Rapid Review: Pharmacology

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VANA Fall Meeting

VANA

1934

Virginia Association of
Nurse Anesthetists

CRNA

Disclaimer

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- The questions in this presentation are my own and are intended to be representative and based on the NBCRNA outline. Any likeness to actual CPCA exam contents is purely by chance.
- For practice tests and official information regarding the CPCA, please visit: https://www.nbcrna.com/continued-certification/CPC_Program

CPC Assessment

- Its purpose is simply to identify potential areas where a CRNA may need additional education.
- CRNAs **will maintain their certification**, even if they do not meet the performance standard, provided that they complete additional focused continuing education in any area where the performance standard is not met.
- Note: If you have an area where you *are perceived* to need additional education and you complete 1 CE in that area, you **HAVE MET the performance standard.**
  - **You are expected to maintain documentation of your remediation credits and provide proof if randomly selected for audit at time of your CPC renewal.**

CPCA: What to expect…

- Three-hour, 150-question ***self-assessment***
  - This is not a test
  - Do not need to complete core modules as a prerequisite
  - May test at home or at a testing center
  - One 10 minute break is allowed
  - 4 domains: physiology, pharmacology, equipment, airway management
- The performance is assessed on a scaled score from 300 to 900
  - The cut off is 450: You will not be given your score.
  - If you are below 450 in any area it means you will be required to refresh your knowledge with an additional 1.0 CE in **that performance area.**
- **The CPCA must be completed no later than 6 months prior to your credential expiration date.**

Home v. Testing Center

Content Outline: Pharm

- NBCRNA: "***It is neither exhaustive nor all-inclusive.***"
- ***Access at: [Content Outline]***

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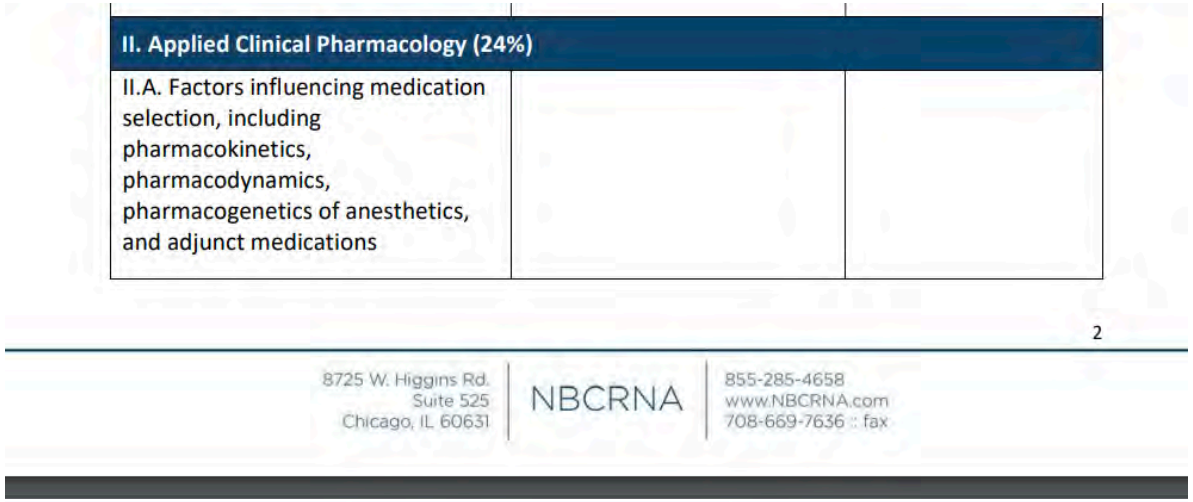

II. Applied Clinical Pharmacology (24%)		
II.A. Factors influencing medication selection, including pharmacokinetics, pharmacodynamics, pharmacogenetics of anesthetics, and adjunct medications		

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II.A.1. Physiological factors	age, fluid volume status	
II.A.2. Pathophysiological/comorbidity factors	neurological disease, end-organ disease, malignant hyperthermia trigger/management, obstructive sleep apnea	
II.A.3. Utilization, actions, interactions, benefits, side effects	American Society of Regional Anesthesia [ASRA] anticoagulant guidelines, anesthetic selection, considerations for substance use disorder, multimodal analgesia	
II.B. Medication safety/infection prevention	safe injection standards, storage, reconciliation, documentation	
II.C. Adverse pharmacological reactions	anaphylaxis, local anesthetic systemic toxicity, hypotension, respiratory depression	

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FY 2023 Approved CPC Assessment References

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Ehrenwerth J, Eisenkraft J, Berry J. Anesthesia Equipment: Principles and Applications. Third edition. Saunders (Elsevier); 2020.

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Hines RL, Jones SB, eds. Stoelting's Anesthesia and Co-existing Disease. 8th edition. Elsevier; 2021.

Gropper MA, Eriksson LI, Fleisher LA, Wiener-Kronish JP, Cohen NH, Leslie K. Miller's Anesthesia (Vols. 1-2). Ninth edition. Elsevier; 2019.

Nagelhout JJ, Elisha S, Heiner JS, eds. Nurse Anesthesia. 7th edition. Elsevier; 2020.

Additional Resource

American Association of Nurse Anesthetists. American Association of Nurse Anesthetists. AANA Practice Documents website. https://www.aana.com/practice/practice-manual. Continuously updated. (Cite specific page URL and date accessed)

Let’s get started!

- Please get out your phones…
- Text: CRYSTALOGUIN652 to 22333

During a cholangiogram, which of the following medications may be requested to relieve a Sphincter of Oddi spasm?

00:30

0

Glucagon

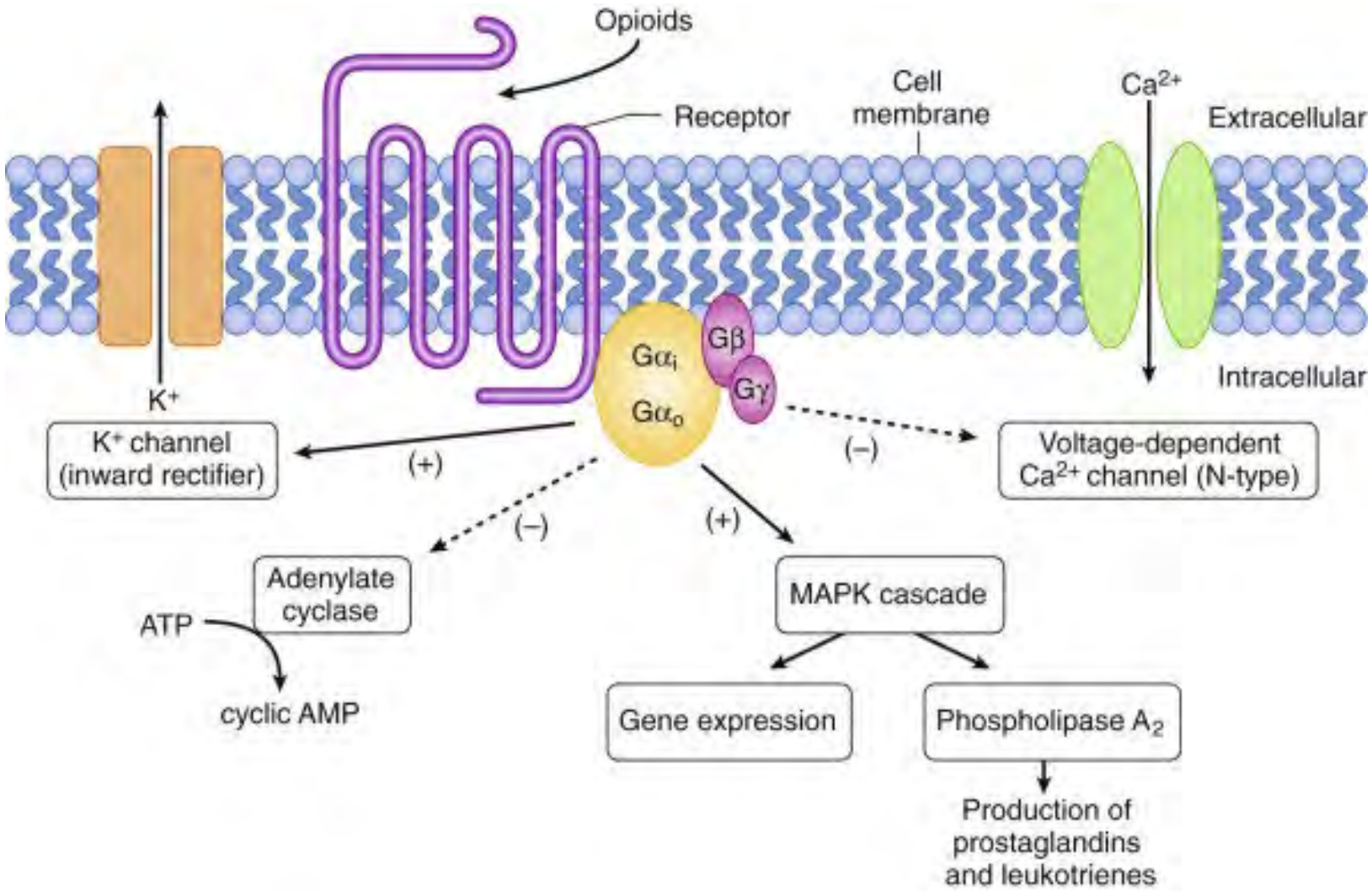
Metoclopramide (Reglan)

Baclofen

Table 16.2 Opioid Receptor Subtypes

OPIOID RECEPTOR SUBTYPE	AGONISTS	AGONIST RESPONSE
Mu-1 (μ-1)	Enkephalin Beta-endorphin Phenanthrenes Phenylpiperidines Methadone	Supraspinal analgesia Euphoria Miosis Urinary retention
Mu-2 (μ-2)	Enkephalin Beta-endorphin Phenanthrenes Phenylpiperidines Methadone	Spinal analgesia Respiratory depression Bradycardia Constipation Dependence
Kappa (κ)	Dynorphin Butorphanol Levorphanol Nalbuphine Oxycodone	Spinal analgesia (Kappa-1) Supraspinal analgesia (Kappa-2) Dysphoria Sedation
Delta (δ)	Enkephalin Deltorphin Sufentanil	Spinal analgesia (Delta-1) Supraspinal analgesia (Delta-2) Respiratory depression Urinary retention Dependence
Nociceptin/orphanin FQ (N/OFQ)	Nociceptin/OFQ	Spinal analgesia Supraspinal hyperalgesia

Medication selection: Opioid



Opioid Pearls

- Codeine and CYP2D6
- Histamine release: morphine; meperidine
- Active metabolites: morphine (M6G; M3G); meperidine; hydromorphone; codeine
- Meperidine: useful for shivering; can lead to serotonin syndrome
- Remifentanil: unique metabolism by esterases; hyperalgesia
- Sufentanil: bradycardia
- Reversal: naloxone; recall short duration of action (30-60 minutes), SNS activation, and acute opioid withdrawal in dependent patients

Which of the following induction agents may cause direct myocardial depression in critically-ill patients?

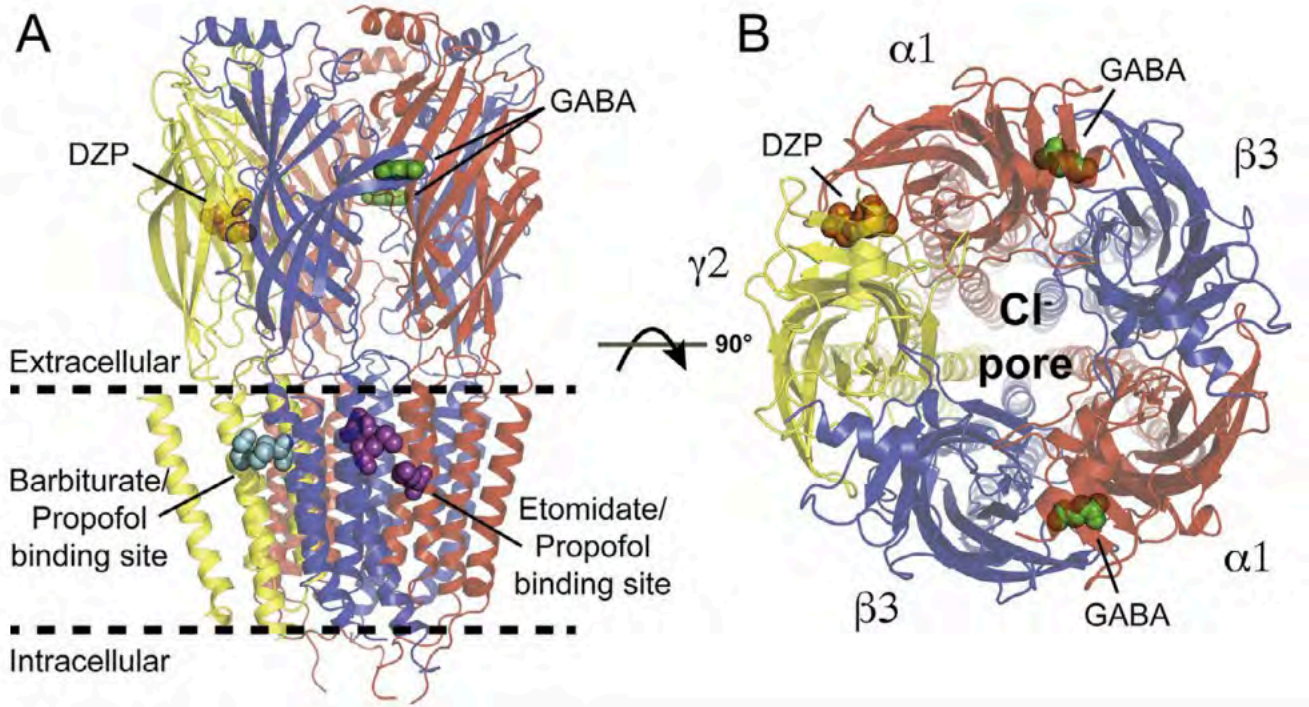
00:30

Propofol

0%

Ketamine

SEE MORE



Chapter 8 INTRAVENOUS ANESTHETICS

Michael P. Bokoch, Po-Yi Paul Su

Medication selection: Induction agents

Table 8.3 Summary of the Pharmacodynamic Effects of Commonly Used Intravenous Anesthetics

Dose/Effect	Propofol	Thiopental	Midazolam	Ketamine	Etomidate	Dexmedetomidine
Dose for induction of anesthesia (mg/kg IV)	1.5–2.5	3–5	0.1–0.3	1–2	0.2–0.3	
Systemic blood pressure	Decreased	Decreased	Unchanged to decreased	Increased[a]	Unchanged to decreased	Decreased[b]
Heart rate	Unchanged to decreased	Increased	Unchanged	Increased	Unchanged to increased	Decreased
Systemic vascular resistance	Decreased	Decreased	Unchanged to decreased	Increased	Unchanged to decreased	Decreased[b]
Ventilation	Decreased	Decreased	Unchanged	Unchanged	Unchanged to decreased	Unchanged to decreased
Respiratory rate	Decreased	Decreased	Unchanged to decreased	Unchanged	Unchanged to decreased	Unchanged
Response to carbon dioxide	Decreased	Decreased	Decreased	Unchanged	Decreased	Unchanged
Cerebral blood flow	Decreased	Decreased	Decreased	Increased to unchanged	Decreased	Decreased
Cerebral metabolic requirements for oxygen	Decreased	Decreased	Decreased	Increased to unchanged	Decreased	Unchanged
Intracranial pressure	Decreased	Decreased	Unchanged	Increased to unchanged	Decreased	Unchanged
Anticonvulsant	Yes	Yes	Yes	Yes?	No	No
Anxiolysis	Yes	No	Yes	No	No	Yes
Analgesia	No	No	No	Yes	No	Yes
Emergence delirium	No	No	No	Yes	No	May reduce
Nausea and vomiting	Decreased	Unchanged	Decreased	Unchanged	Increased	Unchanged
Pain on injection	Yes	No	No	No	Yes	No

[a]May cause direct myocardial depression and hypotension in critically ill or catecholamine-depleted patients.
[b]Bolus injection may increase systemic vascular resistance and blood pressure. *IV*, Intravenous.

Chapter 8 INTRAVENOUS ANESTHETICS
Michael P. Bokoch, Po-Yi Paul Su

Allan is 64 years old and weighs 72 kg. He is undergoing a radical neck dissection. Following induction, you administer a bolus of Dexmedetomidine (1 mcg/kg) over 10 minutes. What transient hemodynamic effects are anticipated during administration?

00:30

A Bradycardia and hypertension.

0%

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Dexmedetomidine (Precedex)

- Analgesia/ opioid sparing/ smooth emergence
- Adjunct to fiberoptic intubation due to maintenance of spontaneous ventilation
- Selective Alpha-2 adrenergic agonist
  - 7-10x more selective than clonidine with shorter duration of action
  - Decreases Plasma catecholamine levels
- Most closely mimics physiological sleep
  - Locus ceruleus (hypnosis)
  - Spinal cord (analgesia)
- Minimal respiratory changes but **upper airway obstruction possible** especially with other anesthetics and opioids
- Decreases heart rate, BP, and SVR
- Transient ↑BP, ↓HR with bolus dosing
- Weak CYP 450 inhibitor: Increased opioid concentrations?

Dosing Recommendations

- 200 mcg vial in 50 ml bag= 4mcg/ml
- Awake Intubation 1mcg/kg over 10 minutes with 0.7mcg/kg/hr infusion
- Typical Dosing
  - 1mcg/kg bolus over 10-15 minutes; followed by 0.2- 1 mcg/kg/hr infusion
  - Reduces SNS responses to noxious stimuli (intubation, incision, etc.)
  - Can reduce ketamine induced emergence delirium
  - Treatment for shivering
- Sedation/ Analgesic adjunct for opioid sparing (ICU)
  - 0.2-0.7mcg/kg/hr

Jack is 14 years old and having emergency surgery for a testicular torsion. Following induction of anesthesia and administration of succinylcholine, mouth opening is difficult and a masseter spasm is suspected. This clinical finding can indicate:

00:30

0

homozygous atypical plasma cholinesterase.

malignant hyperthermia.

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Medication selection: Muscle Relaxant

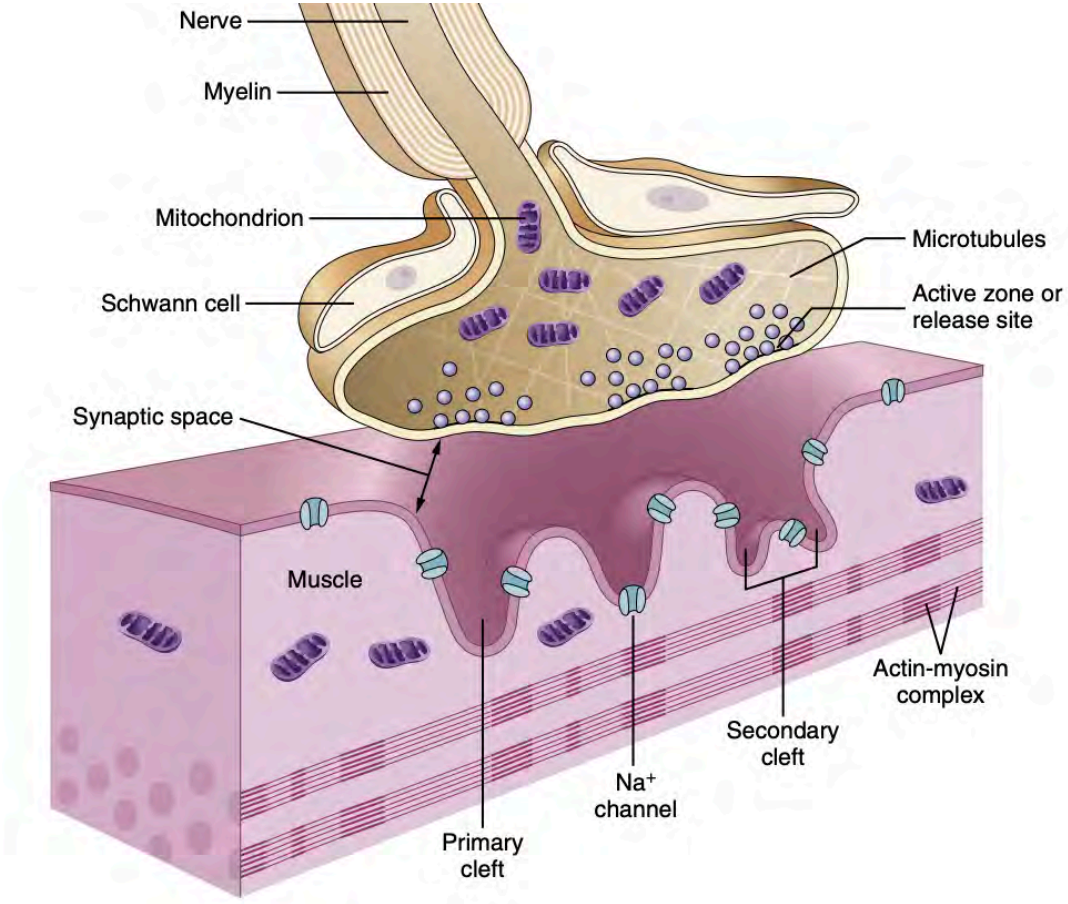


Table 1. Pharmacokinetics of Neuromuscular Blockers

Agent	Dosing	Time to Peak (min)	Duration of Action (min)	Metabolism	Side Effects
NONDEPOLARIZING					
Aminosteroids					
Pancuronium	0.05-0.1 mg/kg bolus; 0.8-1.7 mcg/kg/min infusion	2-3	60-100	Renal	Tachycardia, hypotension, and increased cardiac output
Vecuronium	0.08-0.1 mg/kg bolus; 0.8-1.7 mcg/kg/min infusion	3-4	20-45 (prolonged as active metabolite builds up)	Hepatic via hydrolysis, then bile; metabolites excreted renally	Hemodynamic instability
Rocuronium	0.6-1 mg/kg bolus; 8-12 mcg g/kg/min infusion; RSI: 1-1.2 mg/kg bolus	1-2	20-35 for bolus dose; 60-80 for RSI dose	Hepatic; no active metabolites	NA
Benzylisoquinoliniums					
Atracurium	0.4-0.5 mg/kg bolus; 5-20 mcg g/kg/min infusion	3-4	20-35	Hoffmann reaction	Seizures associated with neurotoxic metabolite (laudanosine), hypotension (histamine release)
Cisatracurium	0.1-0.2 mg/kg bolus; 3 mcg g/kg/min initial infusion; 1-2 mcg g/kg/min maintenance infusion	2-3	30-60	Hoffmann reaction	Bronchospasm
DEPOLARIZING					
Succinylcholine	1 mg/kg bolus; infusions rarely used	<1	5-10	Plasma cholinesterase	Bradycardia, malignant hyperthermia, and hyperkalemia

min: minute; NA: not applicable; RSI: rapid sequence intubation.
Source: References 5-7, 12, 25, 31, 32.

PUBLISHED JANUARY 19, 2017
HOSPITAL/HEALTH SYSTEM

Neuromuscular Blocking Agents: Use and Controversy in the Hospital Setting

Contraindications to Succinylcholine

- Malignant Hyperthermia History (personal or family)
- Neuromuscular disease involving denervation
- Muscular Dystrophy
- Stroke over 72 hours old
- Rhabdomyolysis
- Burn over 48 hours old
- Significant Hyperkalemia
- Children: Risk of undiagnosed muscular dystrophy/ bradycardia

Rose is 84 years old. She had a colon resection for a sigmoid mass. Rocuronium has been administered 45 minutes ago. Upon train-of-four assessment, Rose has 0/4 twitches and 2 post-tetanic twitches. Which of the following medications is appropriate?

00:30

0

Neostigmine 50mcg/kg

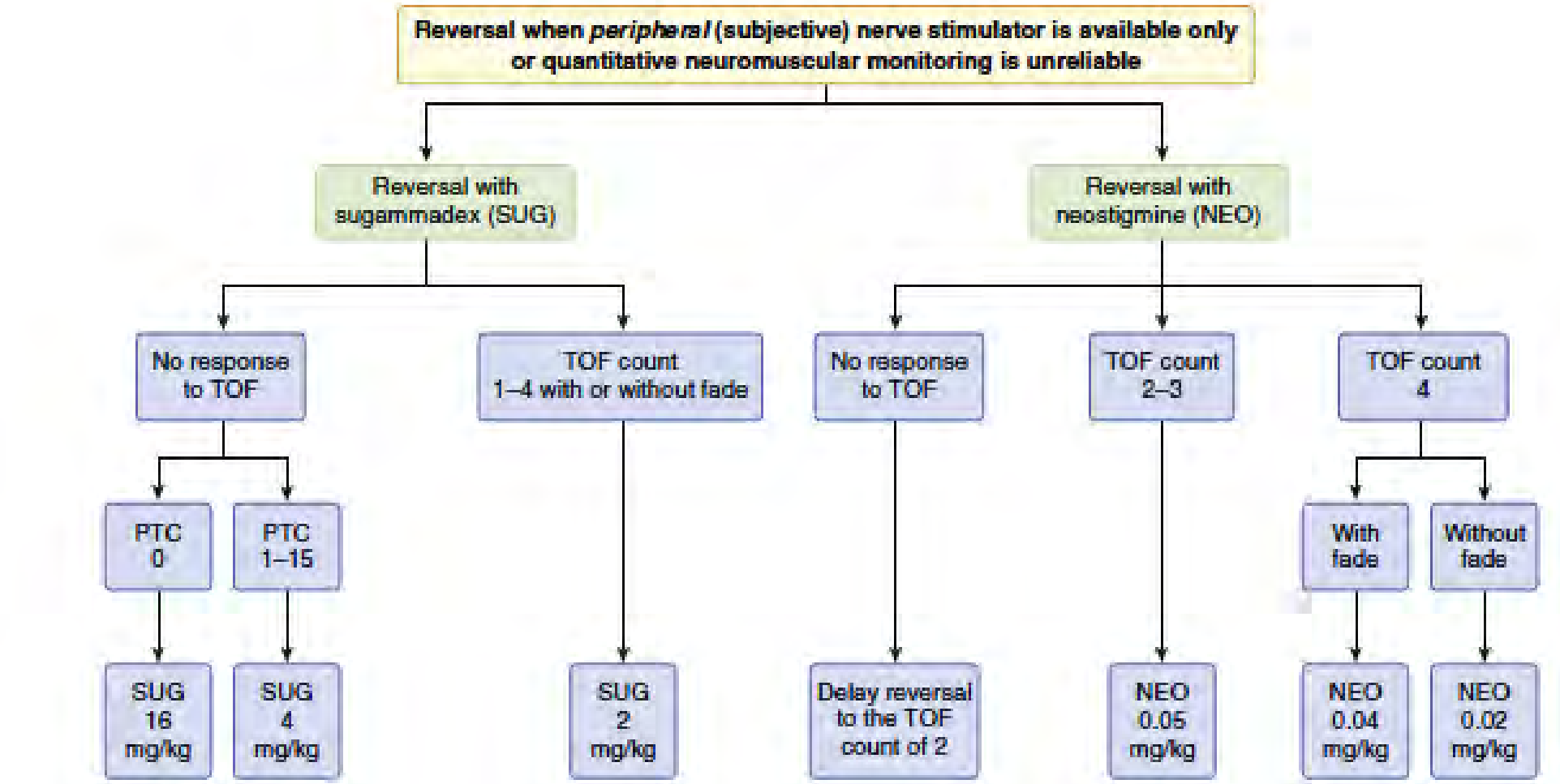
Neostigmine 25mcg/kg

SEE MORE

Reversal agents

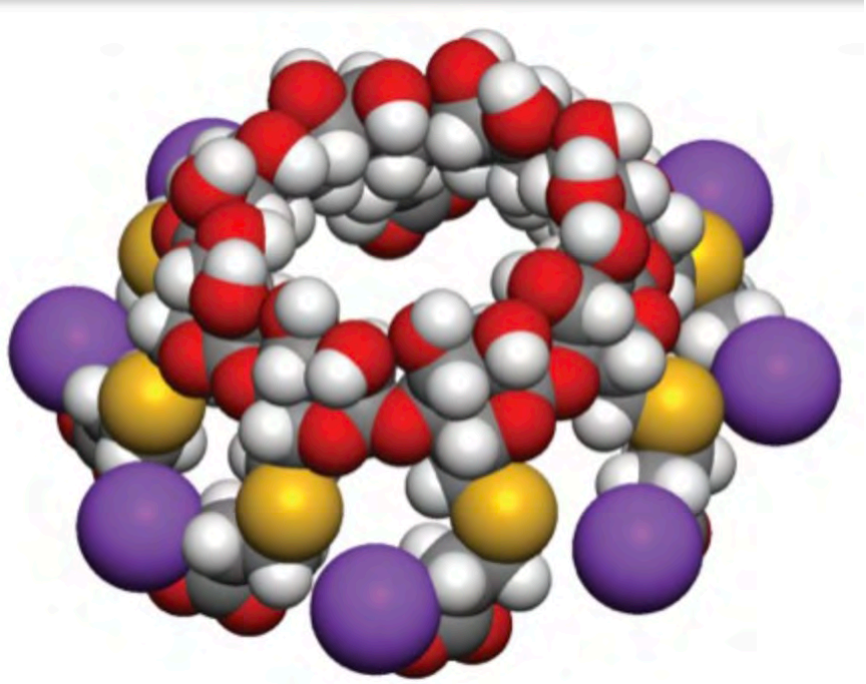
- Acetylcholinesterase INHIBITORS:
  - Quaternary ammonium compounds
  - Allow ↑Ach at NMJ to decrease the competitive effect of any remaining NDNMB
  - ALWAYS given with an anticholinergic
  - UNABLE TO REVERSE PROFOUND BLOCKADE
  - Dose depends on level of neuromuscular blockade
- Cyclodextrin *(Sugammadex)
  - forms a complex with the non-depolarizing NMBAs rocuronium and vecuronium
  - can be used even with deep blockade (1-2 PTC)

Medication Selection: Reversal



Sugammadex

- Dose is dependent on level of blockade
- **Cannot be used for nonsteroidal neuromuscular blocking agents or steroidal neuromuscular blocking agents other than Rocuronium or Vecuronium**
- Safety not established in children; renal failure; or in dialysis patients
- Marked bradycardia, some of which have resulted in cardiac arrest, have been observed within minutes after the administration
- Recurrence of neuromuscular blockade may occur due to displacement of rocuronium or vecuronium from Sugammadex by other drugs
- Rare anaphylaxis, multiple doses of epi required



Sugammadex Dose

- Dose is dependent on level of blockade
- **Administer as a single bolus injection For Rocuronium and Vecuronium:**
  - 4 mg/kg is recommended if spontaneous recovery of the twitch response has reached 1 to 2 post-tetanic counts (PTC) and there are no twitch responses to train-of-four (TOF) stimulation
  - 2 mg/kg is recommended if spontaneous recovery has reached the reappearance of the second twitch in response to TOF stimulation
- **<u>Rocuronium only</u>: 16 mg/kg is recommended if there is a clinical need to reverse neuromuscular blockade soon (approximately 3 minutes) after administration of a single dose of 1.2 mg/kg of rocuronium**

April is 54 years old. She is having a hysterectomy. April's baseline ECG reveals a QT interval of 0.50 seconds. Which of the following antiemetics should be avoided when planning April's anesthesia?

00:30

Ondansetron

0%

Dexamethasone

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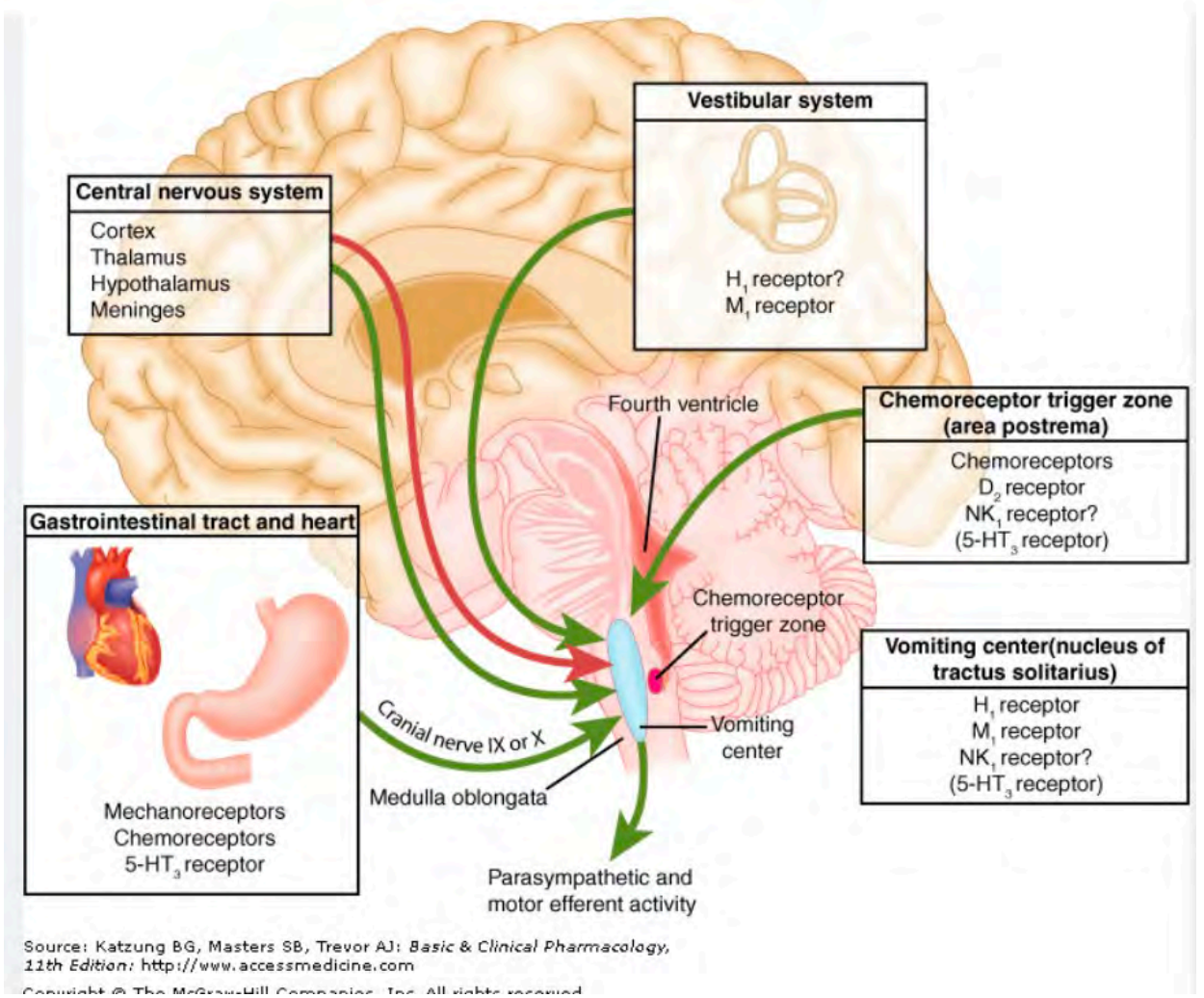
PONV Review

- Post Operative Nausea and Vomiting
  - Incidence general anesthesia: 50% Nausea; 30% Vomiting
  - Risk factors: Apfel
    - *1. Female gender*
    - *2. Non-smoker*
    - *3. History of PONV or motion sickness*
    - *4. Use of an intraoperative opioid*
  - High risk: GYN, breast, ENT, laparoscopic, plastic, and abdominal cases
  - Triggers: volatile anesthetics, nitrous oxide, and opioids
  - Prevent: antiemetic prophylaxis; avoid volatiles; TIVA; propofol induction; regional anesthesia; adequate fluid volume

Antiemetics

- Emesis: complex reflex involving multiple neurotransmitters triggered by activating the vomiting center in the medulla oblongata
- Direct stimuli: noxious odors, pain, vestibular
- Indirect: first activate the chemoreceptor trigger zone (CTZ) in area postrema/floor of 4th ventricle which then activates the vomiting center
    - CTZ is stimulated by signals in the stomach/small intestine or by direct stimulation (ex. opioids, chemotherapy)



Classes of Antiemetics

https://www.grepmed.com/images/8995/internship-antiemetics-vomiting-pharmacology-medications-73

Anti-Emetic Regimen Guide				
Class	**Medication**	**Route**	**Common Side Effects**	**QT-Prolongation**
Serotonin antagonists	Ondansetron (Zofran)	PO, IVP, IM, sublingual	Headache, constipation, drowsiness, diarrhea	✓
	Granisetron (Kytril, Sancuso)	PO, IV, transdermal		✓
Dopamine (DA) antagonists	Metoclopramide (Reglan)	PO, IVP, IM	Drowsiness, EPS, do not use if increased GI motility	✓
	Olanzapine (Zyprexa)	PO, IM, sublingual	EPS, hyperglycemia	✓
	Prochlorperazine (Compazine)	PO, IVP, PR	EPS, NMS	✓
	Haloperidol (Haldol)	PO, IM	EPS, constipation, dry mouth, blurred vision, somnolence	✓
	Chlorpromazine (Thorazine)	IM, IV	EPS, dry mouth	✓
Histamine antagonists	Diphenhydramine (Benadryl)	PO, IVPB, IVP	Dizziness, drowsiness, paradoxical excitation	✓
ACh antagonists	Scopolamine	PO, IVP, IM, transdermal	Bradycardia, flushing, thirst, xerostomia, urinary retention	✓
DA/Histamine/ACh antagonist	Promethazine (Phenergan)	PO, PR, IVP, IM	EPS, NMS, drowsiness, sedation, leukopenia, thrombocytopenia	✓
Neurokinin-1(NK-1) receptor antagonists	Aprepitant (Emend)	PO	Hiccups, bradycardia, neutropenia	
	Fosaprepitant (Ivemend)	IV	Angioedema, bradycardia, neutropenia	
Centrally acting	Dexamethasone	PO, IVP, IM	Leukocytosis, mood changes, adrenal suppression, hyperglycemia	
	Trimethobenzamide (Tigan)	PO, IM	EPS, disorientation, seizure	
	THC, dronabinol	PO	Hyperemesis, tachycardia, nystagmus, ataxia	
	Lorazepam (Ativan)	PO, IVP, IM	Respiratory depression	

When using multiple agents, avoid choosing from the same class

Quick Reminders: Antiemetics

- Multimodal approach to treat high-risk patients with at least two or three different kinds of receptor antagonists
- Scopolamine: Anticholinergic syndrome =restlessness, hallucinations, somnolence and unconsciousness.
  - Tx: Physostigmine
  - Avoid in elderly: tertiary amine (crosses BBB)
- Ondansetron; Droperidol; Metoclopramide: QT prolongation
- Dexamethasone: single dose safety is well established
- Metoclopramide: dopamine antagonist; avoid in Parkinson’s and ileus
- Propofol: 10-20mg antiemetic effect

Which of the following medications are triggers for malignant hyperthermia?

00:30

0

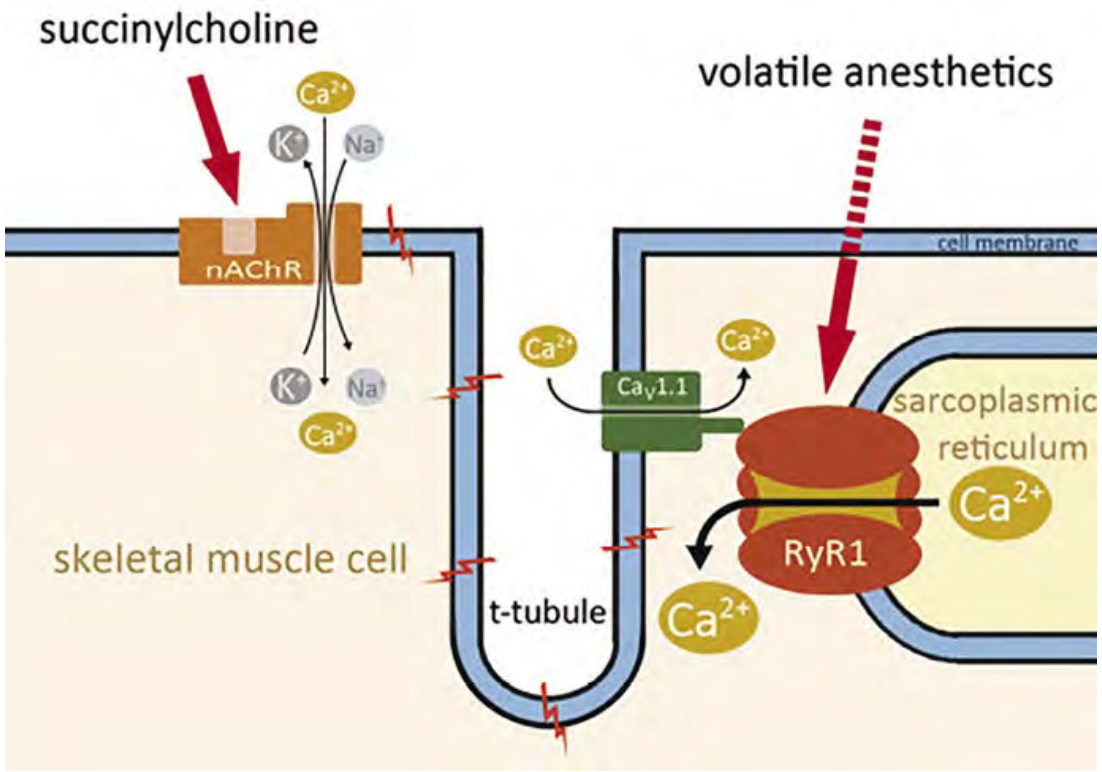
propofol and nitrous oxide

demerol and glycopyrrolate

SEE MORE

Malignant Hyperthermia

- Triggering agents:



Malignant Hyperthermia

May be early signs:	**Mixed (metabolic and respiratory) acidosis** **Increased $EtCO_2$, heart rate, respiratory rate** **Hyperthermia** **Masseter spasm/trismus** **Muscle rigidity without shivering, tremor, or clonus**
May be late signs:	**Myoglobinuria** **Arrhythmias including hyperkalemic cardiac arrest**

TREATMENT

Task	Actions
Crisis Resources	• Inform team • Call for help • Get MH cart with **dantrolene** • Consider pausing procedure
Stop MH Triggers	• **Stop volatile anesthetic and succinylcholine** • **Do NOT change machine or circuit** • **100% O_2 10 - 15 L/min** • If easily available, add charcoal filters to breathing circuit
Airway	• Maximize minute ventilation. Mechanical ventilation is preferred. Avoid air-trapping
Give Antidote Rapidly	• Initial dantrolene dose is 2.5 mg/kg IV. Formulations: • Concentrated, easily soluble formulation: **Ryanodex:** Dilute one 250 mg vial in 5 mL preservative-free **sterile water.** **70 kg patient dose: 175 mg = 3.5 mL** • Non-concentrated formulation: **Dantrium or Revonto: Assign several people to prepare.** Dilute each 20 mg vial in 60 mL preservative-free **sterile water.** **70 kg patient dose: 175 mg = 9 VIALS** • Repeat dantrolene 2.5 mg/kg every 5 min until hypercarbia and rigidity are resolved and temperature is not increasing. May need > 10 mg/kg
Team Recap	• If appropriate, stop procedure • **Give non-triggering maintenance anesthetic or sedation (e.g. propofol, benzodiazepine, opioid)**

RULE OUT

- CO_2 insufflation
- Hypoventilation
- Hypoxemia
- Iatrogenic warming
- Illicit stimulants
- Light anesthesia
- Neuroleptic malignant syndrome
- Pheochromocytoma
- Serotonin syndrome
- Thyroid storm

TREATMENT

Task	Actions
Treat Hyper-K+	• **Calcium** chloride 10 mg/kg IV, max 2 g • Regular **insulin** 5 - 10 units IV **with dextrose/D50** 1 amp IV (25 g); monitor glucose • **Albuterol** 8 - 12 puffs MDI or 2.5 mg nebulized • Sodium **bicarbonate**: 0.5 amp (25 mL) at a time; maintain minute ventilation to exhale additional CO_2 produced • If severe: consider emergent dialysis
Treat Rhythm	• Treat arrhythmias with amiodarone 150 mg IV over 10 - 15 min, esmolol 10 - 20 mg IV bolus followed by infusion, or magnesium sulfate 1 g IV; **avoid calcium channel blockers and sodium channel blockers (e.g. verapamil, diltiazem, lidocaine, procainamide)** • If unstable, call for code cart and also see ACLS event: **Asystole/PEA #1** **Bradycardia #2** **SVT #3** **VFIB/VTACH #4**
Active Cooling	• If core temperature > 38° C: **actively cool** with cold IV fluid (20 - 30 ml/kg normal saline or plasmalyte) • Additional cooling: **Stop active warming;** set forced air on ambient; cool room; put ice packs on head, axilla, and groin; wet skin; cool lavage if open abdomen or peritoneal catheter (avoid bladder lavage to preserve urine output measurement)
Access	• Consider additional IV access and arterial line placement
Labs	• Send ABG, K+, CK, urine myoglobin, coagulation panel, lactate
Urine Output	• Place Foley catheter and monitor urine output: goal 1 - 2 mL/kg/hr; consider IV fluids and diuretics
MH Hotline	• Call 24/7 for expert consultation: **1-800-MH-HYPER** (1-800-644-9737) http://www.mhaus.org
ICU Care	• Transport with experienced personnel after stabilization • Mechanical ventilation commonly required because **20% of MH events relapse within 16 hours.** Extubate once metabolically and hemodynamically stable • **Continue dantrolene: 1 mg/kg bolus every 4 - 6 hours or 0.25 mg/kg/hr infusion for up to 24 hours** • Monitor for rhabdo, DIC, hyperK+, compartment syndrome
Post Event	• Complete AMRA (Adverse Metabolic Reaction to Anesthesia): https://anest.ufl.edu/namhr/ • Test genes: https://www.mhaus.org/testing/genetic-testing/

Mr. Jones would like to have a knee replacement for chronic osteoarthritis. He had drug eluting stents placed 6 weeks ago for coronary artery disease. What is the most appropriate response?

00:30

A “We can schedule your surgery any time since it has been more than 30 days.”

0%

SEE MORE

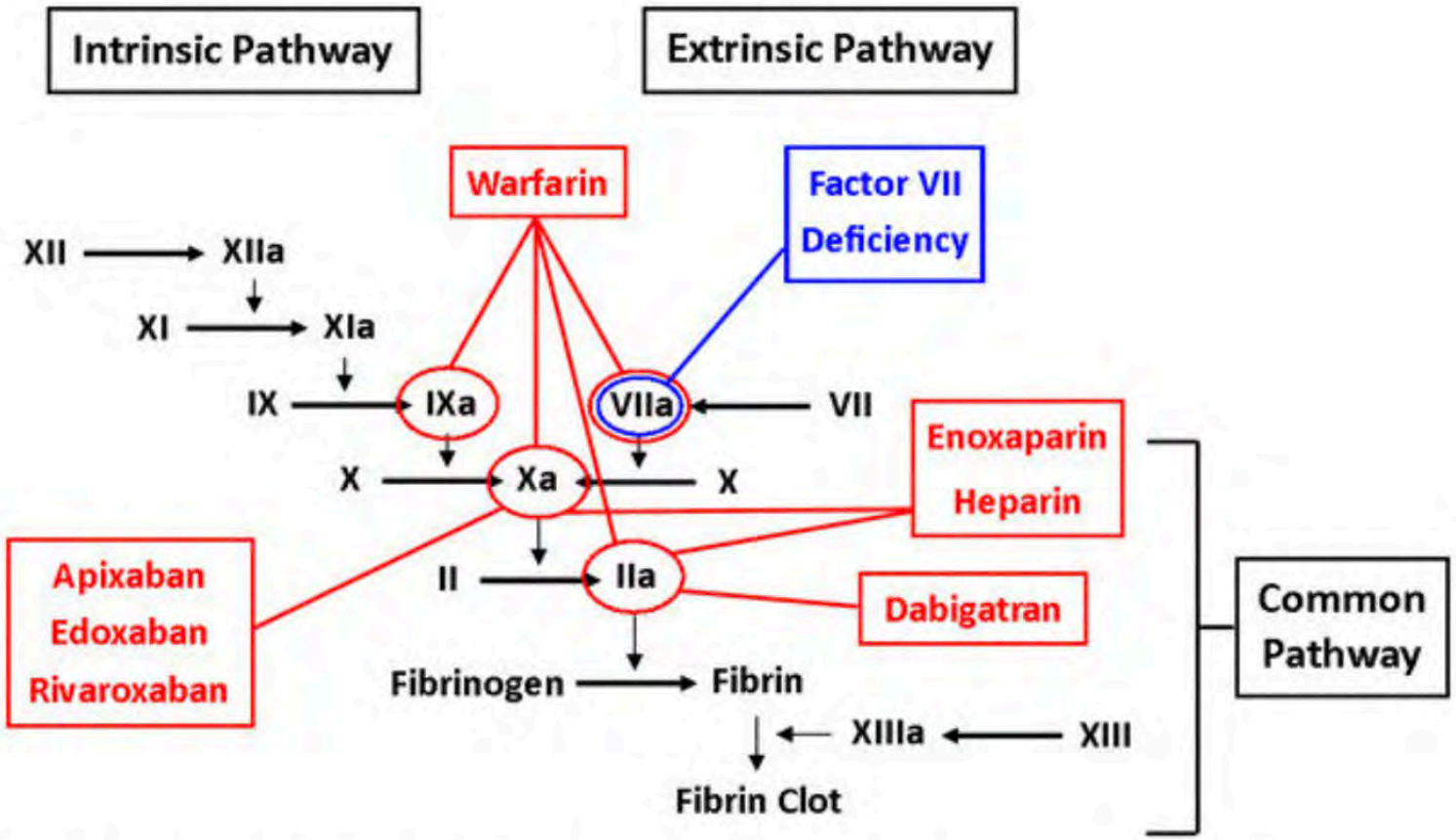
Antiplatelets/ Anticoagulants

Drug Saf - Case Rep (2016)3:8
DOI 10.1007/s40800-016-0031-y

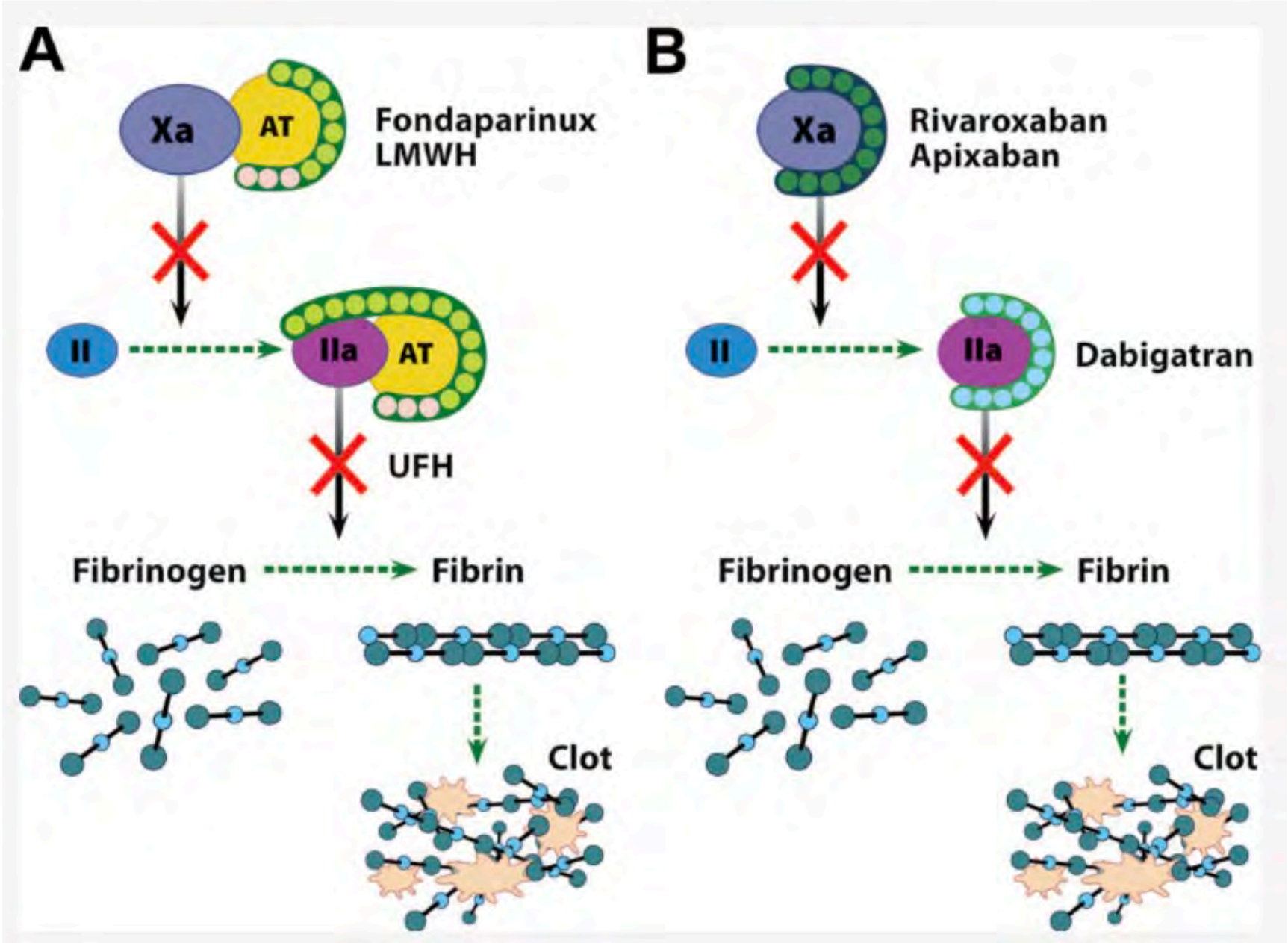
CASE REPORT

Anticoagulation Therapy Considerations in Factor VII Deficiency

Eric Paulus[1] · Kathy Komperda[2] · Gabriel Park[2] · Julie Fusco[2]



Effects of multiple anticoagulant medications on the coagulation cascade



Anesthesiology 2010;113:728. Figure 2.

ASRA Anticoagulation Guidelines

TABLE 4. Perioperative Management of Patients on Antiplatelet Therapy

Patients with coronary stents

- Elective surgery postponed for the following durations if aspirin and thienopyridine (eg, clopidogrel or prasugrel) therapy must be discontinued
  - Bare metal stents: 6 wk
  - Drug-eluting stents: 6 mo
- If surgery cannot be postponed, continue dual antiplatelet therapy throughout perioperative period

Patients at high risk of cardiac events (exclusive of coronary stents)

- Continue aspirin throughout the perioperative period
- Discontinue clopidogrel/prasugrel 5 d prior to surgery
- Resume thienopyridine 24 h postoperatively

Patients at low risk of cardiac events

- Discontinue dual antiplatelet therapy 7–10 d prior to surgery
- Resume antiplatelet therapy 24 h postoperatively

Recommendations from Douketis et al.[36]

ASRA Anticoagulation Guidelines

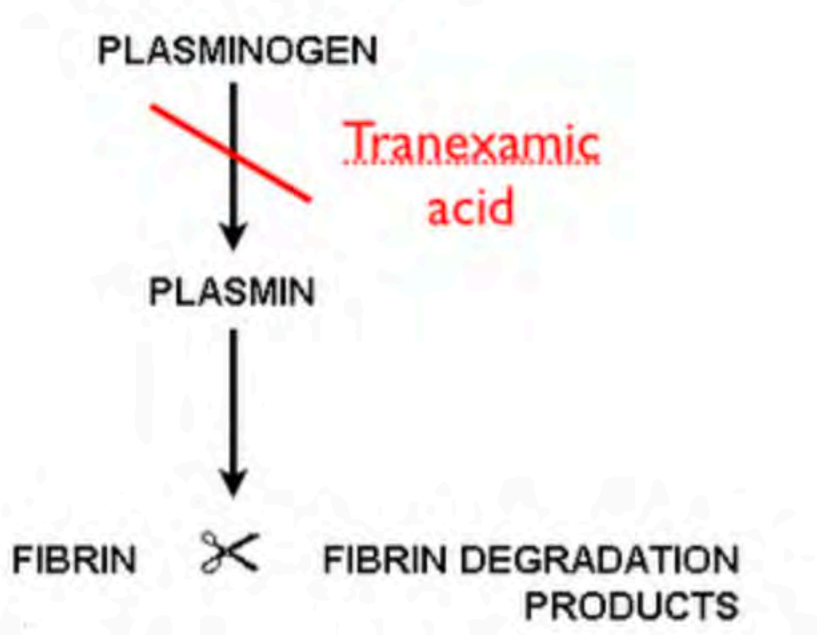
TABLE 7. European Society of Anaesthesiology's Recommended Time Intervals Before and After Neuraxial Puncture or Catheter Removal*

	Time Before Puncture/Catheter Manipulation or Removal	Time After Puncture/Catheter Manipulation or Removal	Laboratory Tests
UFHs (for prophylaxis, ≤15,000 IU/d)	4–6 h	1 h	Platelets during treatment for >5 d
UFHs (for treatment)	IV 4–6 h SC 8–12 h	1 h 1 h	aPTT, ACT, platelets
LMWHs (for prophylaxis)	12 h	4 h	Platelets during treatment for >5 d
LMWHs (for treatment)	24 h	4 h	Platelets during treatment for >5 d
Fondaparinux (for prophylaxis, 2.5 mg/d)	36–42 h	6–12 h	(Anti–factor Xa, standardized for specific agent)
Rivaroxaban (for prophylaxis, 10 mg daily)	22–26 h	4–6 h	(Anti–factor Xa, standardized for specific agent)
Apixaban (for prophylaxis, 2.5 mg BID)	26–30 h	4–6 h	(Anti–factor Xa, standardized for specific agent)
Dabigatran (for prophylaxis, 150–220 mg)	Contraindicated according to the manufacturer	6 h	TT
Coumarins	INR ≤1.4	After catheter removal	INR
Hirudins (desirudin)	8–10 h	2–4 h	aPTT, ECT
Argatroban	4 h	2 h	aPTT, ECT, ACT
Acetylsalicylic acid	None	None	
Clopidogrel	7 d	After catheter removal	
Ticlopidine	10 d	After catheter removal	
Prasugrel	7–10 d	6 h after catheter removal	
Ticagrelor	5 d	6 h after catheter removal	
Cilostazol	42 h	5 h after catheter removal	
NSAIDs	None	None	

*All time intervals refer to patients with normal renal function. Prolonged time interval in patients with hepatic insufficiency.

Adapted from Gogarten et al,[8] with permission.

Antifibrinolytic: Tranexamic Acid (TXA)



Amy is a CRNA. She has given 20 ml's of propofol and plans to draw up an additional 20 ml's propofol for the same patient. Which of the following practices reflect the AANA recommendations?

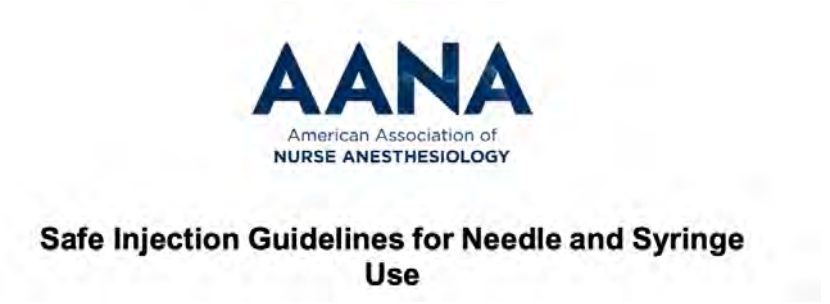
00:30

(A) A The same syringe and needle are acceptable for the same patient for the same drug.

0%

Instructions | Responses | Correctness | Clear responses

Safe Injection Practices:



- Never administer medications from the same syringe to multiple patients, even if the needle is changed.
- Never reuse a needle, or needleless access device even on the same patient. Once a needle or access device has been used, it is considered contaminated and must be discarded in an appropriately identified sharps container.
- Access devices are single- use devices.
- Never refill a syringe once it has been used, even for the same patient.
- Never use an infusion or intravenous administration tubing set for more than one patient.
- Never reuse a syringe or needle to withdraw medication from a multidose vial (MDV).
- A new sterile syringe and needle or access device are required each time an MDV is accessed.

Safe Injection Practices: AANA

- Avoid use of MDV for more than one patient. Practitioners should avoid using MDVs if at all possible.
- If MDV must be used, the practitioner should consider using that MDV on only one patient.
- Do not access an MDV in the immediate patient treatment area unless the MDV is dedicated to a single patient and discarded immediately thereafter.
- Never reenter a single-dose medication vial, ampoule or intravenous infusion bag.
- It is not appropriate to prepare multiple intravenous flush syringes for single or multiple patients from the same single-dose intravenous solution bag or bottle (e.g., normal saline).
- It is not appropriate to prepare multiple fentanyl, midazolam, or propofol syringes for the same or multiple patients from the same single-dose medication vial, ampoule, or solution. Do not store a single-dose medication vial for future use. Do not reenter a single-dose medication vial, even for the same patient.
- When accessing medication vials, complete hand hygiene, don clean gloves, use a new sterile needle, and cleanse the access diaphragm with 70% alcohol prior to needle insertion.

Immediately following administration of 2 grams of cefazolin, hypotension (60/30) and increased peak inspratory pressures are noted (50cm H20). What primary medication should be administered FIRST?

00:30

A Epinephrine

0%

B Benadryl

SEE MORE

Anaphylaxis

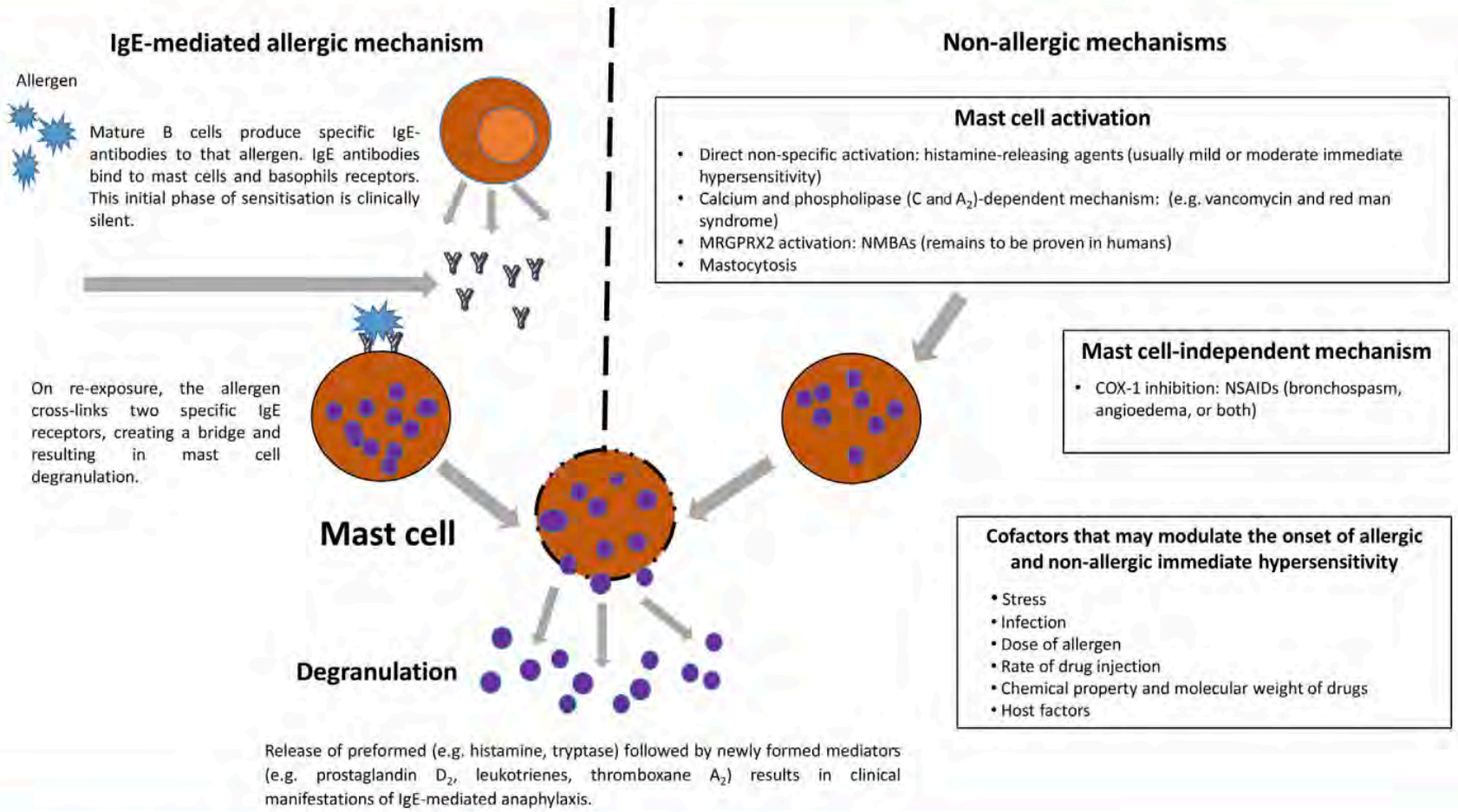


Fig 1 Pathophysiological mechanisms of perioperative immediate hypersensitivity. COX-1, cyclooxygenase 1.

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Anaphylaxis Management

Stanford MEDICINE | Emergency Manual

Anaphylaxis

Severe hypotension	**Angioedema**	**Rash**
Cardiac arrest	**Airway swelling**	**Itching**
Bronchospasm	**Tachycardia**	**Hives (or no skin findings)**
Wheezing	**Arrhythmia**	
High inspiratory pressure	**Flushing**	

TREATMENT

Task	Actions
Crisis Resources	• Inform team • Identify leader • Call for code cart • Consider pausing procedure
Airway	• **100% O_2 10 - 15 L/min** • Secure airway. If angioedema: consider early intubation
IV Access	• Ensure functional large bore IV or IO access
Primary Meds	• **Give epinephrine** to prevent mast cell degranulation: • **Epinephrine** 10 - 100 mcg IV (if no IV: 500 mcg IM); Increase IV dose every 2 min until clinical improvement. May require > 1mg. Start early epinephrine infusion **See Infusion List #29** • If hypotensive: turn off volatile anesthetics and vasodilating drips and consider amnestic agent (e.g. midazolam)
Fluid	• **Give rapid IV fluid bolus.** May require many liters • Consider head down position; elevate legs
Stop Allergens	• **Remove allergens:** e.g. antibiotics, muscle relaxants, chlorhexidine, dyes, blood products, latex, contrast, colloids, protamine, sugammadex
ACLS	• Check pulse. If no pulse or SBP < 50 mmHg: • CPR rate 100 - 120 compressions/min • Depth ≥ 5 cm; allow chest recoil; consider backboard • **Keep $EtCO_2$ > 10 mmHg and diastolic BP > 20 mmHg** • Rotate compressors with rhythm check every 2 min • Check pulse ONLY if signs of ROSC (sustained increased $EtCO_2$, spontaneous arterial waveform, rhythm change) • If mask ventilation: ratio 30 compressions to 2 breaths • If airway secure: 10 breaths/min; tidal volume 6 -7 mL/kg • Place defibrillator pads in case rhythm changes • Consider ECMO or cardiopulmonary bypass

Page 2 Anaphylaxis

ROLE OUT

- Anesthetic overdose **See Local Anesthetic Toxicity #18**
- Aspiration
- Distributive or obstructive shock
- Embolism e.g. air, clot, fat **See Embolism #9**
- Hemorrhage **See Hemorrhage #12**
- Hypotension **See Hypotension #16**
- Myocardial infarction **See Myocardial Ischemia #20**
- Pneumothorax **See Pneumothorax #22**
- Sepsis

TREATMENT

Task	Actions
Additional Access	• Consider additional IV access • Consider arterial line placement
Secondary Meds	• If hypotension: Continue **epinephrine infusion**. May add **vasopressin** and/or **norepinephrine** **See Infusion List #29** • If bronchospasm, give bronchodilator: • If unable to ventilate, treat intravenously: **epinephrine** 5 - 10 mcg IV (or 200 mcg subq) or **ketamine** 10 - 50 mg IV (or 40mg IM) or **magnesium** sulfate 1 - 2 g IV • If able to ventilate: **albuterol** 4 - 8 puffs MDI or 2.5 mg nebulized and **sevoflurane** titrated to 1 MAC • If persistent bronchospasm, consider: • H_1 antagonist: **diphenhydramine** 25 - 50 mg IV • H_2 antagonist: **famotidine** 20 mg IV • Corticosteroid: **hydrocortisone** 100 mg IV or **methylprednisolone** 125 mg IV
ECHO	• Consider TEE / TTE to assess volume status and function
Labs	• Send peak serum tryptase 1 - 2 hr after reaction onset
Dispo	• Monitor for at least 6 hr. If severe, biphasic response is more likely so monitor in ICU for 12 - 24 hours • If intubated: consider keeping intubated
Allergy Follow-up	• Consider adding allergens to patient's allergy list • Refer the patient for follow-up allergy testing

Which of the folowing medications is acceptable for use while resuscitating a patient with suspected local anesthetic systemic toxicity (LAST)?

00:30

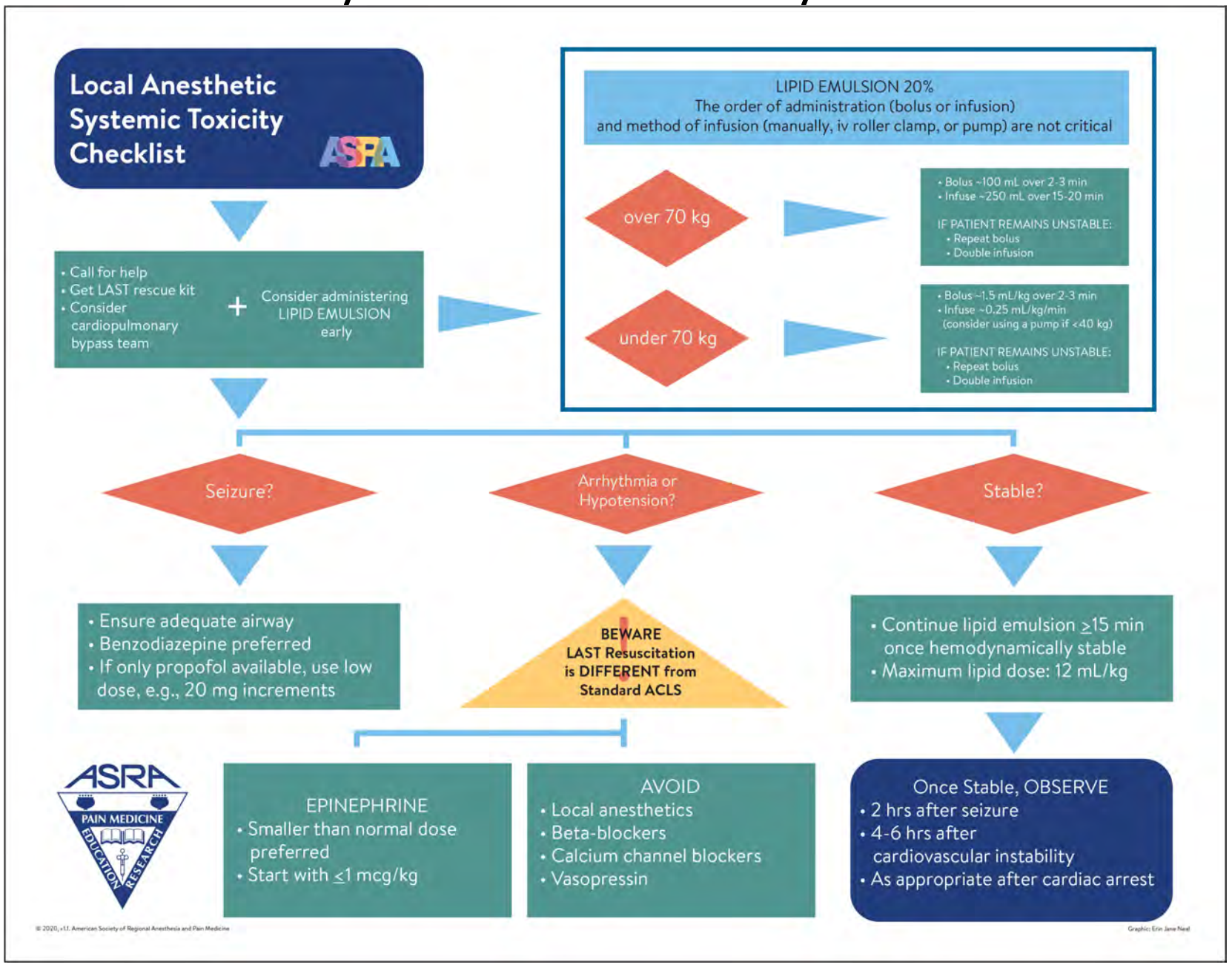
A Vasopressin

0%

B Metoprolol

SEE MORE

Local Anesthetic Systemic Toxicity



In the patient taking Lisinopril on the day of surgery, what medication may be necessary to correct refractory hypotension intraoperatively?

00:30

0

A Ephedrine

B Phenylephrine

SEE MORE

Hypotension: Vasoplegic Syndrome

Table 1
Changes in hemodynamic parameters during vasoplegic syndrome.

MAP	HR	CO/CI	CVP/RAP/PAWP	SVR	Capillary filling	PaO_2	U/O
↓↓	↑	≈ or ↑	↓	↓↓	≈	≈	↓

(MAP: mean arterial blood pressure, HR: heart rate, CO: cardiac output, CI: cardiac index, CVP: central venous pressure, RAP: Right atrial pressure, PAWP: pulmonary artery wedge pressure, SVR: systemic vascular resistance, PaO_2: arterial blood oxygen partial pressure, U/O: urine output, ≈ no change or within normal limits.)

H. Liu et al. / Journal of Clinical Anesthesia 40 (2017) 63–71

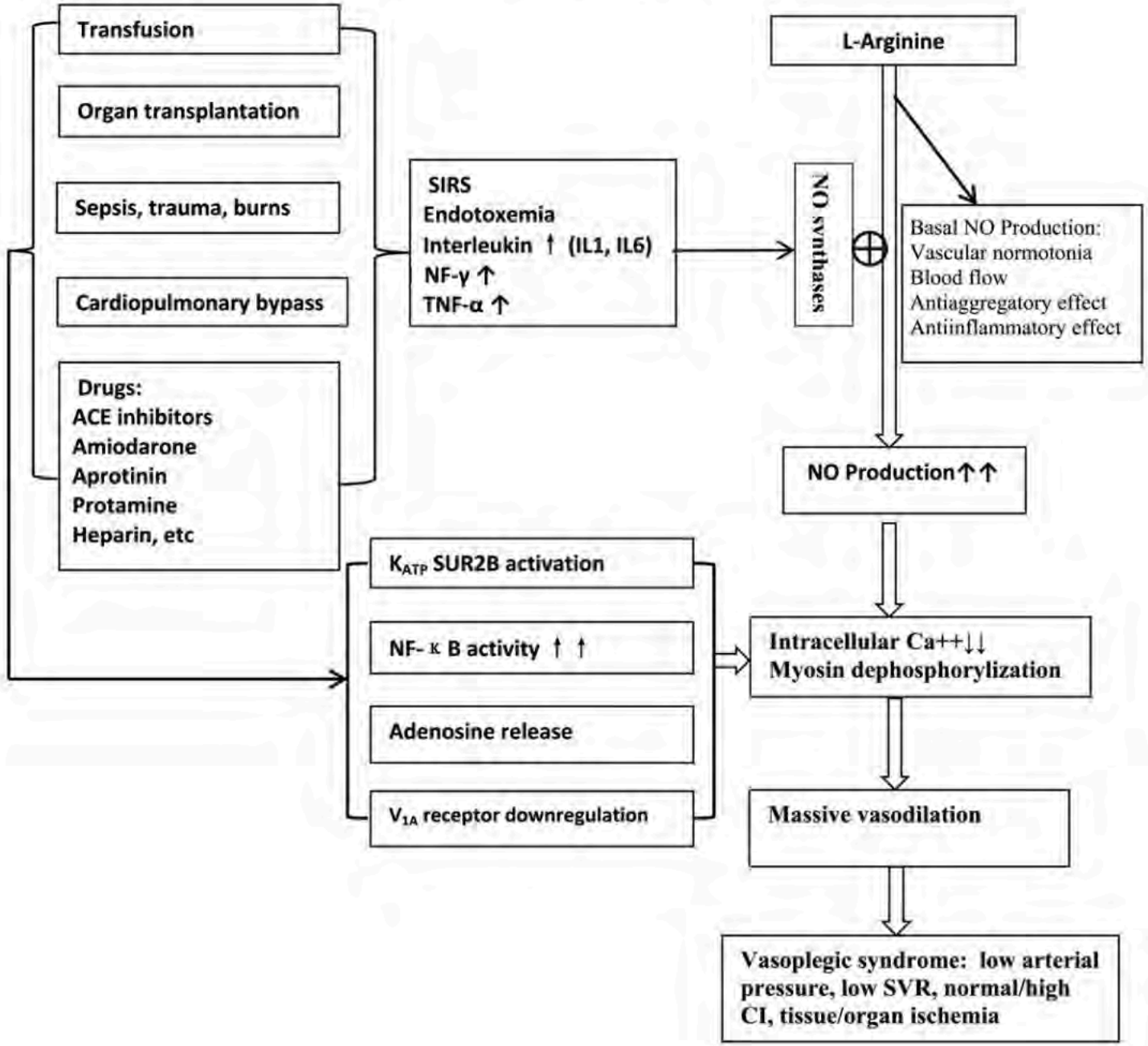

Transfusion
Organ transplantation
Sepsis, trauma, burns
Cardiopulmonary bypass
Drugs:
ACE inhibitors
Amiodarone
Aprotinin
Protamine
Heparin, etc
SIRS
Endotoxemia
Interleukin ↑ (IL1, IL6)
NF-γ ↑
TNF-α ↑
L-Arginine
NO synthases
Basal NO Production:
Vascular normotonia
Blood flow
Antiaggregatory effect
Antiinflammatory effect
NO Production ↑↑
K_{ATP} SUR2B activation
NF-κB activity ↑ ↑
Adenosine release
V_{1A} receptor downregulation
Intracellular Ca++↓↓
Myosin dephosphorylization
Massive vasodilation
Vasoplegic syndrome: low arterial pressure, low SVR, normal/high CI, tissue/organ ischemia

Table 3
Medications used in the management of vasoplegic syndrome [69,73].

Drug category		Mechanisms	Dosage	Notes
Commonly used agents	Epinephrine	Both α & β adrenergic receptors	0.05–5 μg/kg/min iv	Tachycardia can occur
	Norepinephrine	More α & less β adrenergic receptors	1 to 12 mcg/min	Distal extremity ischemia if used long term
	Vasopressin	↑Intracellular Ca++, ↑SVR	0.01–0.07 μ/min iv	
	Methylene blue	Guanylate cyclase inhibition	2 mg/kg iv	
Experimentally or less commonly ued agents	Hydroxocobalamin	Binding of nitric oxide Inhibition of NOS & guanylate cyclase	5 g iv over 10 min	Only case reports
	K_{ATP} channel blocker (glibenclamide)	Block K_{ATP} channel, ↑intracellular Ca^{++}	20 mg po	experimental
	NF-κB inhibitor polyphenol	Inhibition of NF–κB & inducible NOS	Various	experimental
	Indigo carmine	Inhibits endothelium-dependent and -independent vasodilation	40 mg/5 ml, iv	Idiosyncratic reaction can occur. No dilution.

(SVR: systemic vascular resistance. NOS: nitric oxide synthetase. NF–κB: nuclear factor–κB.)

Cardiac Medications: Starting and Stopping

- Cardiac drugs to continue preoperatively:
  - Beta-blockers,
  - Statins
  - Clonidine
  - Calcium channel blockers
  - Digoxin.
- Cardiac drugs to consider holding:
  - Angiotensin-converting enzyme inhibitors
  - Angiotensin receptor blockers.

Summary of Current Evidence: Pharmacologic MINS Prevention

1. If a patient is not taking beta-blockers, ACE-I/ARBs, or aspirin pre-operatively there is no evidence to suggest they should be started on these medications.
2. If a patient is taking beta-blockers preoperatively they should continue to take them in the perioperative period.
3. High risk patients should take aspirin perioperatively (especially following PCI and stent placement).
4. A single dose of statin therapy pre-operatively is unlikely to be helpful, long term statin use may be beneficial.
5. No type of anesthesia or anesthetic drug appears to influence MINS risk; however, perioperative hypotension is a major risk factor. Therefore drugs that offer more hemodynamic stability may be preferable (Sevoflurane).
6. Following a MINS diagnosis dabigatran +/- aspirin should be considered.

Reach out for questions! (oguinc@vcu.edu)