperative Fever

Immediate Causes

- Inflammation due to surgery
- Trauma-related inflammation
- Infections predating the operation
- Immune reactions to blood products
- Malignant hyperthermia

Malignant Hyperthermia

- Rare, dangerous reaction to anesthetics
 - Halothane, succinylcholine
- **Fever, muscle rigidity**
- Tachycardia, hypertension
- **Muscle damage**
- Hyperkalemia
- **Increased creatine kinase**



Wikipedia/Public Domain

Malignant Hyperthermia

- Elevated end-tidal carbon dioxide (hypercarbia)
- Resistant to increased minute ventilation



Malignant Hyperthermia

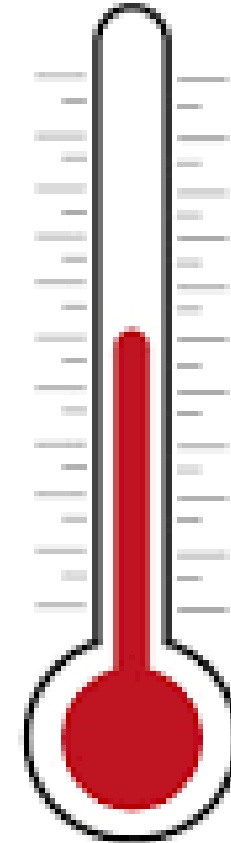
- Cause: ryanodine receptor sarcoplasmic reticulum
 - Ca channel in SR of muscle cells
 - Abnormal in patients who get MH (autosomal dominant)
 - Dumps calcium
 - Ca → consumption of ATP for SR reuptake
 - ATP consumption → heat → tissue damage
- Treatment : **dantrolene** (muscle relaxant)



Postoperative Fever

Early Causes: Days 1 to 3

- Trauma- or burn-mediated inflammation
- Infections predating the operation
- Idiopathic
- Urinary tract infection
- Pneumonia
- Early surgical site infection
- Other noninfectious causes



Early Postoperative Fever

Idiopathic

- Fever common 1 to 3 days after surgery
- Often not caused by serious infection
- Believed to be due to **inflammation/cytokines**
- Previously attributed to atelectasis
 - Atelectasis also common in early period
 - No longer considered cause of fever

Early Postoperative Fever

Infections

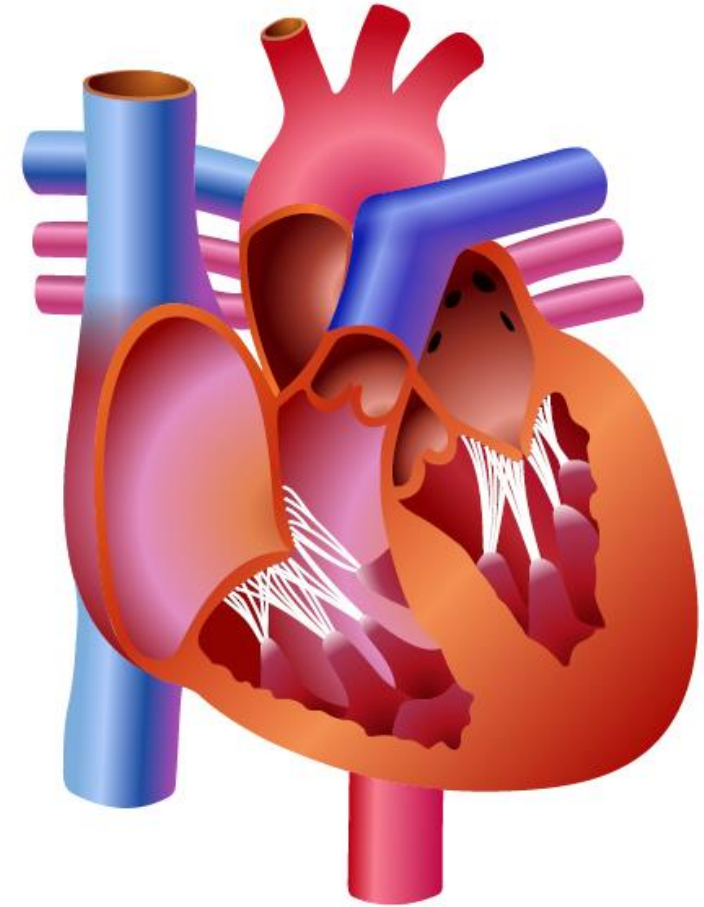
- Pneumonia
- Urinary tract infection
- Early surgical site infection
 - Most site infections occur after day 5
 - Rare early infections with two organisms
 - Group A streptococcus
 - Clostridium perfringens
 - Fever, erythema, wound drainage

Pneumonia



Postoperative Myocardial Infarction

- Most common within 72 hours of surgery
- Rarely can cause a fever
- Treated as STEMI/NSTEMI



Postoperative Fever

Late Causes : Day 3+

- Surgical site infections
- Surgery-specific complications
 - Anastomotic leak
 - Deep abdominal abscess
 - Ischemia (vascular surgery)
- Noninfectious causes
 - **Febrile drug reactions**
 - Venous thromboembolism
 - Gout



Pixabay.com

Surgical Site Infections

- **Erythema**, warmth, edema and pain at incision site
- Purulent drainage may be present
- Fever, leukocytosis
- Treatment: antibiotics +/- surgical debridement



KVDP/Public Domain



Muhammad Saleem/SlideShare

Venous Thromboembolism

- Surgery causes a hypercoagulable state
- Risk of DVT or PE
- Non-pharmacologic prevention:
 - Early ambulation
 - Pneumatic compression
- Pharmacologic prevention:
 - LMW heparin
 - Low dose UFH
 - Fondaparinux (Xa inhibitor)



Public Domain

Postoperative Fever

- Wind: atelectasis or pneumonia
 - 24 to 48 hours post-op
- Water: UTI
 - 3 to 5 days post-op
- Wound: wound infection
 - 5 to 7 days post-op
- Walking: venous thromboembolism
 - 7 to 10 days post-op
- Wonder drug
 - Drug fever

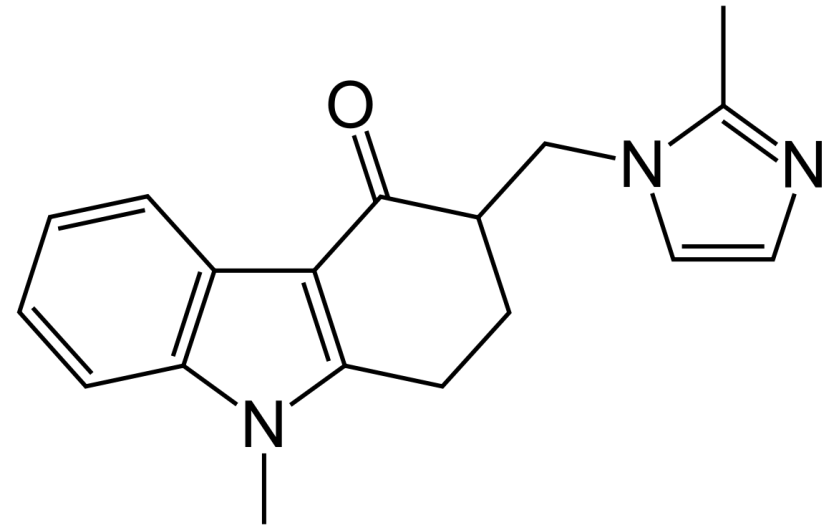
Post Operative Fever

Workup

- History and physical exam
 - Examine surgical site
- CBC with differential
- Chest x-ray
- Urinalysis and culture
- Sputum culture and gram stain
- Blood cultures

Post Operative Nausea and Vomiting

- Occurs in approximately 30% of patients after anesthesia
 - More common with volatile (gas) anesthetics and opioids
- Commonly treated with **serotonin 5-HT₃-receptor antagonists**
 - Ondansetron
 - May cause constipation or headache
 - **Prolonged QT interval on EKG**
 - Rare cases of torsades de pointes reported
- Some patients treated prophylactically



Ondansetron

Fascial Dehiscence

- Occurs with abdominal surgical incisions
- Wall tension overcomes suture strength
- Risk factors:
 - Inadequate closure
 - Infection
 - Malnutrition
 - Diabetes
- Treatment:
 - Wound exploration/repair



Shutterstock

Other Wound Complications

- **Evisceration**
 - Protrusion of viscera through wound
 - Surgical emergency
- **Fistula**
 - Abnormal communication between two organs
 - Enteric fistula: bowel lumen to skin or other organ

Bowel Evisceration



Shutterstock

Postoperative Ileus

- Paralysis of bowel motility following surgery
- Affects small and large bowel
- Common in early postoperative period
- Risk factors
 - Anesthesia or pain meds, especially opioids
 - Gastrointestinal surgery
 - Open abdominal surgery
 - Prolonged surgery abdominal/pelvic surgery



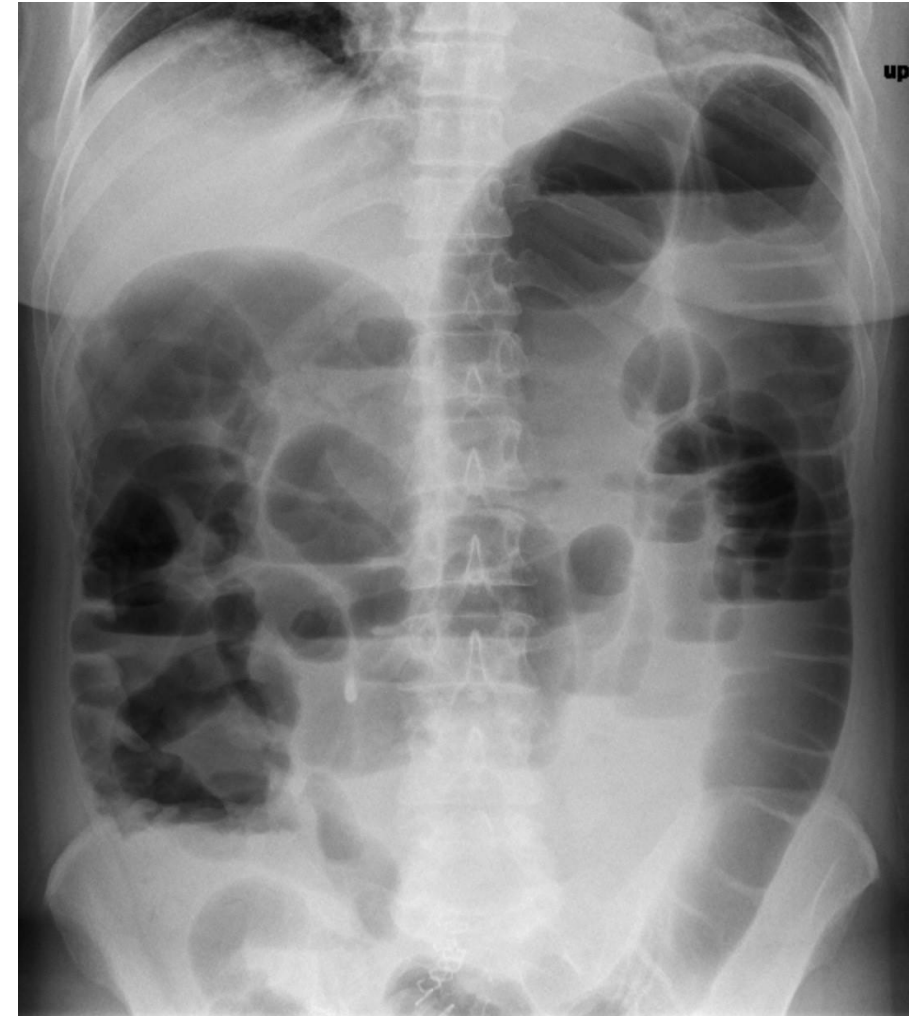
Elya/Wikipedia

Postoperative Ileus

Clinical Features

- **Lack of flatus or bowel movements**
- Dull abdominal pain
- Absent bowel sounds
- **KUB: *diffuse* bowel distention**
- Dilated loops of bowel
- Air in the colon and rectum (no obstruction)
- No transition zone

Ileus



Postoperative Ileus

Treatment

- **Out of bed**
- Fluids



Shutterstock

Postoperative Bowel Obstruction

- Occurs in small bowel (SBO)
- **Within six weeks** after abdominal surgery
- Caused by **adhesions**
- Distended abdomen
- Dull abdominal pain
- Diagnosis:
 - KUB: Dilated small bowel, compressed colon
 - Abdominal CT

Distended Abdomen



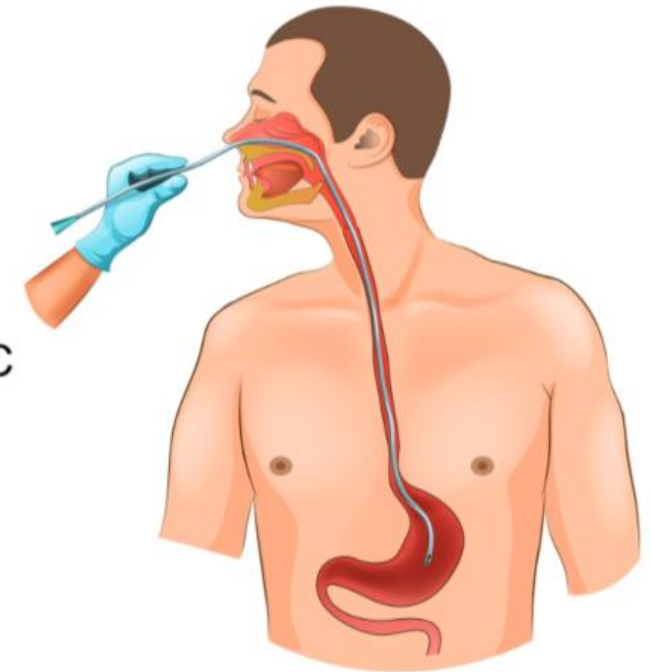
Shutterstock

Postoperative Bowel Obstruction

Treatment

- Placement of NG tube
- Abdominal decompression
- Pain control
- Often managed without surgery
- Post-op adhesions (10-14 days) thick, dense
- Surgery difficult

NASOGASTRIC
INTUBATION



Shutterstock

Ogilvie Syndrome

- **Acute “pseudo-obstruction” of colon**
- Dilated colon in absence of a lesion
- Usually in hospitalized or nursing home patients
- Often with severe illness or recent surgery
- Often associated with narcotics



Postoperative Urinary Retention

- Common after anesthesia
- Patients usually required to void before discharge
- May develop acute urinary retention (AUR)
 - Inability to void
 - Lower abdominal or suprapubic discomfort
- Diagnosis: ultrasound or catheterization



General Anesthesia

Jason Ryan, MD, MPH



General Anesthesia

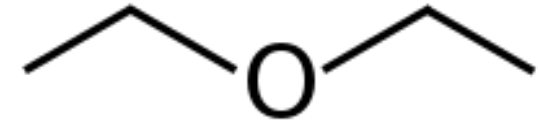
- Anesthesia: insensitivity to pain
- Anesthetic drugs produce:
 - Loss of consciousness
 - Analgesia
 - Amnesia
 - Muscle relaxation
- Inhaled
- Intravenous
- Neuromuscular blockers
- Local



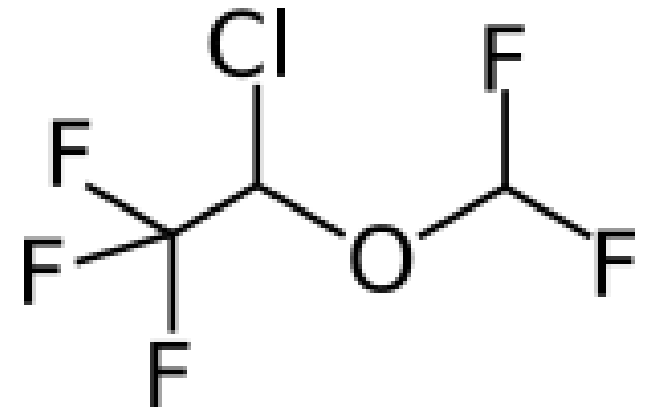
Inhaled General Anesthetics

- Desflurane
- Halothane
- Isoflurane
- Enflurane
- Sevoflurane
- Methoxyflurane
- Nitrous oxide
- Two key gas properties determine clinical effects:
 - Blood solubility
 - Lipid solubility

Diethyl Ether



Isoflurane

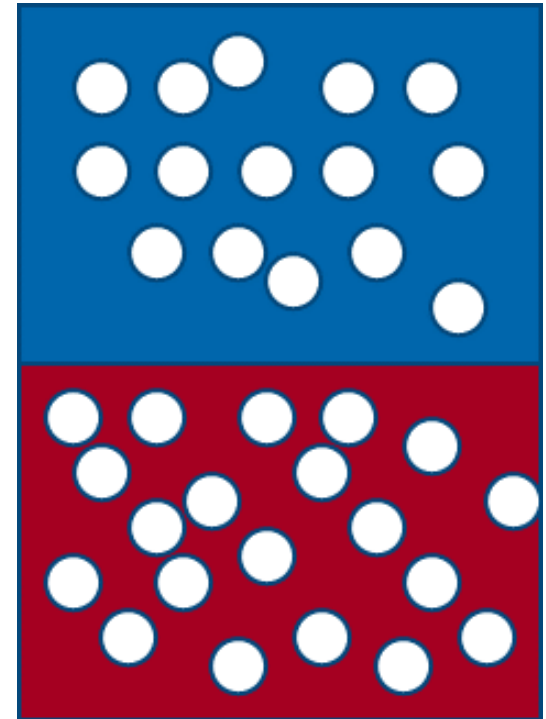


Blood Solubility

- Determines **onset and offset time** of inhaled anesthetics
- Molecules dissolved in blood: no anesthetic effect
- Molecules not dissolved: anesthetic effect
- Need to saturate blood before undissolved molecules accumulate
- High solubility = longer to take effect

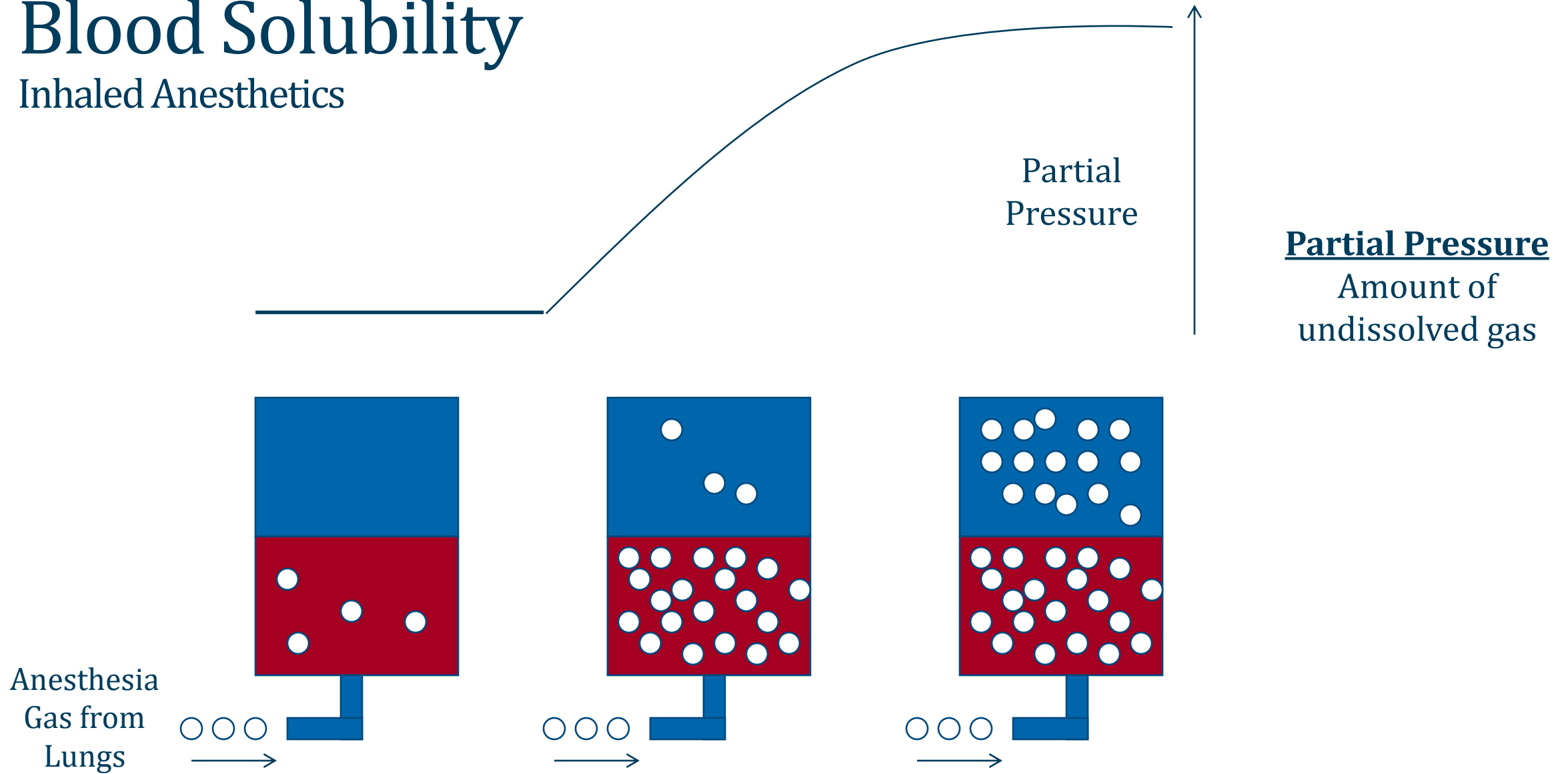
Gas
Good effect

Blood
No effect



Blood Solubility

Inhaled Anesthetics



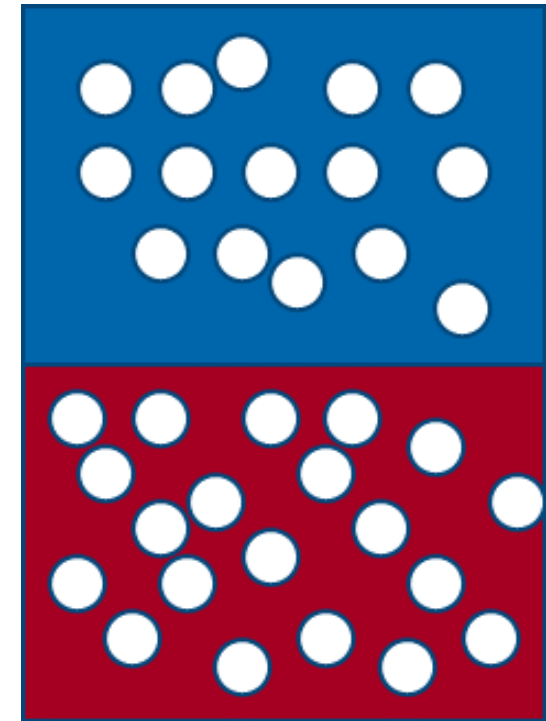
Blood Solubility

Inhaled Anesthetics

- **High blood solubility**
 - Higher tendency to stay in blood
 - Longer time to saturate blood
 - Longer time for partial pressure to rise
 - SLOWER induction and washout time
- **Low blood solubility**
 - Quickly saturates blood
 - Partial pressure rises rapidly
 - Quickly exerts effects on brain
 - SHORTER induction and washout time

Gas
Good effect

Blood
No effect



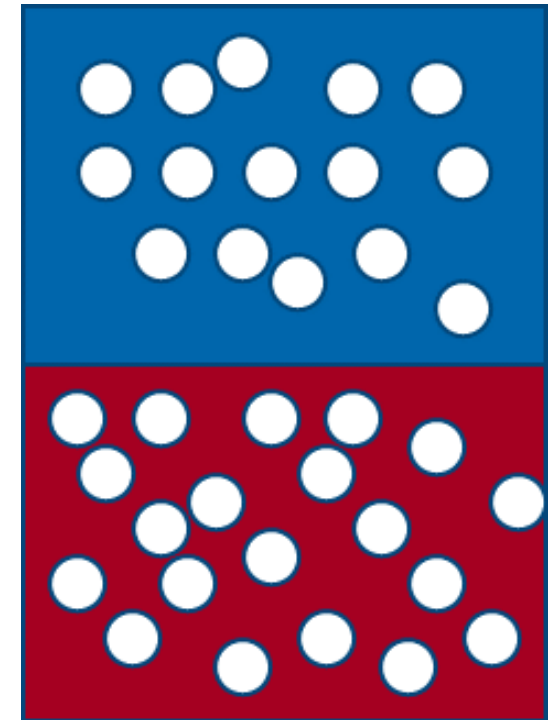
Blood Solubility

Inhaled Anesthetics

- Blood solubility described by **blood/gas partition coefficient**
 - Isoflurane: 1.4
 - $[\text{blood}] 1.4 > [\text{alveoli}]$
- High partition coefficient = high solubility
- Low partition coefficient = low solubility

Gas
Good effect

Blood
No effect



Blood Solubility

Inhaled Anesthetics

Gas	Blood : Gas Partition Coefficient
Halothane	2.3
Isoflurane	1.4
Sevoflurane	0.69
Nitrous Oxide	0.47
Desflurane	0.42

Halothane → SLOW induction/washout

Nitric Oxide → FAST induction/washout

Lipid Solubility

Inhaled Anesthetics

- Affinity of gas for lipids
- Lipid soluble gasses easily diffuse into brain
- ↑ lipid affinity = more potent (Meyer-Overton rule)
- Lower gas concentration required to produce anesthetic effect
- Described by the **oil/gas partition coefficient**

Lipid Solubility

Inhaled Anesthetics

Gas	Oil:gas Partition Coefficient
Halothane	224
Enflurane	99
Isoflurane	98
Sevoflurane	47
Desflurane	28
Nitrous Oxide	<10

Minimum Alveolar Concentration

- Gas concentration (1%, 5%, 10%)
- Prevents movement in **50% of subjects in response to pain**
- Useful parameter in clinical practice
- Determines concentration of gas to administer to patient
- Low MAC = low gas concentration needed = high potency
- High MAC = high gas concentration needed = low potency
- MAC related to lipid solubility

$$\text{Lipid Solubility} = \frac{1}{\text{MAC}}$$

Minimum Alveolar Concentration

Inhaled Anesthetics

Gas	MAC (%)	Oil:gas PC
Halothane	0.8	224
Enflurane	1.8	99
Isoflurane	1.3	98
Sevoflurane	2.5	47
Desflurane	7.2	28
Nitrous Oxide	>100	<10

Minimum Alveolar Concentration

Additive Properties

- When using multiple drugs, MACs are additive
- Allows use of lower concentration of each drug
- Example:
 - Sevoflurane ½ MAC – 25% efficacy
 - Nitrous oxide ½ MAC – 25% efficacy
 - Combination: 1 MAC, 50% efficacy
 - Patient exposed to less of each drug
 - Lower risk of adverse effects

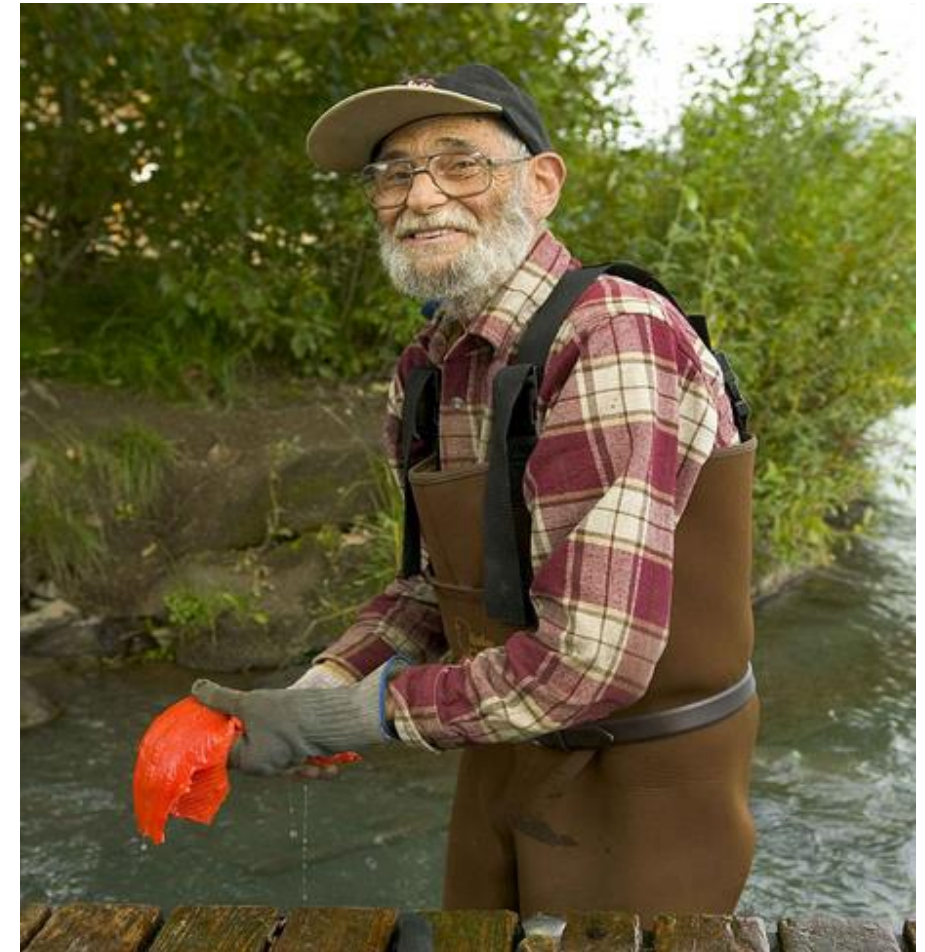
Gas	MAC (%)	Oil:gas PC
Halothane	0.8	224
Enflurane	1.8	99
Isoflurane	1.3	98
Sevoflurane	2.5	47
Desflurane	7.2	28
Nitrous Oxide	>100	<10

Minimum Alveolar Concentration

Inhaled Anesthetics

- Decreases with age
- Also decreases in pregnancy and hypothyroidism

Gas	MAC (%)	Oil:gas PC
Halothane	0.8	224
Enflurane	1.8	99
Isoflurane	1.3	98
Sevoflurane	2.5	47
Desflurane	7.2	28
Nitrous Oxide	>100	<10



Public Domain

Inhaled Anesthetics Summary

- **Onset of action and washout**
 - Blood : gas partition coefficient (higher = slower)
 - Solubility in blood (higher = slower)
- **Potency**
 - Oil : gas partition coefficient (higher = more potent)
 - Solubility in lipids (higher = more potent)
 - MAC (lower = more potent)

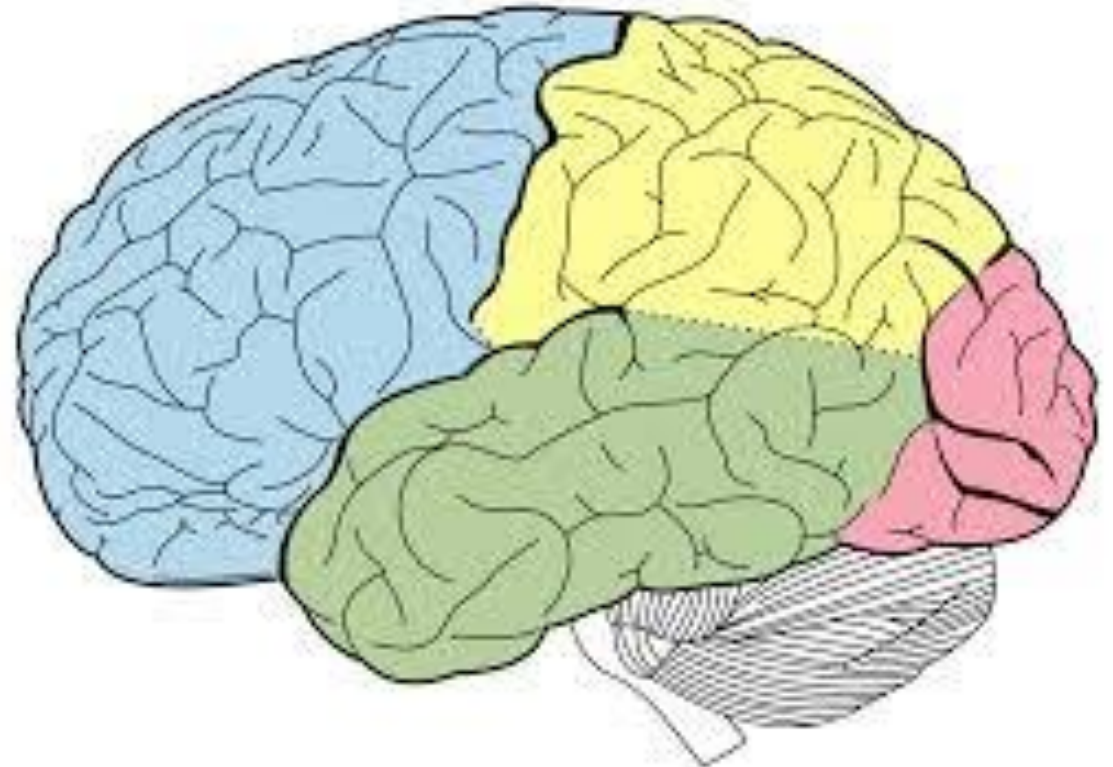


Pxhere.com/Public Domain

Inhaled Anesthetics

Physiologic Effects

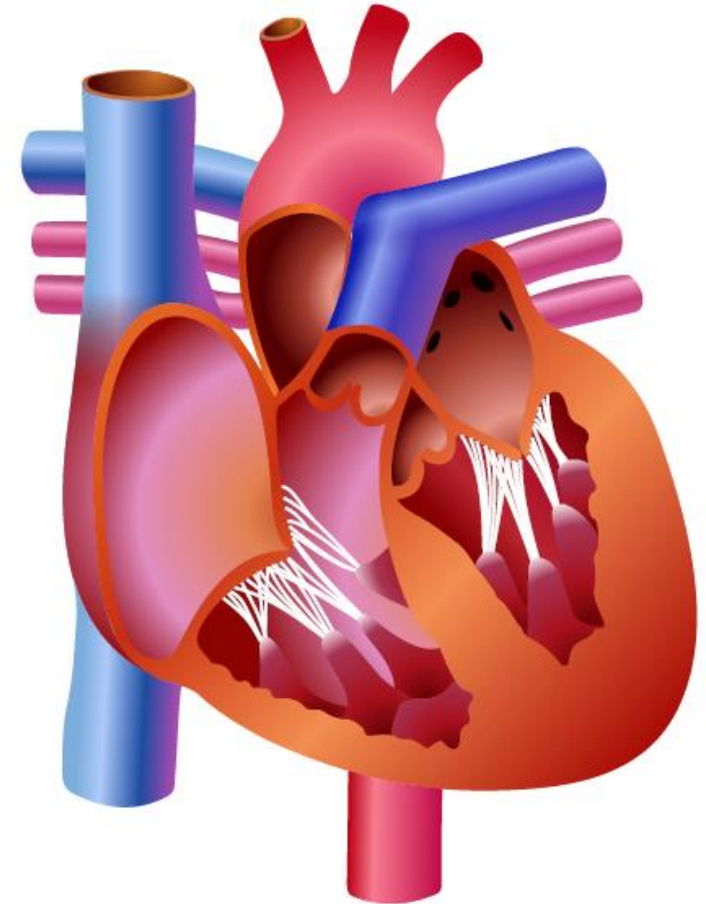
- **↑ cerebral blood flow**
 - Cerebral vasodilation
 - Blood flow goes up
 - ICP goes up
- **Dose-dependent hypotension**
 - Vasodilation:
 - ↓ SVR and ↓ MAP
- Decreased GFR



Inhaled Anesthetics

Physiologic Effects

- **Respiratory depression**
 - ↓ tidal volume
 - ↑ CO₂
- **Myocardial depression**
 - ↓ Cardiac output
 - Minimal with sevoflurane and isoflurane



Specific Inhaled Anesthetics

- **Desflurane, isoflurane, and sevoflurane**

- Most commonly used agents
- Least adverse effects
- Minimal myocardial depression

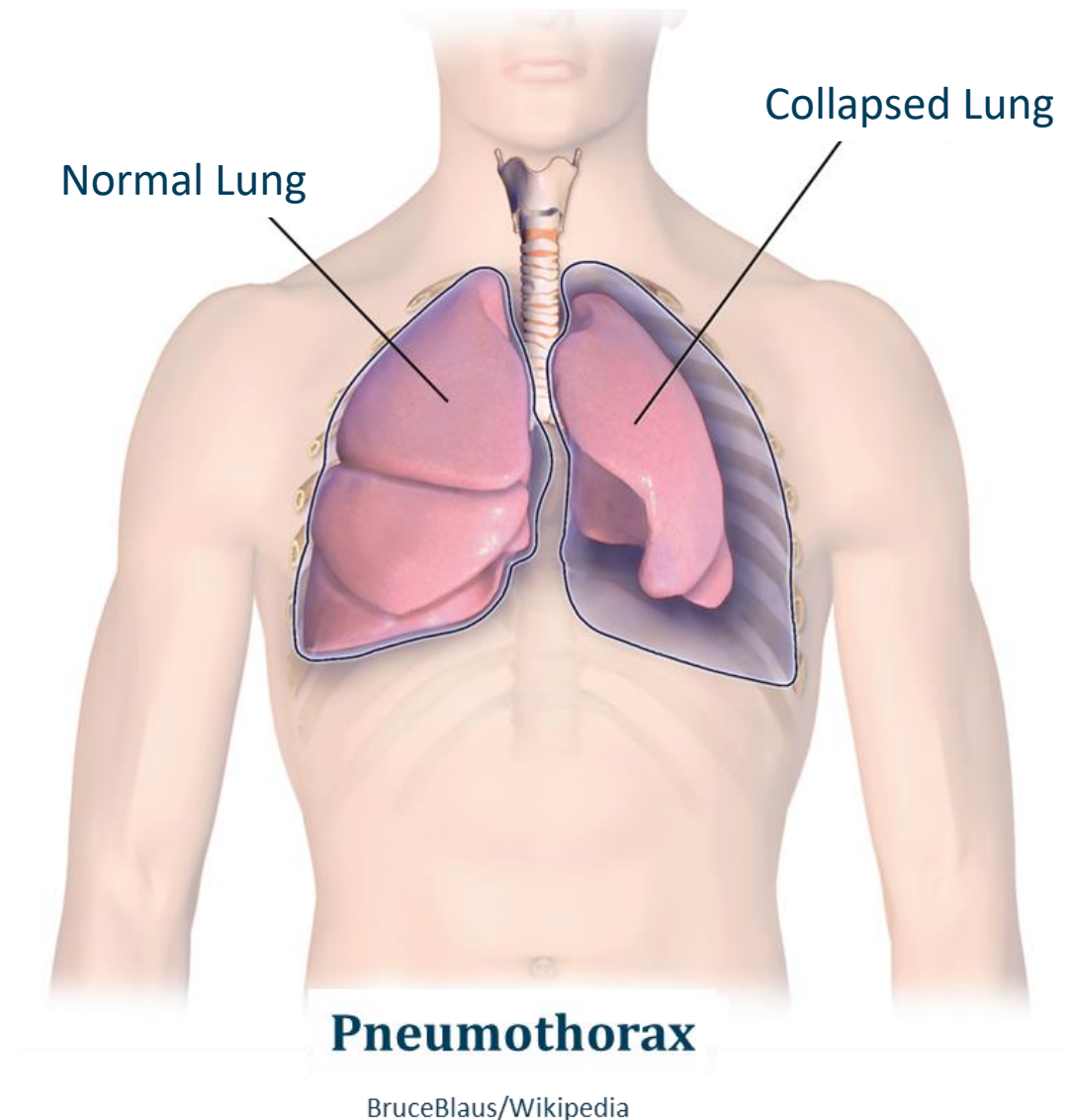
- **Nitrous oxide**

- Low potency
- Cannot deliver more than 0.75 MAC
- Rapid onset/offset
- Can switch to this gas toward end of case
- Frequent nausea and vomiting



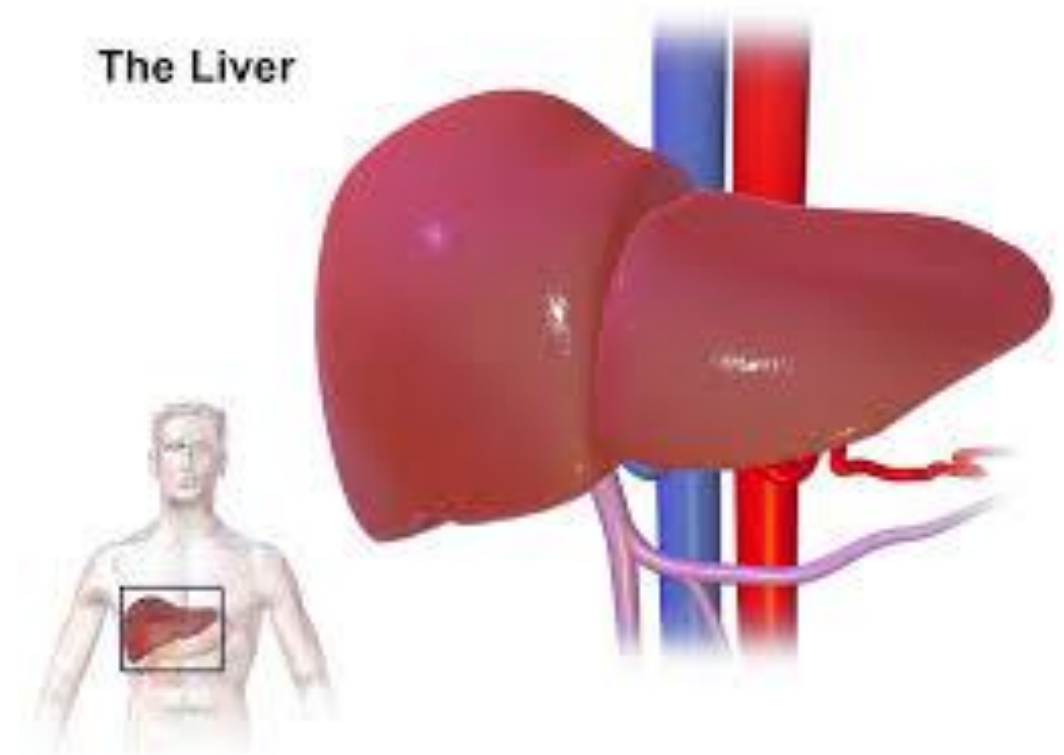
Nitrous Oxide

- Diffuses rapidly into air spaces
- Will increase volume
- Cannot use:
 - Pneumothorax
 - Abdominal distention



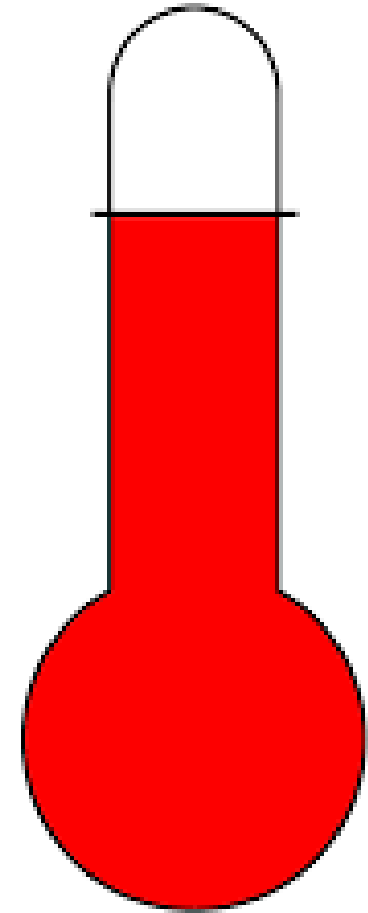
Special Adverse Effects

- **Halothane: hepatotoxicity**
 - Liver toxicity: rare, life-threatening
 - Massive necrosis, increased AST/ALT
 - Still used outside US in resource-poor settings
- **Methoxyflurane: nephrotoxicity**
 - Renal-toxic metabolites
- **Enflurane: seizures**
 - Lowers seizure threshold



Malignant Hyperthermia

- Rare, dangerous reaction to anesthesia drugs
- Associated with inhaled anesthetics
- Also succinylcholine (paralytic)
- Presents as **fever and muscle rigidity**
- Diffuse muscle damage: ↑ CK and hyperkalemia
- Tachycardia and hypertension
- Treatment:
 - Stop offending drug
 - Administer oxygen
 - **Dantrolene (muscle relaxant)**



Stages of Anesthesia

- **Induction**
 - Drugs used to put patient to sleep
 - Usually IV propofol with an opioid (Fentanyl)
 - Once asleep, paralytic agent used prior to intubation
- **Maintenance**
 - Drugs to keep patient asleep
 - Inhaled or intravenous anesthetics (or combination)
 - Sometimes ongoing use of paralytics
- **Emergence**
 - Discontinuation of anesthetics
 - Reversal of neuromuscular blockade
 - Extubation

Intravenous Anesthetics

Jason Ryan, MD, MPH



Intravenous Anesthetics

- **Induction agents**
 - Induce anesthesia
 - Propofol
 - Etomidate
 - Ketamine
- **Adjuvant agents**
 - Supplement effects of induction agents
 - Allow lower dosages of induction agents
 - Opioids
 - Benzodiazepines
 - Lidocaine

Propofol

- **Induction of anesthesia in stable patients**
- GABA modulator
- Causes sedation and amnesia
- Not an analgesic (does not treat pain)
- White liquid
- Rapid onset and offset (minutes)



Propofol

Beneficial Effects

- Antiemetic
- Anticonvulsant
- Antipruritic
- Bronchodilator
- Can be used with liver or renal impairment



Propofol

Adverse Effects

- **Hypotension**
 - Vasodilation and decreased contractility
 - Avoided in hypotensive patients
 - Minimal heart rate change (blunting of baroreceptor reflex)
- Respiratory depression
 - Dose-dependent
- Pain on injection
 - Venous irritation
 - Lidocaine or opioids often co-administered
 - Less likely with central vein infusion



Etomidate

- **Induction of anesthesia in unstable patients**
- Modulates GABA receptors
- Causes sedation and amnesia
- Not an analgesic
- **Relatively hemodynamically neutral**
 - Little effect on HR and BP
 - Good for hypotensive patients
- Rapid onset and offset (like Propofol)
- Anticonvulsant
 - Useful in stroke patients



Etomidate

Adverse Effects

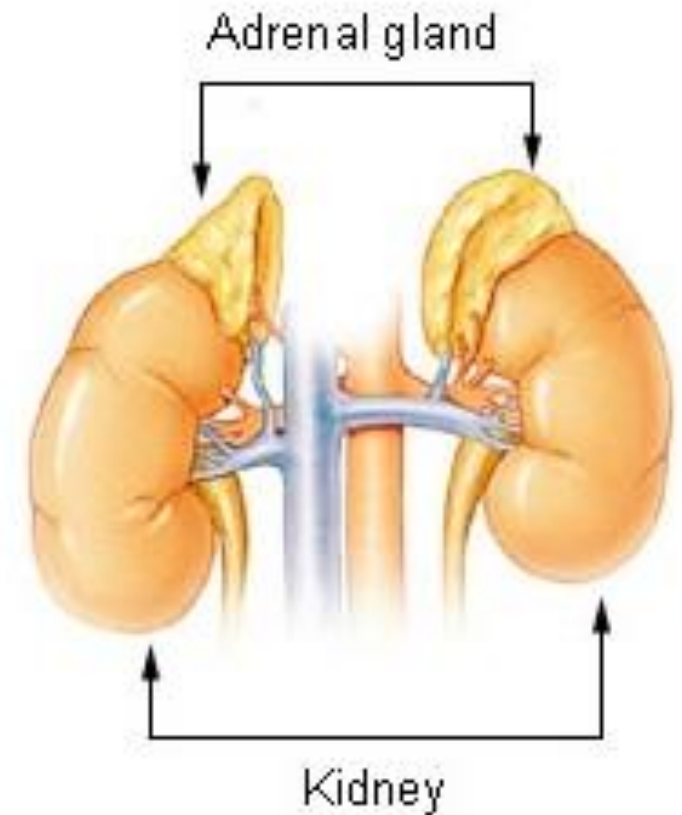
- **Nausea and vomiting**
 - Occurs in up to 30% of patients
 - Contrast with propofol
- **Pain at injection site**
 - Venous irritation
 - Lidocaine or opioids often co-administered
 - Less likely with central vein infusion



Etomidate

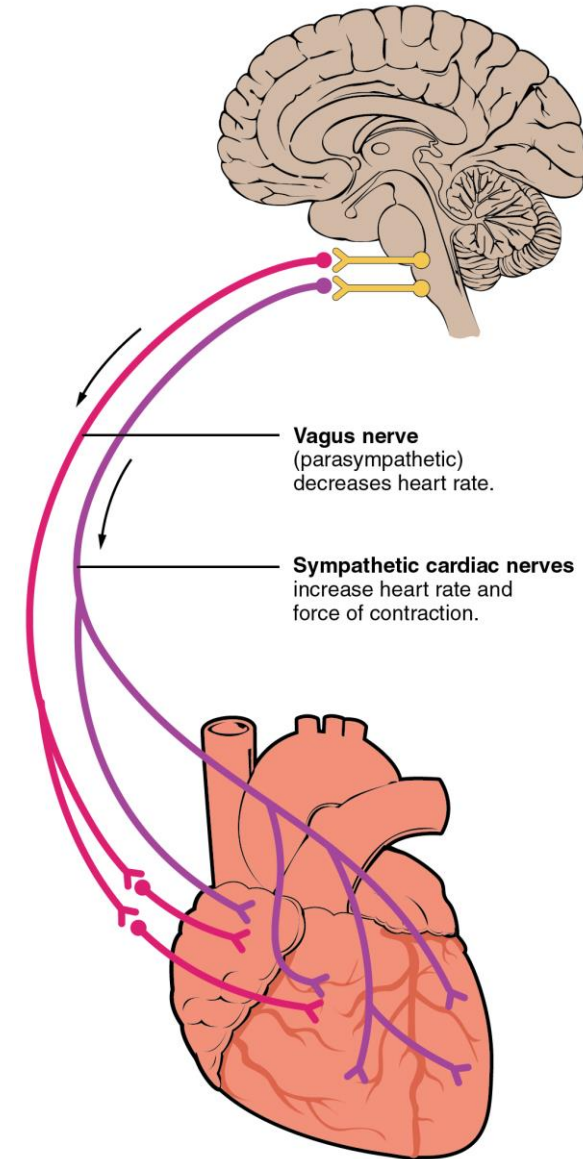
Adverse Effects

- **Myoclonic movements**
 - Subcortical disinhibition
 - Co-administration of opioids or benzodiazepines limits myoclonus
- **Transient acute adrenal insufficiency**
 - Inhibits cortisol synthesis
 - Caution with suspected adrenal insufficiency
 - Caution in patients on chronic steroids



Ketamine

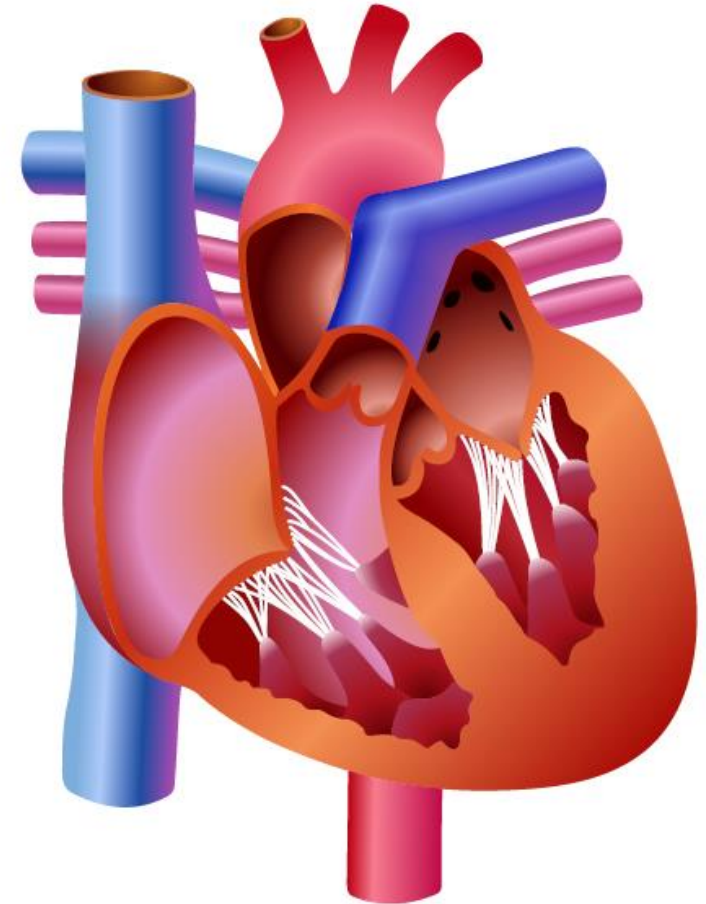
- PCP derivative
- Antagonist of NMDA receptor (glutamate)
- **Increases sympathetic activity**
 - Increased HR, BP, and CO
 - Bronchodilator
 - Increases pulmonary arterial pressure
- Rapid onset and offset (like Propofol)
- Powerful analgesic properties



Ketamine

Adverse Effects

- **Sympathetic nervous system activation**
 - Dangerous in certain patient populations
 - Ischemic heart disease
 - Systemic hypertension
 - Pulmonary arterial hypertension
 - Right heart failure



Ketamine

Adverse Effects

- **“Emergence Reactions”**
 - Occur on emergence from anesthesia
 - Disorientation
 - Vivid dreams, nightmares, or hallucinations
 - Can be frightening to patients
- Co-administration of benzodiazepines reduces these effects



Piqsels

Rapid Sequence Intubation

- Standard practice for emergent intubation
- Renders patient sedated and flaccid
- Induction: **etomidate**
 - Lack of hemodynamic effects useful
 - Alternative agents can be used
 - Ketamine, Propofol, benzodiazepines, opioids
- Paralysis: **succinylcholine**
 - Alternatives: rocuronium or vecuronium



Privatarchiv Foto von MrArifnajafov

Opioids

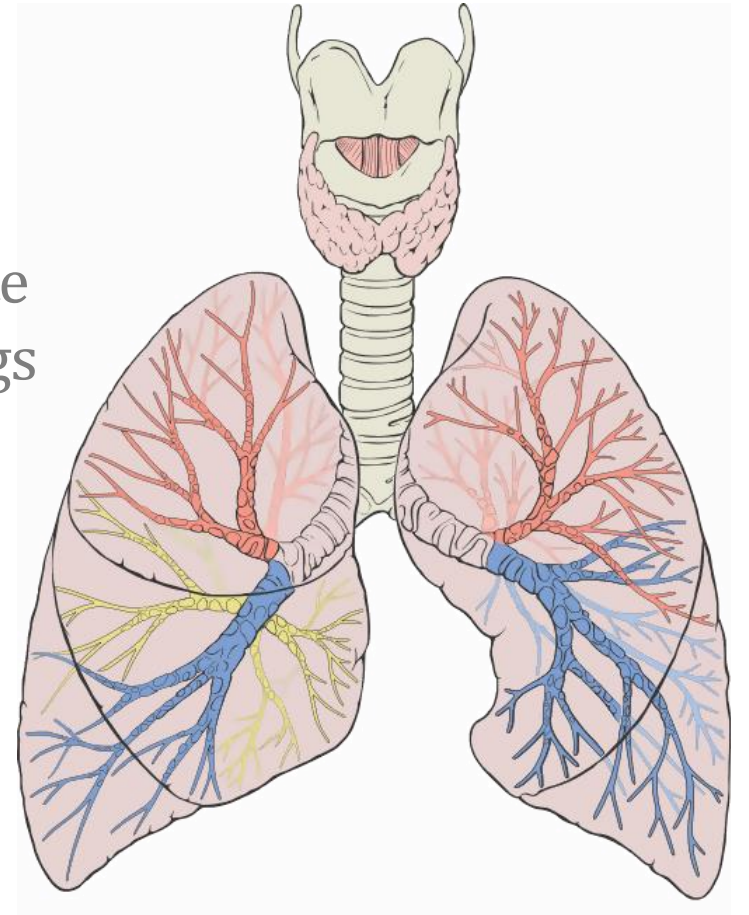
Fentanyl

- Act on opioid receptors in brain, spinal cord, and nerves
- Sedative and analgesic effects
- No amnesia effects
- **Intravenous fentanyl** commonly used in anesthesia

Opioids

Advantageous Effects

- **Suppression of airway reflexes**
 - Minimizes stress response to intubation
 - Avoids tachycardia and hypertension during intubation
- Reduces pain from IV injection of propofol or etomidate
- Sedative effects reduce dose requirement of other drugs



Patrick Lynch/Wikipedia

Opioids

Adverse Effects

- Hypotension
- Respiratory depression
- Post-op opioid adverse effects
 - Nausea and vomiting
 - Constipation
 - Urinary retention
 - Delirium

Benzodiazepines

Midazolam

- Bind to GABA receptors → ↑ GABA activity
- Low dose: anti-anxiety effects (anxiolytic)
- High dose: sedation, amnesia, and anticonvulsant effects
- **Intravenous midazolam (Versed)**
 - Short acting benzodiazepine
 - Used for brief procedures (endoscopy)
 - Continuous infusion as adjunct for longer procedures

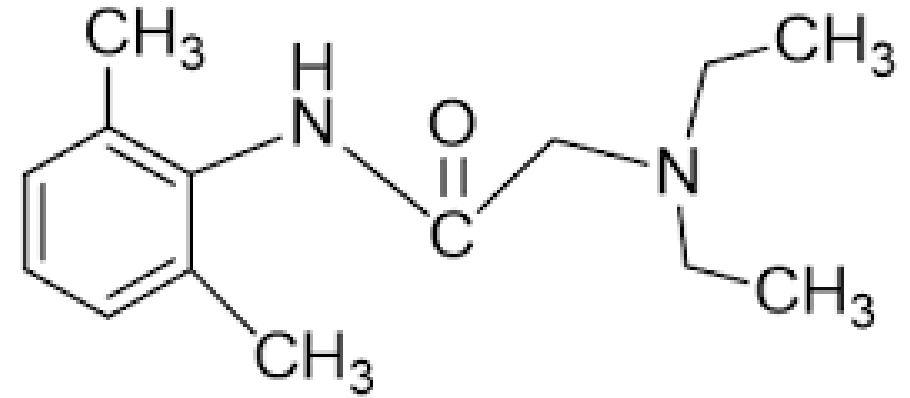
Benzodiazepines

Midazolam

- Beneficial effects
 - Anxiolytic prior to procedure
 - Amnesia
 - Anticonvulsants
 - Sedative effects reduce dose requirement of other drugs
- Few adverse effects
 - Mild fall in blood pressure may occur
 - Dose-dependent respiratory depression

Lidocaine

- Local anesthetic
- Given intravenously as anesthesia adjunct
- Sodium channel blockade
- Inhibits sympathetic nerve function
- Suppresses cough reflex for intubation
- Reduces pain from IV injection of propofol or etomidate
- Adverse effects
 - Increases hypotensive effects of other anesthetics
 - Increases the ventricular rate in patients with atrial fibrillation



Stages of Anesthesia

- **Induction**
 - Drugs used to put patient to sleep
 - IV propofol with an opioid (Fentanyl)
- **Maintenance**
 - Drugs to keep patient asleep
 - Inhaled or intravenous anesthetics (or combination)
 - Propofol plus fentanyl
- **Emergence**

Neuromuscular Blockers

Jason Ryan, MD, MPH



Neuromuscular Blocking Agents (NMBAs)

Paralytics

- **Non-depolarizing NMBAs**
 - Rocuronium
 - Vecuronium
 - Atracurium
 - Cisatracurium
- **Depolarizing NMBAs**
 - Succinylcholine



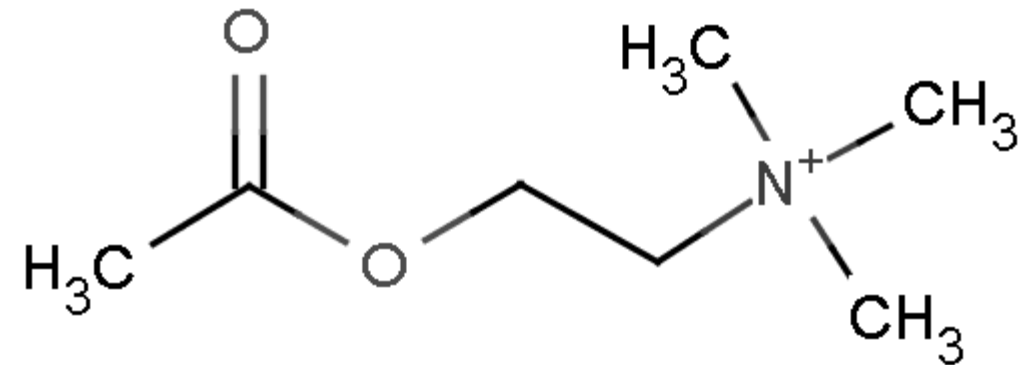
Pxhere.com/Public Domain

Non-depolarizing NMBA

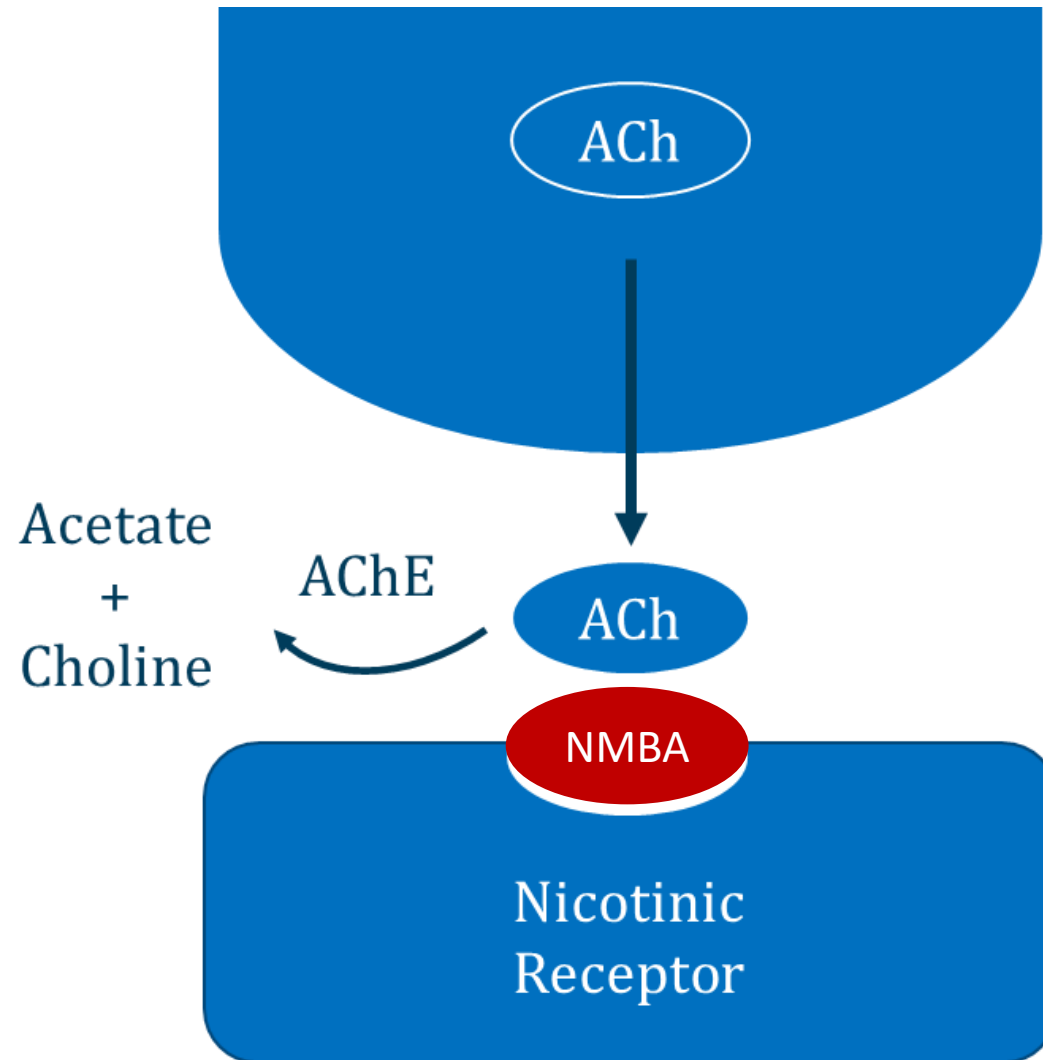
Rocuronium, Vecuronium, Atracurium, Cisatracurium

- **Competitive antagonists** of acetylcholine at nicotinic receptors
- Block acetylcholine effects
- Do not cause muscle depolarization
- Produce flaccid paralysis
- Paralysis can be reversed by flooding synapse with ACh
- Done by inhibiting acetylcholinesterase

Acetylcholine



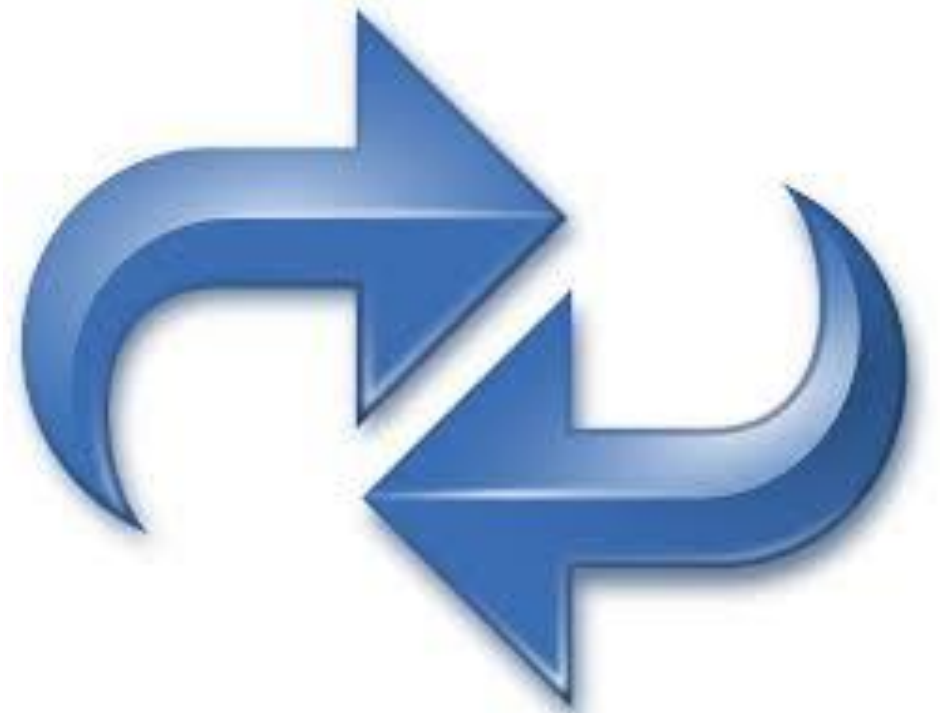
Non-depolarizing NMBA



Acetylcholinesterase Inhibitors

Reversal of non-depolarizing NMBAs

- **Neostigmine**
 - Preferred drug
- **Edrophonium**
 - Faster acting but weaker effect
- Usually given with **glycopyrrolate or atropine**
 - Muscarinic antagonists
 - Prevent excessive muscarinic activation



Non-depolarizing NMBAs

Rocuronium, Vecuronium, Atracurium, Cisatracurium

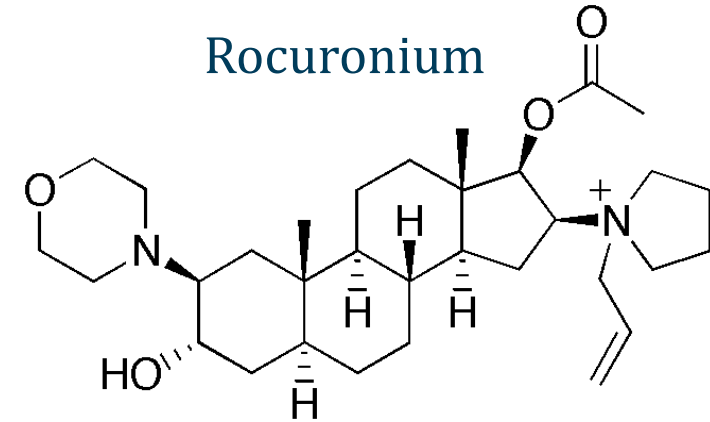
- **Steroidal compounds**

- Rocuronium
- Vecuronium

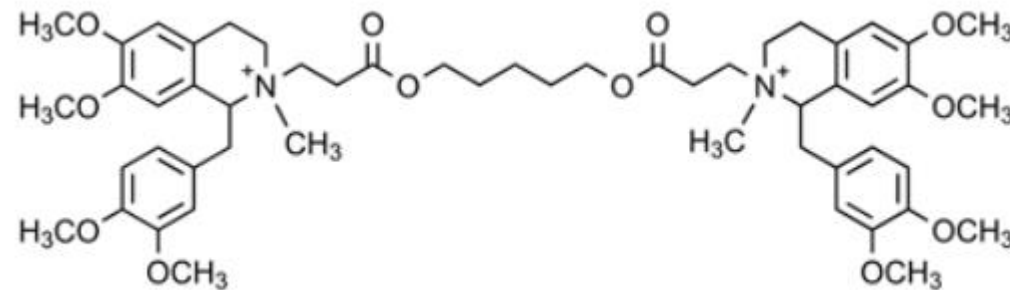
- **Benzylisoquinolinium compounds**

- Atracurium
- Cisatracurium

Rocuronium



Atracurium



Non-depolarizing NMBA

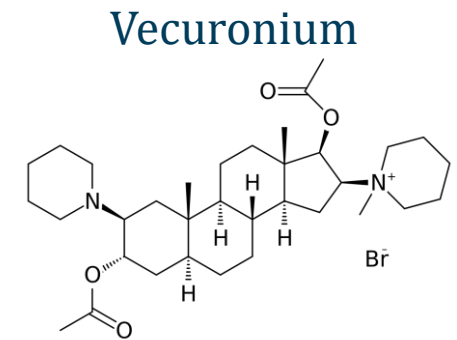
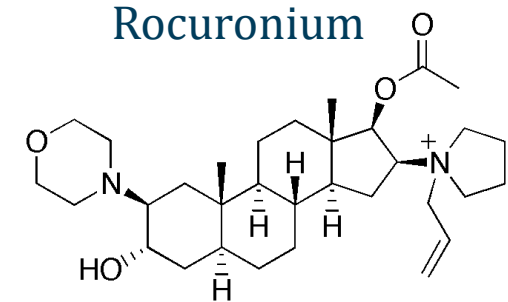
Steroidal Compounds

Drug	Characteristics
Rocuronium	Rapid onset like succinylcholine Mostly biliary excretion with some renal
Vecuronium	Slower onset than rocuronium Biliary and renal excretion

* Caution in patients with liver or kidney disease

Sugammadex

- **Inactivates steroidal NMBAs**
 - Binds and encapsulates drug molecules
 - Pulls drug from plasma and away from receptors
 - Used to reverse vecuronium and rocuronium
- **No cholinergic effects like neostigmine**
- **Faster acting than neostigmine**
- Adverse effects
 - Reports of anaphylaxis
 - Bradycardia and asystole may occur
 - EKG monitoring required



Asystole



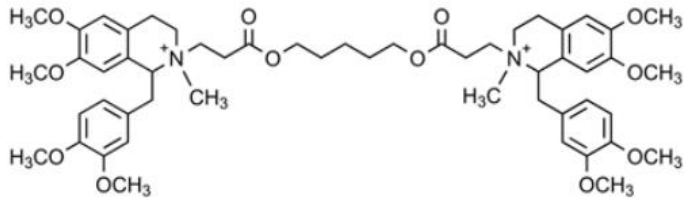
Non-depolarizing NMBA

Benzylisoquinolinium compounds

Drug	Characteristics
Atracurium	Can cause histamine release Flushing, hypotension, and tachycardia Hoffman elimination
Cisatracurium	Isomer of atracurium More potent than atracurium No histamine release Hoffman elimination

Hofman Elimination

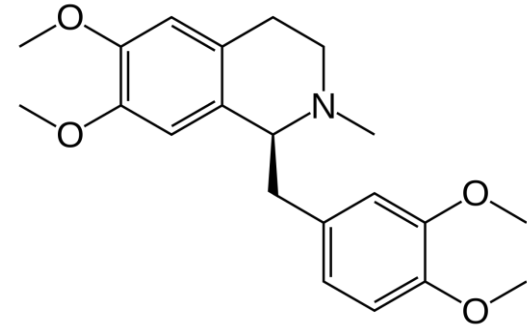
Atracurium



Spontaneous
Non-enzymatic



Laudanosine
(inactive metabolite)



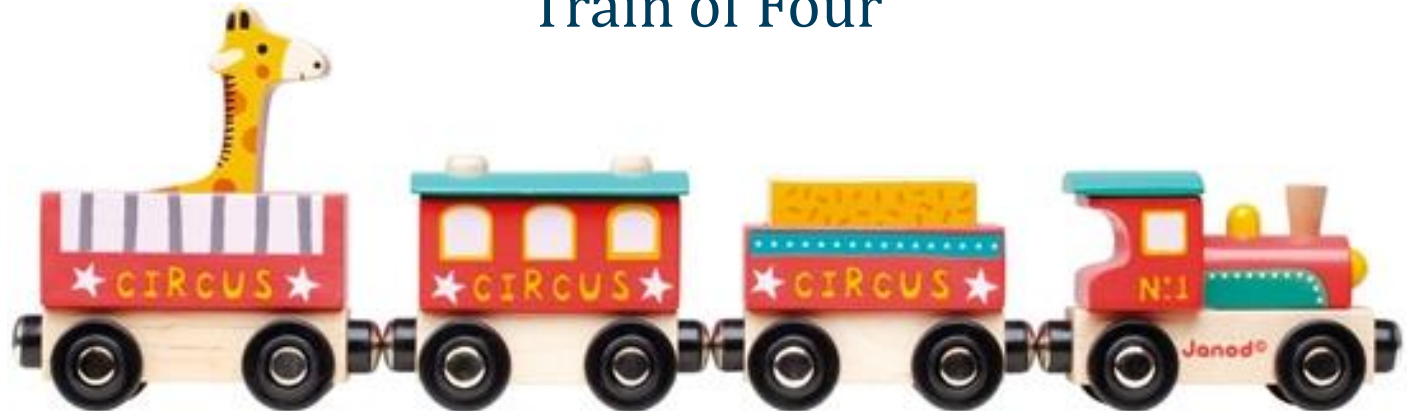
- Not dependent on liver or renal function
- No dose adjustment for liver/renal impairment

Non-depolarizing NMBAs

Assessing Neuromuscular Blockade

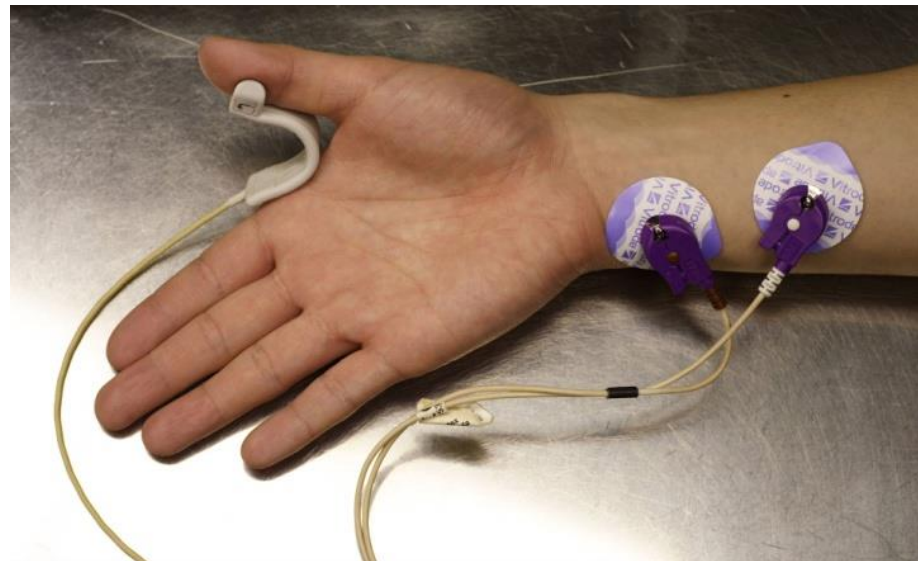
- Neuromuscular blockade fades with time
- Additional doses may be required
- Need assessment of blockade status
- Common assessment methods:
 - Train-of-Four
 - Tetanic Stimulation

Train of Four



Train of Four

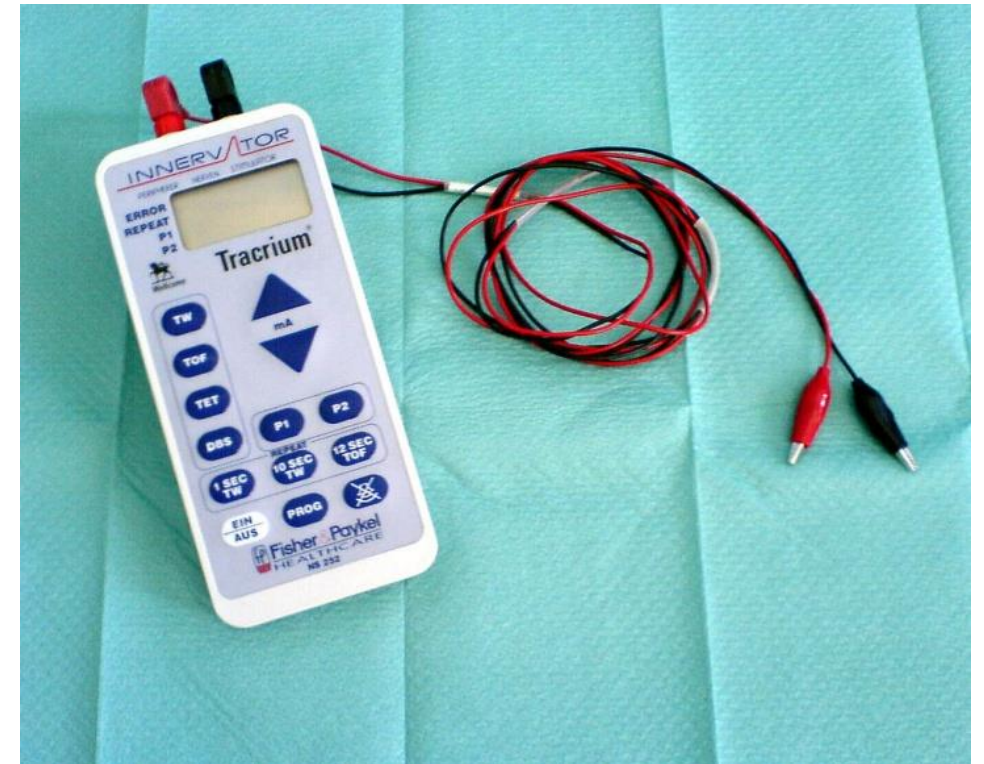
- Assessment of neuromuscular blockade in patients under anesthesia
- Four electrical stimulations applied to nerve (usually ulnar)
 - First stimulation: T1
 - Last stimulation: T4
- Amplitude of twitch will decrease with each stimulation (“fade”)



Ignis

Train of Four

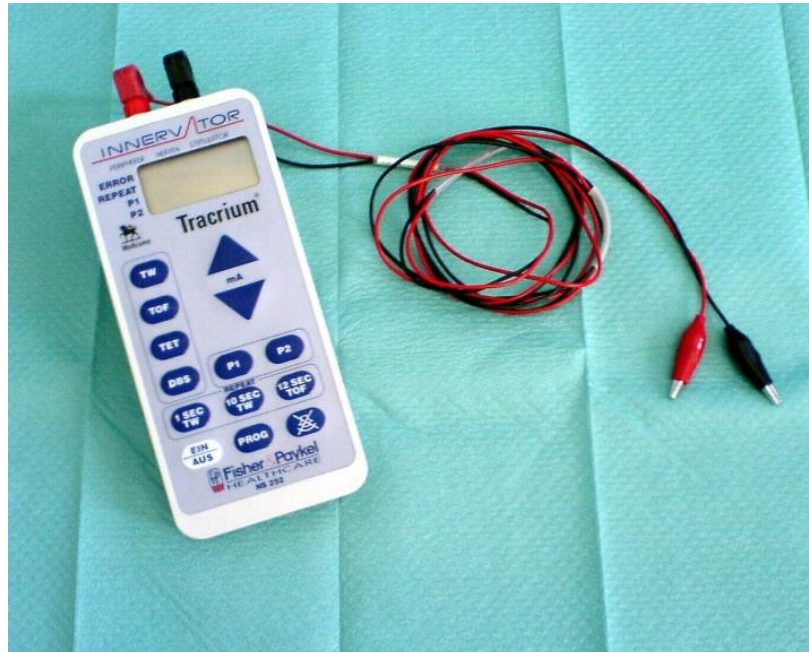
- **Eventually T4 lost, followed by T3, T2, and T1**
 - More block by drug → less contraction
 - Zero = all receptors blocked
- On recovery, pattern reverses
 - T1 returns first, T4 last



Paunami

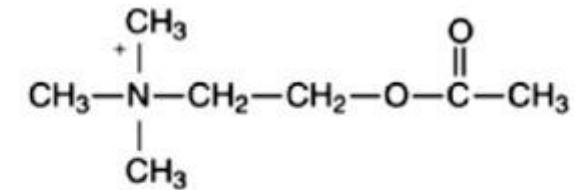
Tetanic Stimulation

- Nerve stimulated at high frequency for about 5 seconds
- Normal response is sustained contraction (tetany)
- After NMBA, contraction absent, weak, or cannot be sustained

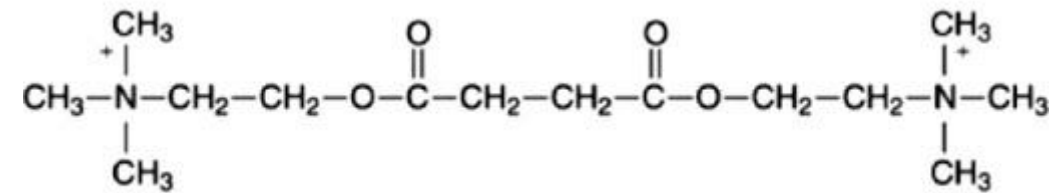


Succinylcholine

- Unique paralytic agent
- Only **DEPOLARIZING** neuromuscular blocker
- Two acetylcholine molecules joined together
- Strong nicotinic Ach receptor agonist
- Metabolized by butyrylcholinesterase
- Binds receptors → sustained depolarization
- Muscle unable to contract
- No fade with train of four

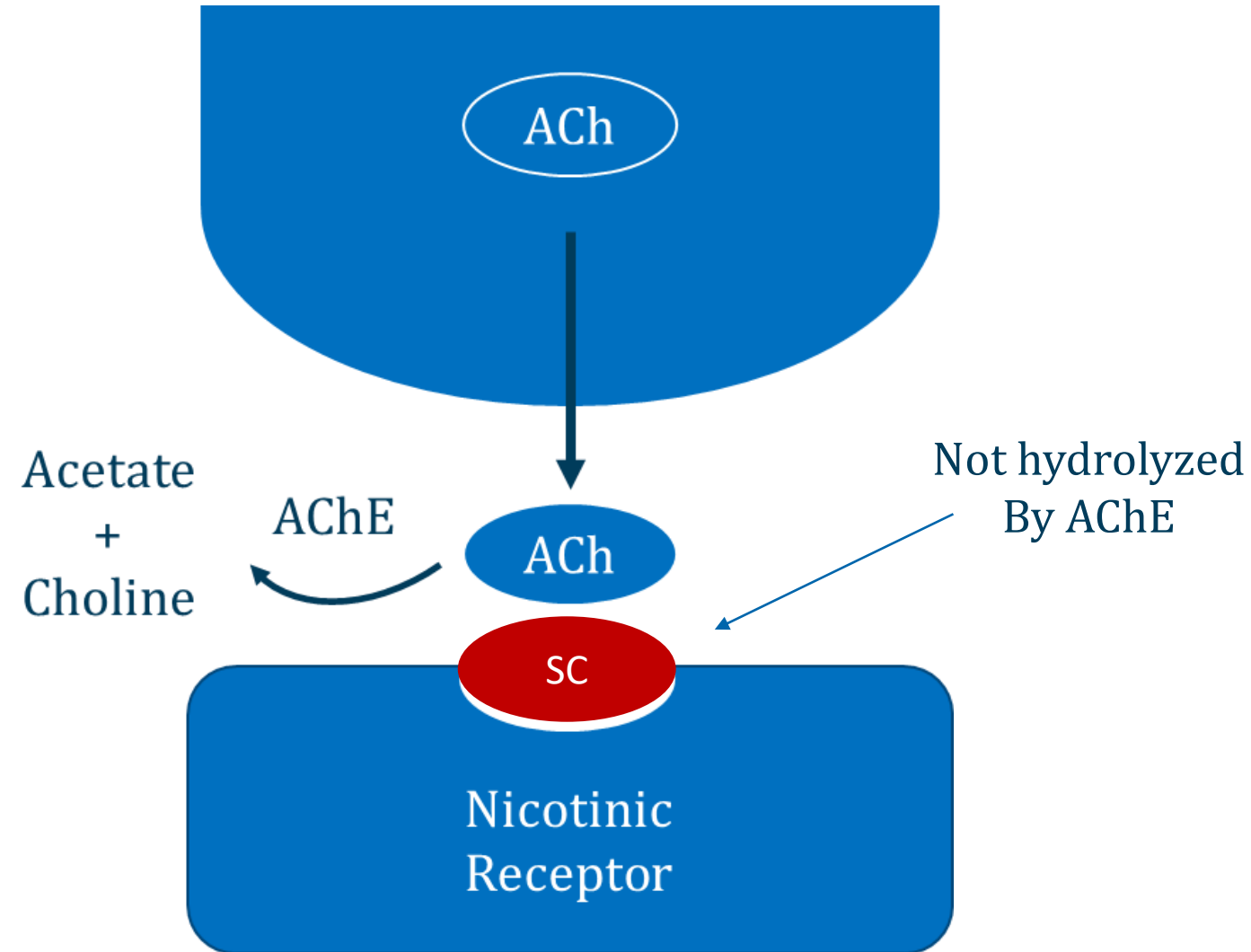


Acetylcholine



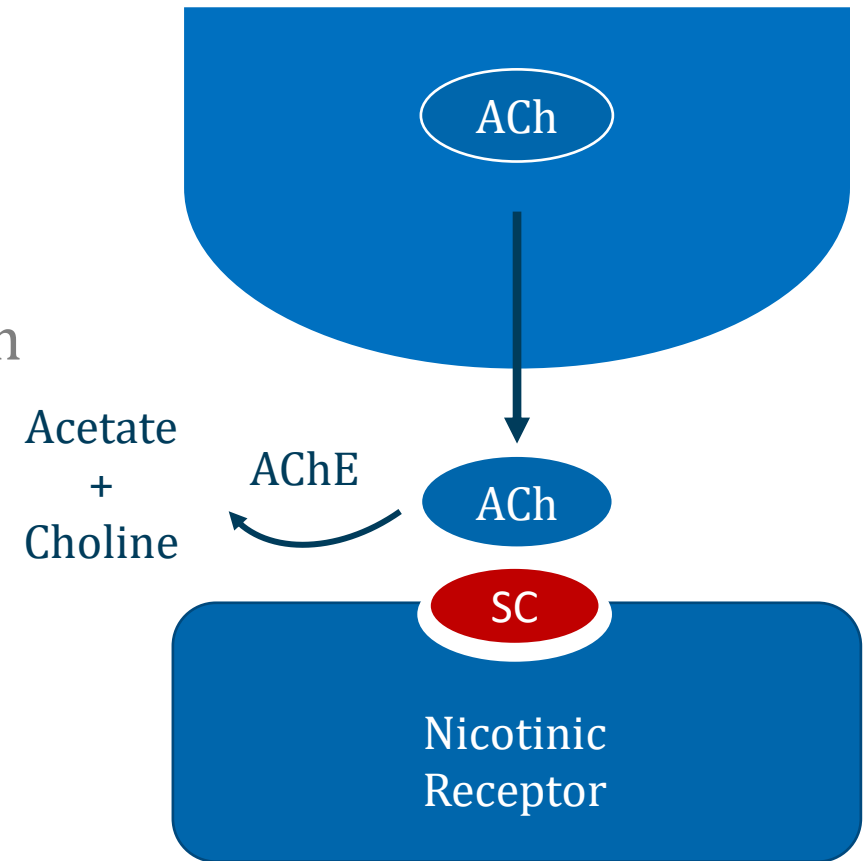
Succinylcholine

Succinylcholine



Succinylcholine

- **Fastest onset and washout of NMBAs**
 - Onset within 30 seconds
 - Paralysis in 1 to 2 minutes
 - Duration of usual dose ~10 minutes
- Usually given as a bolus for temporary paralysis
- Initially causes fasciculations from depolarization
- Followed by flaccid paralysis
- Cannot be reversed
 - Must wait for washout
 - Metabolized by butyrylcholinesterase



Rapid Sequence Intubation

- Standard practice for emergent intubation
- Renders patient sedated and flaccid
- Induction: **etomidate**
- Paralysis: **succinylcholine**



Privatarchiv Foto von MrArifnajafov

Succinylcholine

- Main side effect is **hyperkalemia**
 - Depolarization causes leakage of potassium
 - Usual increase of 0.5 to 1.0 mEq/L
 - Avoid in patients with hyperkalemia
- **Burn patients and stroke patients**
 - Upregulated nicotinic ACh receptors
 - High risk of hyperkalemia
 - Avoid succinylcholine

1 H			
3 Li	4 Be		
11 Na	12 Mg		
19 K	20 Ca	21 Sc	22 Ti
37 Rb	38 Sr	39 Y	40 Zr

Succinylcholine

- **Malignant hyperthermia**
 - Fever and muscle rigidity
 - Associated with inhaled anesthetics and succinylcholine
- **Myalgias**
 - Half of patients have myalgias after receiving succinylcholine
 - Treat with NSAIDs



Succinylcholine

Phases of Neuromuscular Block

- **Phase 1 block**
 - Typical phase seen clinically with bolus dosing
 - Muscles depolarize
 - Initial contraction, then flaccid paralysis
 - **Cannot overcome block with more Ach**
 - No fade with train of four



Succinylcholine

Phases of Neuromuscular Block

- **Phase 2 block**
 - Occurs after large or sustained dosages (rare)
 - Membrane repolarizes but receptor desensitized
 - Muscle no longer reacts normally to acetylcholine
 - Can overcome block with more ACh
 - Paralysis behaves like non-depolarizing drugs
 - Can see TOF fade



Succinylcholine

Phase II Block

- Suspected if succinylcholine given as infusion or in large doses
- **Paralysis similar to non-depolarizing block**
 - Fade with train-of-four
 - Absent in phase I block
- Management
 - Block may be reversed by acetylcholinesterase inhibitors (controversial)
 - Or simply wait until block resolves



NMBAs

Common Clinical Uses

- Intubation
- Surgery
- Severe hypoxemia
 - ICU patients on ventilators
 - Prevent spontaneous respiratory efforts
 - Limits ventilator desynchrony



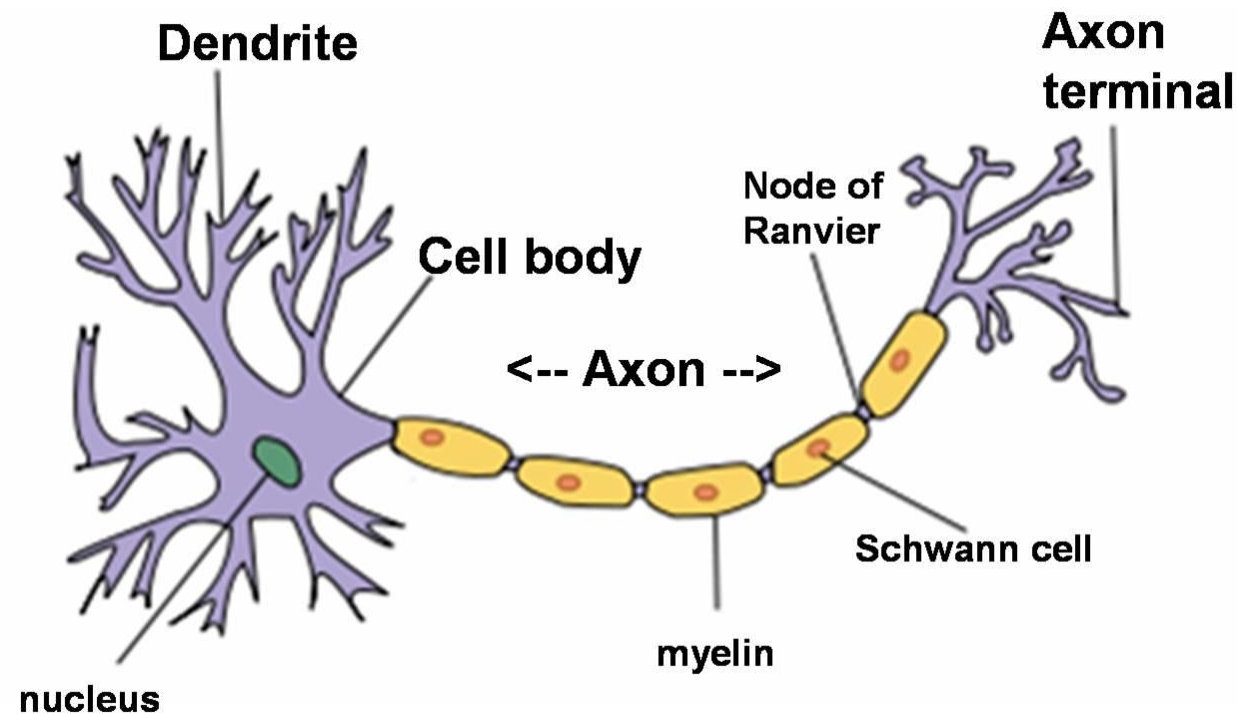
Local and Regional Anesthesia

Jason Ryan, MD, MPH



Local Anesthetics

- Block sodium channels in nerves
- Limits signal propagation → loss of sensation



Local Anesthetics

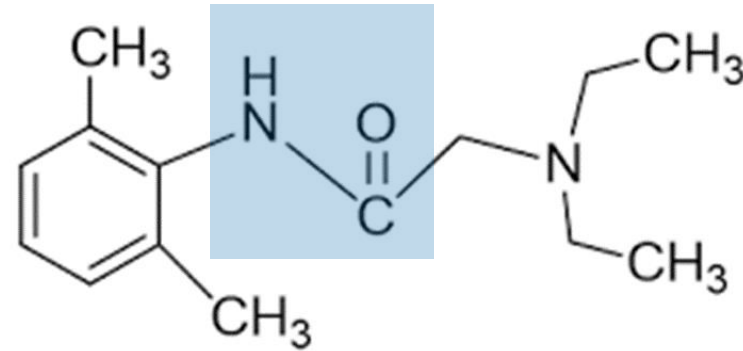
- **Amides**

- Lidocaine
- Mepivacaine
- Bupivacaine

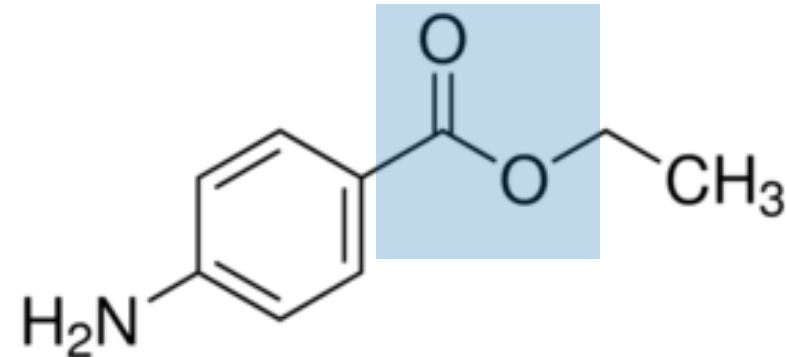
- **Esters**

- Procaine
- Benzocaine
- Tetracaine

Lidocaine



Benzocaine



Differential Blockade

- Certain nerve fibers affected before others
- Loss of sympathetic tone often causes **vasodilation**

Order of Block	Nerves
1	Sympathetic
2	Pain
3	Temperature
4	Pressure
5	Motor

Duration of Action

- Varies by drug
- Shortest duration: procaine
- Medium duration: lidocaine and mepivacaine
- Longest duration: bupivacaine and tetracaine



Flickr/Public Domain

Local Anesthetics

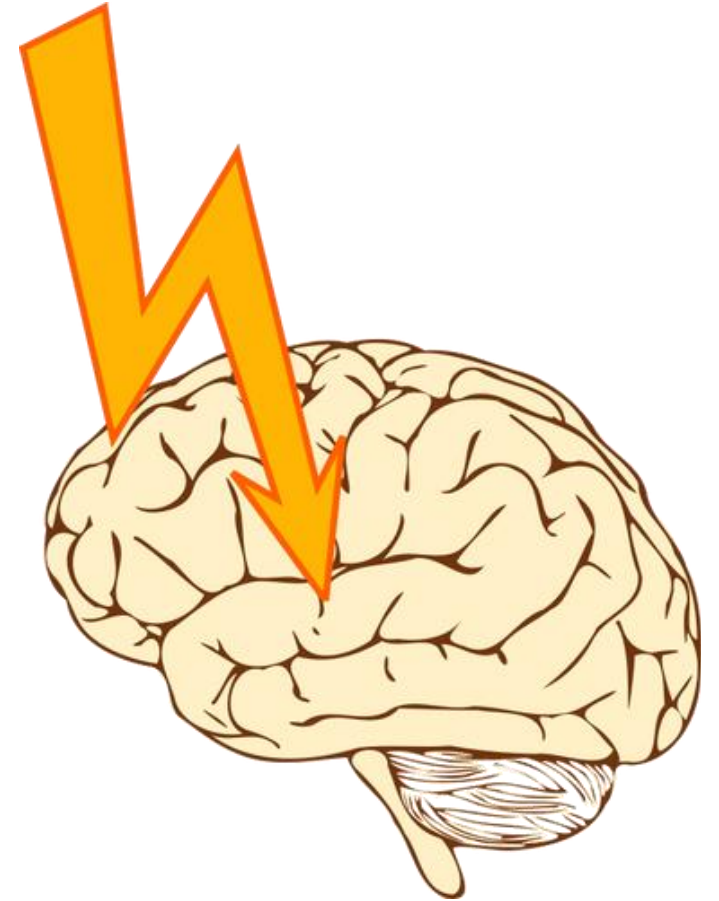
Adverse Effects

- Systemic adverse effects are rare
- Occur with accidental injection into a blood vessel
- Or excessive dose that exceeds maximum recommended dose
- No antidote: treatment of adverse effects is supportive
- Major systems affected: **central nervous system** and **heart**

Local Anesthetics

CNS Effects

- Drugs block inhibitory nerve pathways → excitement
- Perioral numbness
- Metallic taste
- Mental status changes or anxiety
- Muscle twitching
- Seizures

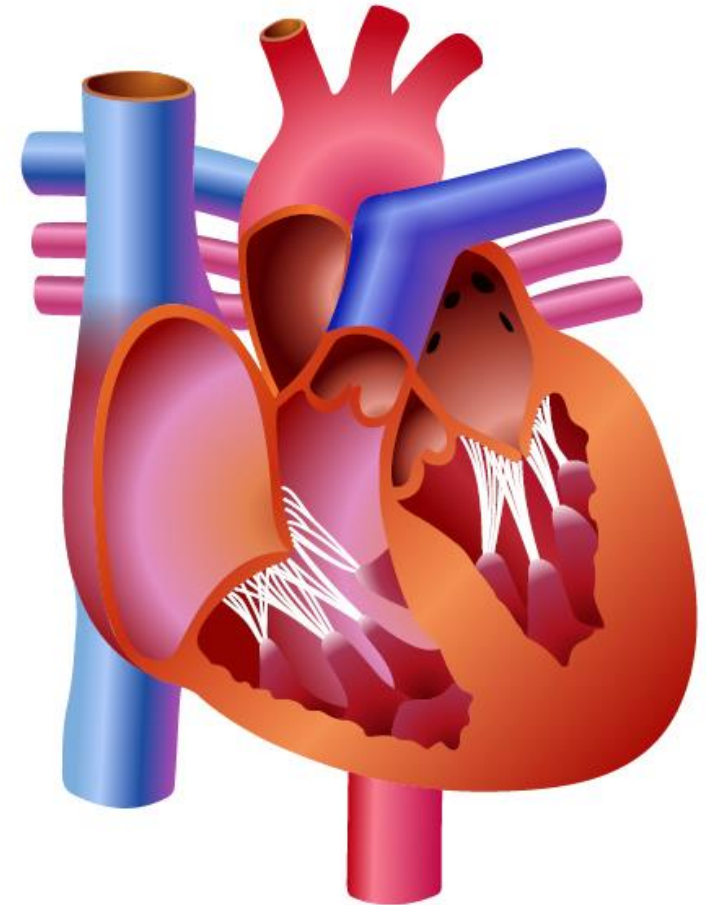


Public Domain

Local Anesthetics

Cardiac Effects

- Variable effects
- Tachycardia and hypertension
- Sometimes bradycardia and hypotension
- Ventricular arrhythmias or asystole
- Bupivacaine most cardiotoxic



Methemoglobinemia

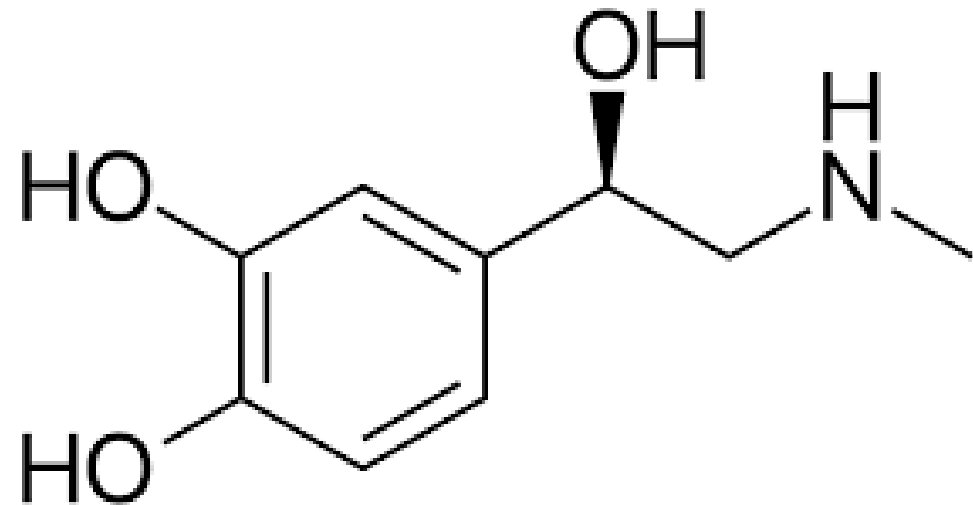
- Iron in hemoglobin $\text{Fe}^{2+} \rightarrow \text{Fe}^{3+}$
- Loss of oxygen binding ability
- Leads to dyspnea that does not improve with oxygen
- “Chocolate-brown blood”
- Acquired methemoglobinemia from drugs
 - Local anesthetics
 - Nitric oxide
 - Dapsone
- Treatment: **methylene blue**



Adding Epinephrine

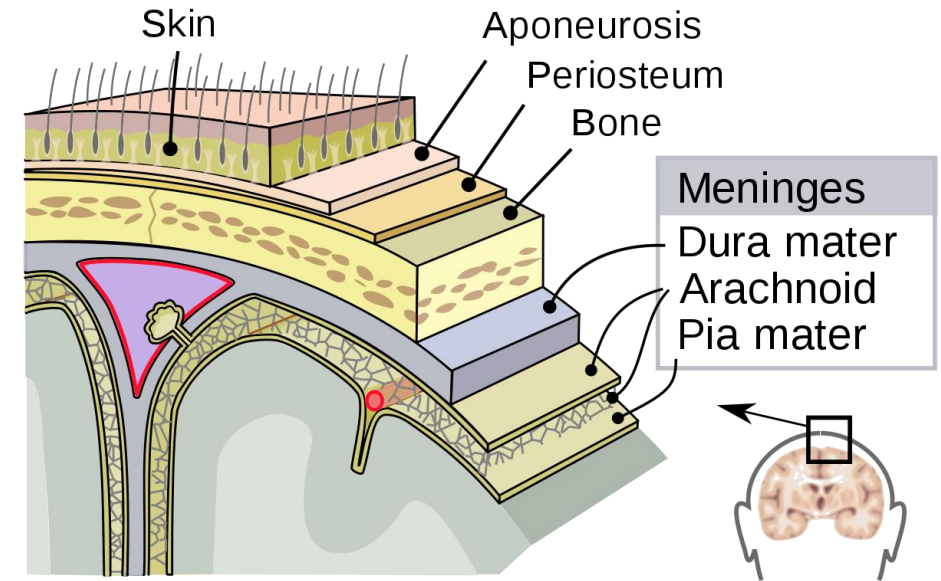
- Local anesthetics can be given with epinephrine
- Causes vasoconstriction
- Less bleeding
- Less washout → more local effect

Epinephrine



Spinal and Epidural Anesthesia

- Needle or catheter inserted for injection of a local anesthetic
- Spinal anesthesia: subarachnoid space
 - Injection into CSF
 - “Intrathecal” injection
- Epidural anesthesia: epidural space
- Patient remains conscious

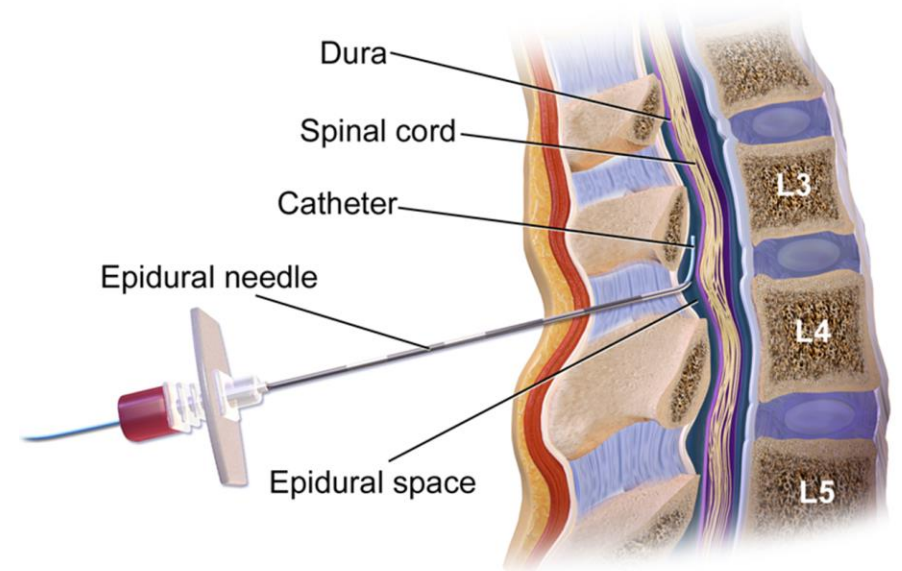


Wikipedia/Public Domain

Spinal and Epidural Anesthesia

- Most commonly used drug: **bupivacaine**
- Other drugs often co-administered: fentanyl, morphine
- Used in procedures involving lower body
 - Lower abdominal surgery
 - Lower extremity surgery
 - OB/GYN surgery
 - Childbirth

Epidural Anesthesia



Wikipedia/Public Domain

Spinal and Epidural Anesthesia

- **Spinal**
 - Usually a single injection of medication
 - Rapid onset of block
- **Epidural**
 - Usually a continuous infusion
 - Allows prolonged sensory block
- **Combined spinal-epidural**
 - Initial spinal for quick nerve block
 - Followed by epidural



Privatarchiv Foto von MrArifnajafov

Spinal and Epidural Anesthesia

Adverse Effects

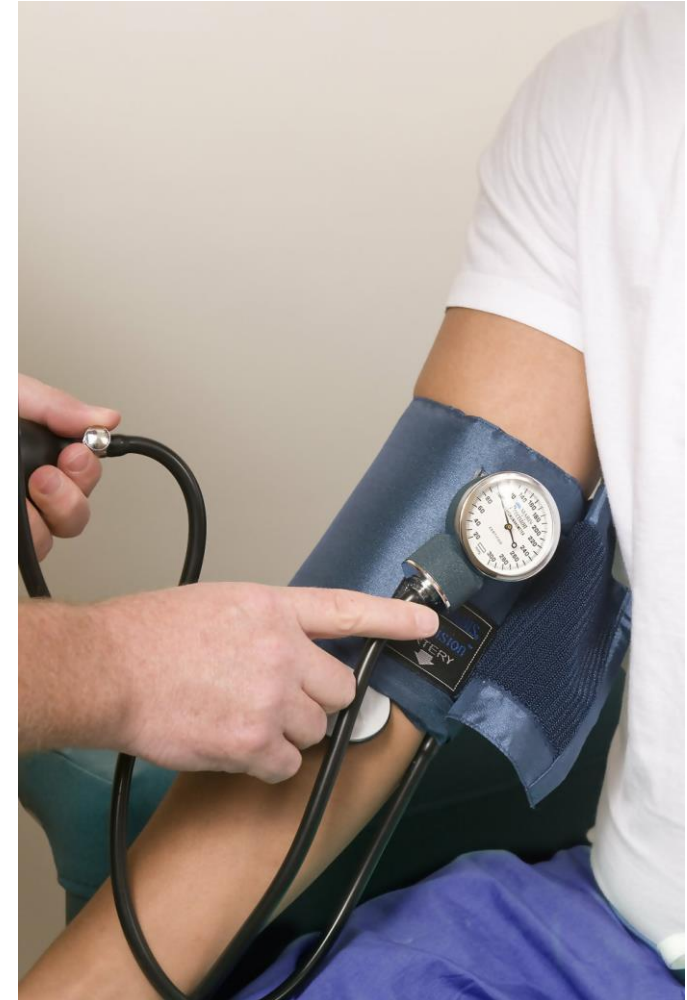
- **Transient neurologic symptoms**
 - Pain or paresthesias in buttocks or lower extremities
 - Hours after spinal anesthesia
 - Neuro exam normal
 - Etiology unclear
 - Improves with ambulation or NSAIDs
 - Almost always resolves within days



Spinal and Epidural Anesthesia

Adverse Effects

- Hypotension
 - Inhibition of sympathetic nerves
- Systemic toxicity
 - Accidental injection of high volume
 - Or injection into an epidural vein



Public Domain

Spinal and Epidural Anesthesia

Adverse Effects

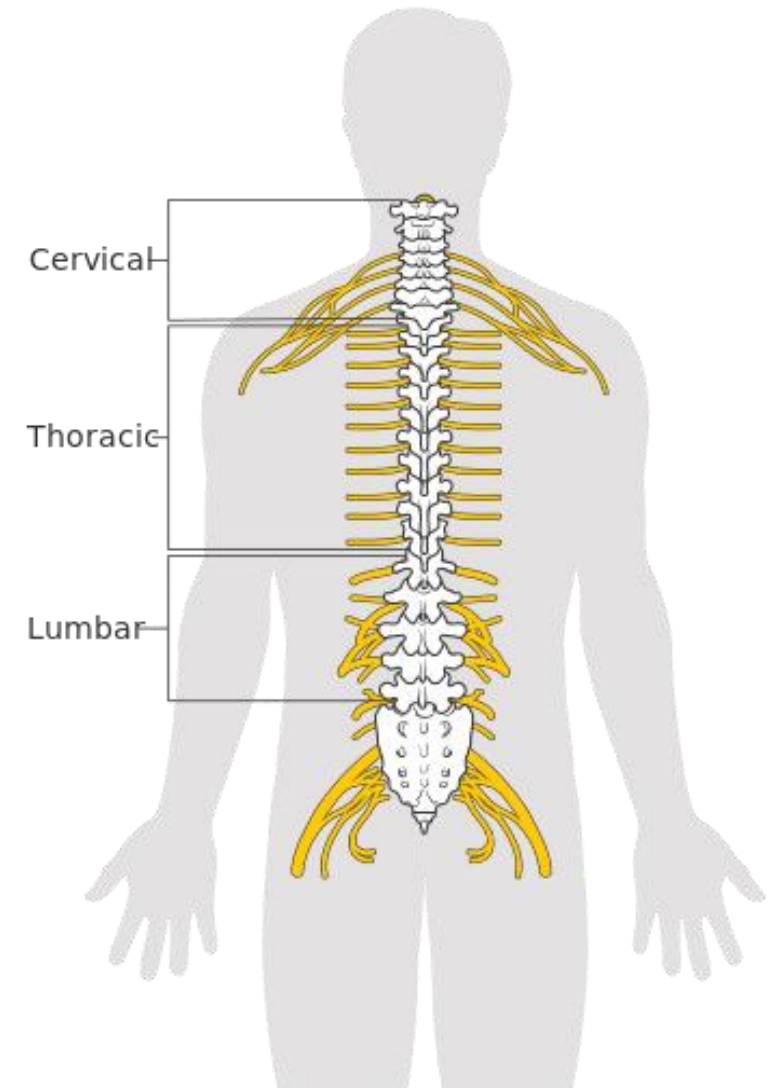
- Meningitis
- **Spinal epidural abscess**
 - Back pain worse with palpation
 - Fever
 - Neurologic deficits
- Diagnosis: **MRI with gadolinium contrast**
- Antibiotics
 - Cover MRSA, Strep and gram-negative rods
 - Vancomycin and ceftriaxone
- Surgical drainage

Spinal MRI



High Spinal

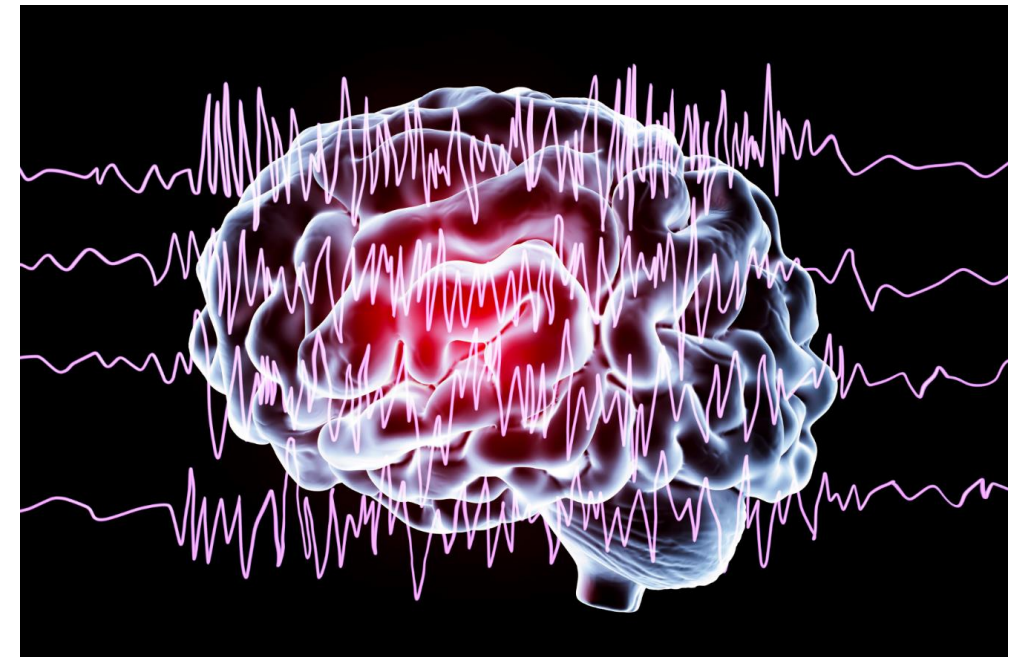
- Spread of anesthetic effects above T4
- Ascending sympathetic, sensory, and motor block
- Bradycardia and hypotension
- Dyspnea (diaphragm paralysis)
- Difficulty swallowing or speaking
- Can occur with spinal or epidural anesthesia
- Caused by excess anesthetic
- Or improper needle/catheter position



Wikipedia/Public Domain

Total Spinal

- Severe form of high spinal
- Intracranial spread of local anesthetic effects
- Can cause loss of consciousness



Low Pressure Headache

Postdural puncture headache (PDPH)

- Drop in CSF pressure leading to headache
- Believed due to CSF leak from dural puncture
- Common after lumbar puncture
- Common after **epidural/spinal anesthesia**
- Classic feature: **postural headache**
 - Improved lying flat
 - Worse sitting up

Lumbar Puncture

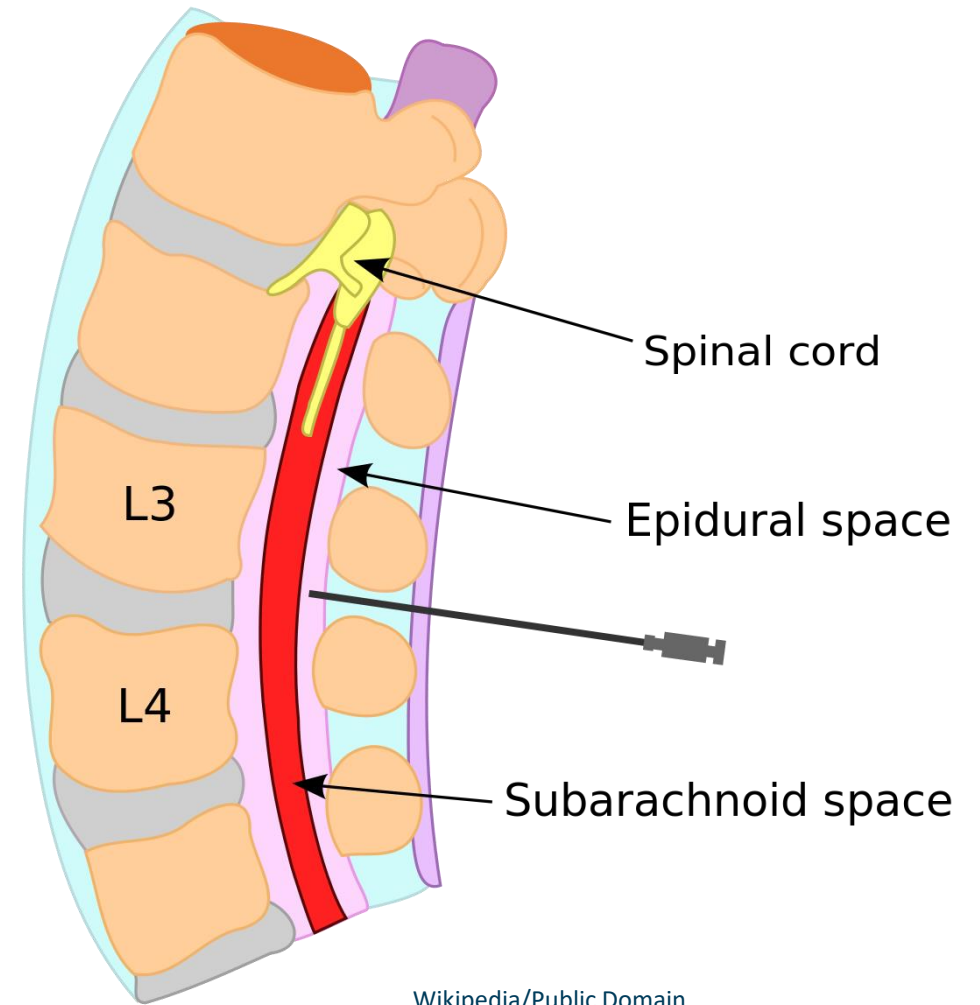


Wikipedia/Public Domain

Low Pressure Headache

Postdural puncture headache (PDPH)

- Diagnosis: clinical
- Treatment: NSAIDs +/- **epidural blood patch**
 - Infusion of blood into epidural space
 - Clots over dural CSF leaks
 - Often immediate symptom relief



Regional Anesthesia

- **Peripheral Nerve Block**
 - Used for upper or lower extremity procedures
 - Specific nerve or plexus identified by US or nerve stimulator
 - Local anesthetic applied directly to nerve
- **Intravenous regional anesthesia**
 - Alternative to peripheral nerve block for short procedures (< 1 hour)
 - Usually for hand/forearm surgery like carpal tunnel release
 - Apply tourniquet to limit blood return
 - Inject local anesthetic into IV catheter in hand