

A Novel Approach to Differential Diagnosis and Crisis Management in the Operating Room

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It's Go Time



Learning Outcomes

- Discuss a methodology to assess and treat anesthesia emergencies
- Describe the signs and symptoms and treatment of an
- Describe the signs and symptoms and treatment for
- Describe the signs and symptoms and management of
- Describe the signs and symptoms and management of



A Cognitive Template for Management of Perioperative Adverse Events

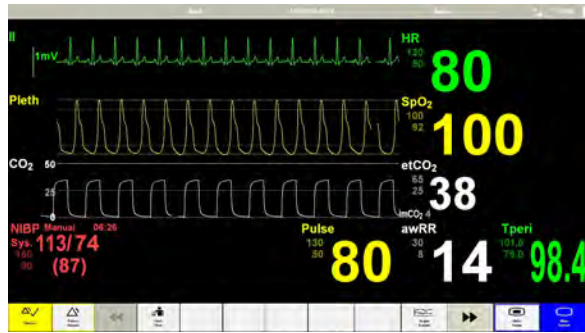
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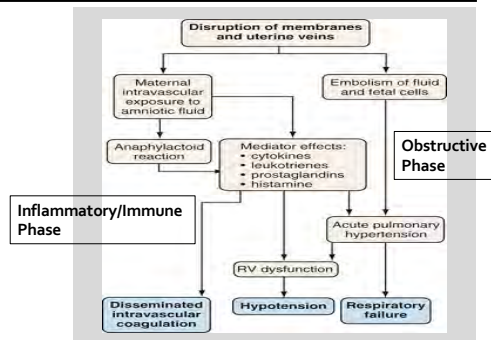
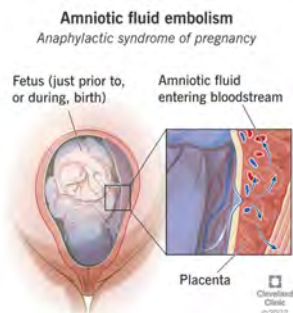
1. **Verification:**
Does the adverse event represent artifact or is the value correct?
2. **Generic Response:**
What are the general steps that will likely initiate appropriate therapy for the adverse event regardless of the etiology?
3. **Identification of precipitating incident:**
Cause and Effect – What event preceded the adverse event?
4. **Formulate a broad differential diagnosis:**
"Front Shelf" and "Back Shelf" diagnoses
5. **Formulate a narrowed differential diagnosis:**
Overlapping signs and symptoms and clinical condition
6. **Targeted Response:**
Specific treatment(s)



Dilation and Evacuation



AFE Pathophysiology



AFE-Signs and Symptoms

Signs or symptoms	Frequency
Hypotension	100%
Fetal distress	100%
Pulmonary edema or ARDS	93%
Cardiopulmonary arrest	87%
Cyanosis	83%
Coagulopathy	83%
Dyspnea	49%
Seizure	48%
Uterine atony	23%
Bronchospasm	15%
Transient hypertension	11%
Cough	7%
Headache	7%
Chest pain	2%

ARDS = adult respiratory distress syndrome.
Adapted from Clark SL, Hankins GD, Dudley DA, Dildy GA, Porter TF. Amniotic fluid embolism: analysis of the national registry. *Am J Obstet Gynecol* 1996;172:1156-67.

Thomas's Case

- Amniotomy occurs, then.....
- Normotensive (first 15 min post AFE)
- Tachycardia-70-120 BPM-Light??
- Tachypnea (LMA)-Light??
- Hypoxia (LMA)50-60%-Laryngospasm/bronchospasm-Light??
- Hypocapnia-12-14 mm/Hg
- Fibrinogen <60 mg/dL, normal 200-400mg/dl

AFE-Differential Diagnosis

Differential Diagnosis of AFE

Nonobstetric	Obstetric	Anesthetic
Myocardial infarction Pulmonary embolism Aspiration Sepsis Anaphylaxis	Placental abruption Eclampsia Uterine rupture Hemorrhage	High neuraxial blockade Local anesthetic systemic toxicity Medication error



Case #1-Dilation and Evacuation (AFE)

1. **Verification (Artifact)**-No
2. **Generic response**-100% FiO₂, manual ventilation, auscultate
3. **Identification of cause**-Amniotomy immediately prior to event
4. **Broad differential dx**-Severe hypoxia, CHF, MI, AFE
5. **Narrowed differential dx**-AFE
6. **Targeted treatment**-See TNA Checklist- **Hypotension**



HYPOTENSION

MECHANISM: Decrease in systemic blood pressure primarily caused by reduction in cardiac output and peripheral vascular resistance.

Management	Signs & Symptoms	Differential Diagnosis
PRIMARY ACTIONS: <ol style="list-style-type: none"> 1. Call for help & obtain "cough test" 2. Administer FiO₂ 100% & ensure patent airway 3. Decrease/turn off inhaled agent 4. Recheck blood pressure, re-zero transducer if A-line present 5. Palpate peripheral pulses 6. Administer IV fluid bolus 7. Vasopressors 8. Stop surgery if severe refractory hypotension exists 9. Elevate the patient's legs 10. Discontinue PEEP if applicable 11. Place additional IV SECONDARY ACTIONS: <ul style="list-style-type: none"> • IDENTIFY & TREAT THE SPECIFIC CAUSE • Initiate ACLS or PALS as needed 	NEUROLOGIC: <ul style="list-style-type: none"> • Altered level of consciousness • Decreased or no response CARDIOVASCULAR: <ul style="list-style-type: none"> • Bradycardia • Decreased peripheral/central pulses, poor capillary refill • Tachycardia, bradycardiac dysrhythmias • Myocardial ischemia/infarction RESPIRATORY: <ul style="list-style-type: none"> • Shortness of breath • Tachypnea followed by apnea OTHER: <ul style="list-style-type: none"> • Metabolic acidosis • Increased serum magnesium; decreased serum sodium • Oliguria 	<ul style="list-style-type: none"> • Shock (anesthetic, hypovolemic, cardiogenic, anaphylactic, septic) • Respiratory: pulmonary embolism, pulmonary edema, pneumonia, PEET, hypoxia (ate) • Cardiac: embolism, dysrhythmias, high intracranial pressure, hemorrhage, myocardial ischemia/infarction, reperfusion of ischemic tissue, acute adrenal crisis, vagal stimulation, vasospastic syndrome • Endotracheal intubation, hypoxemia, hypotension • Local anesthetic regional (LAST) • Medication error • Medications that cause vasodilation (i.e., nitroglycerin, morphine, or propofol) or those that cause myocardial depression (i.e., general anesthetics), or medications (i.e., Dalf/Vigra) • Positioning: reverse Trendelenburg, supine position during pregnancy

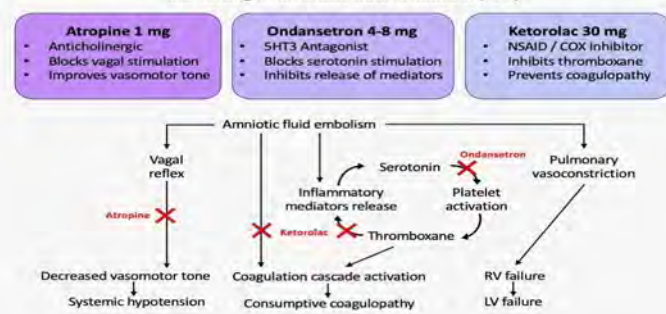
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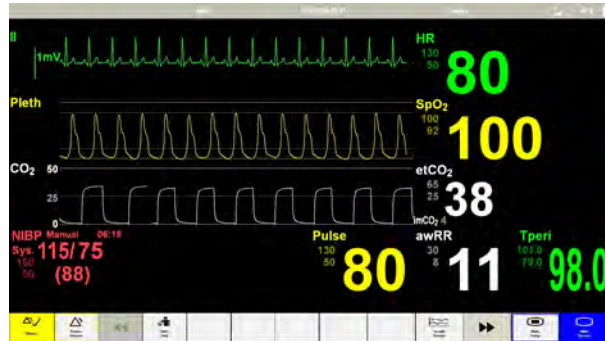


A-OK Protocol

The proposed mechanism of the "A-OK" protocol is in the setting of amniotic fluid embolism (AFE)



Circumcision-22 year old



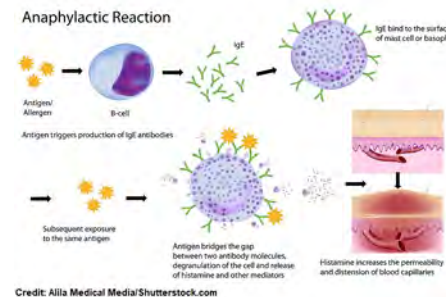
Anaphylaxis-Onset

- Food allergy: 30-35 min
- Insect stings: 10-15 min
- IV medications-within 5 min
- Cause and effect!!!!

Diana's Case

- Onset of first symptom-3 min
- Initial symptoms:
Heart rate increases from 80 to 150 BPM
Blood pressure decreases from 110/60 to 80/40
- What is the first diagnosis that we would all make with only this information?

Anaphylaxis-Pathophysiology



- Antigen sensitizes IgE antibodies causing degranulation of mast cells & basophils resulting in the release of histamine & other inflammatory mediators.
- A large histamine release causes dramatic vasodilation & severe hypotension.
- Examples:**
 - Drug sensitization: neuromuscular blockers, antibiotics, Sugammadex
 - Others: latex, venom, foods

Causes of perioperative anaphylaxis

- Neuromuscular blocking agents: 50-70%
 - Rocuronium - 56%
 - Succinylcholine - 21%
 - Vecuronium - 11%
 - Cisatracurium/Atracurium - 12%
- Latex: 15-20%
- Antibiotics: 12-15%
 - Most often β -lactam antibiotics (i.e., amoxicillin, ampicillin, cephalosporins and penicillin)
 - Cross reactivity very rare
- Other: 5-10% (i.e., IV contrast, iodine)



Anaphylaxis Signs & Symptoms - *Sudden onset/rapid progression*

Airway

- Bronchospasm:
 1. Desaturation
 2. Increased PIP
 3. Sloped expiratory EtCO₂ waveform
 4. Wheezing
- Angioedema
- Pulmonary edema

Circulation

- Severe hypotension*
- Compensatory tachycardia*
- Reduced preload = Decreased CO & Decreased EtCO₂
- New onset cardiac dysrhythmias
- Cardiovascular collapse



Anaphylaxis Signs and Symptoms



https://allergyfacts.org.au/_interest/urticaria/

- Skin/mucosal flushing, rash, itching, hives

Present Case

New onset rash of the face/neck/chest



Anaphylaxis-Differential Diagnosis

Font Shelf

- Deep plane of anesthesia
- Volume depleted
- Bronchospasm (wheezing, hypertension)
- Medication error

Back Shelf

- All shock states (except neurogenic)
- Pulmonary embolism
- Congestive heart failure
- Air/CO₂ gas embolism
- Aspiration



Anaphylaxis-Definitive Diagnosis

- Tryptase is a major protein contained within mast cell granules.
- Tryptase levels:
 1. Increase within 30 minutes
 2. Peak in 1-2 hours after an anaphylaxis
 3. Back to normal within 6-8 hours

Diana's Case

- Normal Tryptase <10.9 mcg/L
- After episode=18.9 mcg/L, 14:40=36.2 mcg/L, 18:00=18.9 mcg/L



Epinephrine Dose for Anaphylaxis

- Initial:10-100 mcg
- Preparation: gold box-100 mcg/mL

Diana's Case

- SBP approximately 50 mm/Hg
- Initial-100 mcg epinephrine, 3 units vasopressin
- After approximately 5 min-SBP approximately 100 mm/Hg



Case #2-Circumcision (Anaphylaxis)

- **Verification (Artifact)-No**
- **Generic response**-Decreased anesthetic depth, fluid, phenylephrine
- **Identification of cause**-Antibiotic minutes prior to event
- **Broad differential dx**-Severe hypotension unresponsive to phenylephrine, deep anesthesia, volume ↓
- **Narrowed differential dx**-Anaphylaxis
- **Targeted treatment**-See TNA checklist-**Anaphylaxis**



ANAPHYLAXIS

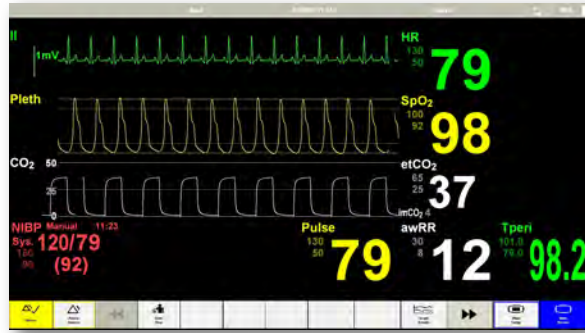
MECHANISM: IGE mediated response to a foreign substance causing degranulation of mast cells and histamine release

Management	PRIMARY ACTIONS: 1. Call for help & obtain "crash cart" 2. Administer FIO ₂ 100% & ensure patent airway 3. Discontinue/turn off inhaled agent 4. Stop/remove allergen (neuromuscular blockers, latex, antibiotics, blood/blood products, opioids, local anesthetics, sugammadex) 5. Consider EARLY intubation	MEDICATIONS: 1. EPINEPHRINE 10-100 mcg IV bolus every 2 minutes • Infusion 1-10 mcg/min 2. Diphenhydramine 25-50 mg IV bolus - H1 blockade first FOLLOWED BY: 3. Pepcid (Famotidine) 20 mg IVPB - H2 blockade 4. Hydrocortisone 100 mg IV bolus		
Signs & Symptoms	SECONDARY ACTIONS: • Emergent completion of surgical procedure • Consider lab evaluation of tryptase level • Institute ACLS or PALS as needed			
Differential Diagnosis	<table style="width: 100%; border: none;"> <tr> <td style="vertical-align: top; width: 50%;"> NEUROLOGIC: • Anesthetics • Altered level of consciousness CARDIOVASCULAR: • Severe hypotension (possibly unresponsive to vasopressors) • Tachycardia/bradycardia OTHER: • Flushing, rash, hives, metastatic nodules </td> <td style="vertical-align: top; width: 50%;"> RESPIRATORY: • Bronchospasm (with or without wheezing) • Secretions of breath • Hypercapnia • Sloped tracheal segment/absent ETCO₂ waveform • Increased peak airway pressures • Desaturation/hypoxemia/hypoxia/cyanosis • Airway edema </td> </tr> </table>		NEUROLOGIC: • Anesthetics • Altered level of consciousness CARDIOVASCULAR: • Severe hypotension (possibly unresponsive to vasopressors) • Tachycardia/bradycardia OTHER: • Flushing, rash, hives, metastatic nodules	RESPIRATORY: • Bronchospasm (with or without wheezing) • Secretions of breath • Hypercapnia • Sloped tracheal segment/absent ETCO ₂ waveform • Increased peak airway pressures • Desaturation/hypoxemia/hypoxia/cyanosis • Airway edema
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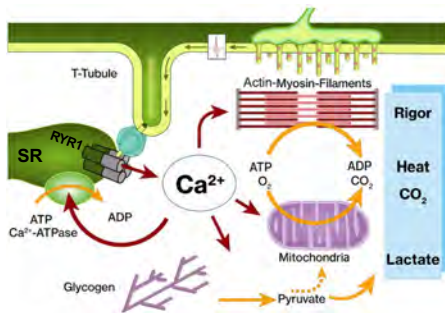
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 Clinical experience and individual practitioner's best practices should be followed in treatment that best fits the clinical circumstance.
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Neck Mass Excision-6 year old



Pathophysiology of MH



- Ryanodine receptor
- Sarcoplasmic reticulum
- Massive calcium release
- Hypermetabolism (creation of heat and CO₂)
- Increased O₂ consumption & ATP depletion
- Lactic acidosis

Signs and Symptoms

- **Increased HR – First sign**
- **Rise in EtCO₂ – Most reliable sign**
- Increased temperature
- Muscle rigidity
- Arrhythmias
- Rhabdomyolysis/Myoglobinuria
- Mottled/cyanotic skin
- Decreased SaO₂

	REVONTO	DANTRIUM	RYANODEX
Manufacturer	US WORLDMEDS	PAR PHARMACEUTICAL	EAGLE PHARMACEUTICAL
Dantrolene dose per vial	20 mg	20 mg	250 mg
Number of vials for initial dose*	Give 9 vials (540 mL) = 180 mg	Give 9 vials (540 mL) = 180 mg	1 vial (5 mL) Give 4 mL = 200 mg
Water to reconstitute 1 vial	60 mL	60 mL	5 mL
Vials required to stock	36	36	3
Price	\$3,000	\$3,000	\$6,900
Shelf life	3 years	3 years	2 years

* Assumes a 70 kg patient at 2.5 mg/kg

Ryanodex® for Malignant Hyperthermia
5mL vial = 250 mg of powdered dantrolene

Case #3-Neck mass excision (MH)

- **Verification (Artifact)-No**
- **Generic response**-Intubated, increased minute ventilation and depth of anesthesia
- **Identification of cause**-None
- **Broad differential dx**-Exhausted CO₂ granules, LMA placement, hypoventilation, laparoscopic surgery, MHⓈ
- **Narrowed differential dx**-MH
- **Targeted treatment**-See TNA checklist-MH

MALIGNANT HYPERTHERMIA (MH)

MECHANISM: Dysregulation of the ryanodine receptor within skeletal muscle causing calcium overload with sustained muscle contraction & breakdown & cellular hypermetabolism

Management

PRIMARY ACTIONS:

1. Call for help. Declare MH emergency
2. Obtain "MH Cart", complete surgery ASAP
3. Turn off isolation agent/anesthetics
 - Continue with "non-triggering anesthetic agents"
4. Hyperventilate with FIO₂ 100%
5. Apply external chamber filter to endotracheal/ventilatory limb
6. Administer **DANTROLENE**
7. Consult Malignant Hyperthermia Association of the United States (MHAUS): 1-800-444-9937
8. Cooling measures
 - Forced air cooling
 - Covered in Rags
 - Apply ice packs to head, arms, etc., groin
 - Intraperitoneal/intragastric lavage
9. Obtain vital laboratory tests
 - ABG
 - Electrolytes (potassium)
 - Creatinine/urea
 - Creatinine kinase (CK)
 - Myoglobin

MEDICATIONS:

1. **DANTROLENE** 2.5 mg/kg IV bolus, repeat every 5 minutes up to 30 mg/kg until symptoms resolve
 - Dantrium® & Revonto®, 20 mg/vial – reconstituted with 60 mL sterile water
 - Initial bolus (70 kg patient) administer 3 vials (180 mg)
 - Ryanodex®, 250 mg/vial – reconstituted with 5 mL sterile water
 - Initial bolus (70 kg patient) administer 4 mL (200 mg)

CONSIDER:

- Treat hyperkalemia
 1. Calcium chloride 10% (5-10 mL) or Calcium gluconate 10% (5-10 mL) NPB
 2. Regular insulin 5 units IV AND D50 (25 g Dextrose) 1 ampule IV
 3. Treat metabolic acidosis
 4. Sodium bicarbonate (1 ampule)

SECONDARY ACTIONS:

- Insert Foley catheter
- Insert PTTM line
- Hemodynamic monitoring as needed
- Intubate ACLS or PALS as needed

CARDIOVASCULAR:

- Tachycardia
- Hypertension
- Dysrhythmias (peaked T waves)
- Dyspnea

RESPIRATORY:

- Continuously increasing ETCO₂/Paco₂
- Decreased SpO₂/PaO₂
- Exhausted CO₂ absorbent

OTHER:

- Hyperthermia
- Skeletal muscle rigidity
- Muscular muscle spasm
- Myoglobinuria
- Metabolic acidosis
- Hyperkalemia

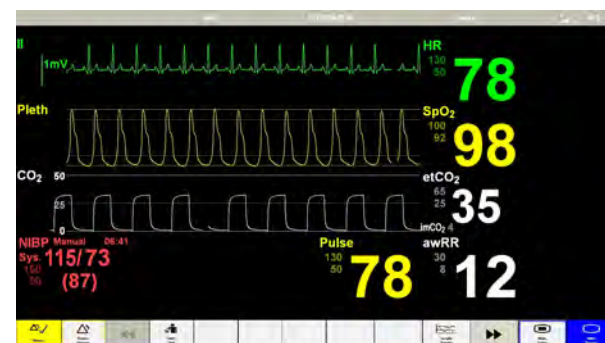
Signs & Symptoms

Differential Diagnosis

- Pharmacologic drug intoxication (i.e., malingham's syndrome, central anticholinergic syndrome)
- Respiratory exhausted CO₂ absorbent, hypoventilation
- Sepsis
- Hypermetabolic syndrome pheochromocytoma, thyroid storm, neuroleptic malignant syndrome, carcinosarcoma

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AV Fistula Creation





Case #2: A-V Fistula

1. **Verification (Artifact)** - Confirm pulse oximetry & EtCO₂ line connection
2. **Generic response** - 100% FiO₂, verify airway placement & patency, confirm adequate ventilation, call for assistance
3. **Preceding event** - Recent extubation with airway obstruction
4. **Broad differential dx** – Cannot intubate/cannot oxygenate or ventilate
5. **Narrowed differential dx** – Severe hypoxia
6. **Targeted treatment** - See TNA checklist – **Failed Airway**



FAILED AIRWAY

MECHANISM: inability to provide/maintain adequate patient oxygenation after multiple attempts at ventilation using different airway interventions.

PRIMARY ACTIONS:

1. Call for help & verbalize **FAILED INTUBATION**
- Limit to 2-3 initial attempts by competent airway provider

MEDICATIONS:

- Anesthetics can include propofol, ketamine, or etomidate

If Ventilation Unsuccessful & Oxygen Saturation Critically Low:

1. Declare **FAILED VENTILATION**
2. Declare need for **FRONT OF NECK ACCESS** (cricothyrotomy)
3. Prepare for surgical airway & sterilize the neck with betadine
4. Perform cricothyrotomy
5. Confirm placement with ETCO₂ & bilateral breath sounds

Signs & Symptoms	<p>NEUROLOGIC:</p> <ul style="list-style-type: none"> • Altered level of consciousness <p>CARDIOVASCULAR:</p> <ul style="list-style-type: none"> • Early tachycardia, late bradycardia • Dysrhythmias 	<p>RESPIRATORY:</p> <ul style="list-style-type: none"> • Apnea • Oxygen saturation < 85% • Hypernasal/stridor/stridor • Absent breath sounds
Differential Diagnosis	<ul style="list-style-type: none"> • Respiratory: Airway obstruction, pulmonary embolism, pulmonary edema, pneumonia, gastric aspiration, bronchospasm • Respiratory pathophysiology that can lead to a failed intubation (i.e., airway tumors, trauma to the airway, laryngeal spasm) • Cardiac: Congestive heart failure • Mechanical: Circuit/breathing system, pulse oximetry probe malposition, circuit or ETCO₂ sample line disconnection • Perioperative considerations: Residual anesthetic medications (halothane agent, narcotic, neuromuscular blockade) 	

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Clinical expertise and individual presentation may necessitate variations in treatment that depart from the checklist information.
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