

The Critical Care Transport Handbook

Featuring the P.A.M. Approach

PATHOPHYSIOLOGY | ASSESSMENT | MANAGEMENT

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THIS BOOK IS A COMPILATION OF CURRENT MEDICAL THERAPIES, BUT YOU SHOULD ALWAYS FOLLOW YOUR MEDICAL DIRECTION AND PROTOCOLS/GUIDELINES. THIS WORK IS INTENDED FOR EDUCATIONAL PURPOSES.

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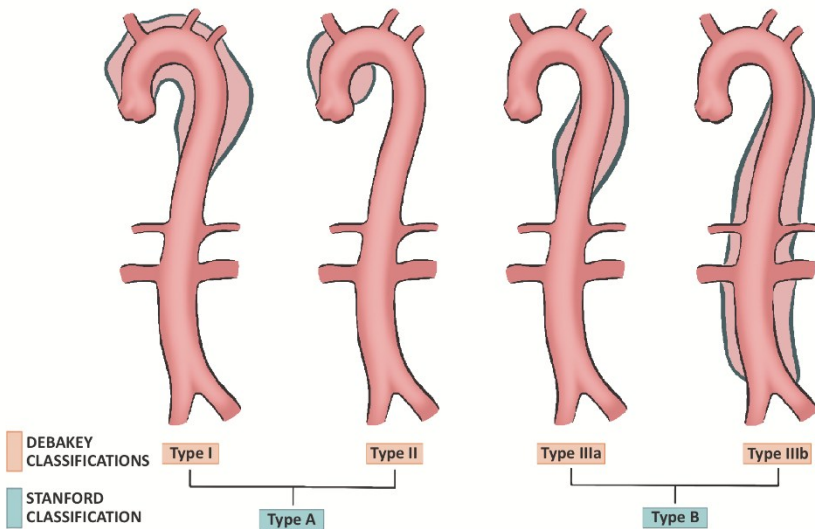
AORTIC DISSECTION

PATHOPHYSIOLOGY:

Force of blood impacts aortic wall → weakens media layer → unglues aortic layers → area bulges outward → intima tears away from media → blood accumulates between layers. → Tear may extend back to the heart → regurgitation and coronary blood flow affected. Commonly classified on the DeBakey and Stanford scales (Stanford A = DeBakey Types I and II, Stanford B = DeBakey Type III).

ASSESSMENT:

Constant moderate to severe back pain, tearing pain, an urge to defecate, pain unrelieved by position change, wide mediastinum on x-ray.



MANAGEMENT:

1. Provide supportive and general care PRN
2. Invasive hemodynamic monitoring
3. **Pain Control**

- a. **Morphine:** 2-6 mg IV
 - b. **Fentanyl:** 50-100 mcg IV
4. Control rate **THEN** control systolic blood pressure (SBP)
5. **CONTROL RATE** (Target HR \leq 60/min) to decrease shearing stress:
 - a. **Esmolol:** 50-200 mcg/kg/min
 - b. **Labetalol:** 10-20 mg IVP, then 0.5-5 mg/min
 - c. **Diltiazem:** 0.25 mg/kg IV (max 25 mg), then 5-15 mg/hr
 - d. **NOTE:** You will have times where you give one of these, and the HR doesn't decrease. Be ready to add a second one. If you cannot get rate down, contact med control to discuss moving to vasodilators without rate control. Not very common, but also not uncommon.
6. **CONTROL SBP** (Target SBP < 120 mmHg) to limit progression:
 - a. **Nicardipine:** 5-15 mg/hr initially, titrate by 2.5 mg/hr q5min
 - b. **Nitroprusside:** 0.1-2 mcg/kg/min
 - c. **Clevidipine:** 1-21 mg/min
 - d. **AVOID:** Nitroglycerin, Hydralazine due to reflex tachycardia
7. W/poor perfusion/hypotension/shock
 - a. **Isotonic crystalloid:** 10-20 mL/kg
 - b. W/ hemorrhage/rupture:
 - i. **PRBCs** 1-2 units (type O- or cross/matched)
 - ii. **PRBCs/platelets/FFP 1:1:1** (type O- or cross/matched)
 - iii. **Whole Blood** 1-2 units (type O- or cross/matched)
 - iv. **TXA** 1-2 grams/100 mL IV over 10 min
 - v. **Vasopressin:** 0.04 units/min
 - vi. **Calcium gluconate** 2 g or **Calcium chloride** 1 g for every 3 units PRBCs or whole blood
 - c. **Norepinephrine:** 1-50 mcg/min (0.01-0.5 mcg/kg/min)
 - d. **Phenylephrine:** 50-500 mcg/min (0.25-5 mcg/kg/min) (Push dose: 50-200 mcg/dose)
 - e. **Epinephrine:** 1-30 mcg/min (0.01-1 mcg/kg/min) (Push dose: 5-20 mcg/dose)
 - f. **Dopamine:** 5-20 mcg/kg/min (falling out of favor due to its perceived tax on the myocardium)
8. W/persistent/refractory hypotension:
 - a. **Hydrocortisone:** 100 mg IV (Peds: 2 mg/kg); Adjunct to vasopressors for increased vasoconstriction from depleted cortisol
 - b. **Calcium** (Adjunct to vasopressors for increased strength of vasoconstriction)
 - i. **Calcium Gluconate** 2 g IV peripheral (30-60 mg/kg)
 - ii. **Calcium Chloride** 1 g IV central only (10-20 mg/kg)
 - c. **Sodium Bicarb:** 1-2 mEq/kg IV (Adjunct to vasopressor therapy)

for improved pharmacodynamics from the buffering of acidic serum)

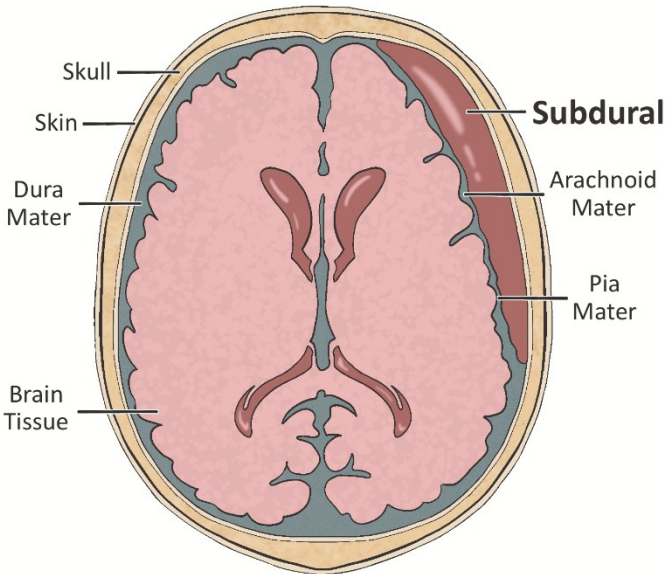
9. W/ anticoagulation therapy or delayed clotting:

- a. Warfarin related: **Vitamin K** 10 mg IV & **KCentra** 1500 units IV
- b. DOAC related (-xaban): **KCentra** 25-50 units/kg (max 2500 units or 5000 units respectively)
- c. Heparin or Enoxaparin related: **Protamine** 50 mg
- d. Pradaxa (Dabigatran) related: **Praxbind** (Idarucizumab) two 2.5-gram doses - the second dose should be administered 15 minutes after the first
- e. Aspirin or antiplatelet therapy related: **Desmopressin** (DDAVP) 0.3 mcg/kg IV (enhances platelet adhesion clot formation)

BLEEDS: SUBDURAL HEMATOMA

PATHOPHYSIOLOGY:

Head trauma or spontaneous → venous rupture → bleeding into subdural space → brain edema → increased ICP.



ASSESSMENT:

Mechanism (head injury); HA- slowly developing; gradual mental status changes; nausea and vomiting; CT- crescent shaped (concave) hematoma

MANAGEMENT:

1. Provide supportive and general care PRN.
2. Prevent secondary injury (prevent hypoxia and hypotension) by maintaining ABCs.
3. Obtain “last known well” time.
4. Perform GCS, NIH & Cincinnati Prehospital Stroke Scale
5. R/O Stroke Mimics
 - a. Seizures
 - b. Hypoglycemia
 - c. Hypertensive encephalopathy

- d. Migraine w/aura
- e. Psychogenic
- f. Others: Psychogenic, Wernicke's, Drugs, CNS tumor, Bell's palsy)
- 6. Manage elevated ICP:
 - a. Indicated: ipsilateral pupil changes, new posturing
 - b. Raise HOB to ~ 30°
 - c. Hyperosmolar therapies
 - i. **Hypertonic saline**
 - ii. **Mannitol 20%: 1 g/kg (max 100 g) over 30 min**
 - 1. Can lower BP, and therefore threaten CPP.
 - 2. Consider hypertonic saline in hypotensive and poly trauma patients.
 - d. ICP monitoring via EVD
 - i. HOB set to 30°
 - ii. Set EVD height
 - iii. Transducer at 'Zero Height'
 - iv. Zero transducer at level of the tragus/external auditory canal/ Foramen of Monroe
 - v. Follow orders from neurosurgery
- 7. Obtain CT head (non-contrast) within 25 minutes and have it read within 45 minutes of ED arrival (as per AHA).
- 8. Medications to obtain Goal BP of 140-160 mmHg:
 - a. **Nicardipine**: 5-15 mg/hr, start at 5 mg/hr and increase by 2.5 mg/hr q15min to a max of 15 mg/hr; Peds 0.5-1 mcg/kg/min initially to maximum 4-5 mcg/kg/min.
 - b. **Labetalol**: 5-20 mg slow IVP, then 0.5-2 mg/min (may require titration up to 10 mg/min); Peds 0.2-1 mg/kg/dose initially (max of 20 mg), then 0.25-3 mg/kg/hr
 - c. **Clevidipine** 1-21 mg/hr
 - d. **AVOID**: Nitroglycerin, Nitroprusside as they can increase cerebral blood flow
- 9. Reversal of anticoagulation/antiplatelet therapy (PRN):
 - a. Warfarin related: **Vitamin K** 10 mg IV & **KCentra** 1500 units IV
 - b. DOAC related (-xaban): **KCentra** 25-50 units/kg (max 2500 units or 5000 units respectively)
 - c. Heparin or Enoxaparin related: **Protamine** 50 mg
 - d. Pradaxa (Dabigatran) related: **Praxbind** (Idarucizumab) two 2.5 gram doses - the second dose should be administered 15 minutes after the first
 - e. Aspirin or antiplatelet therapy related: **Desmopressin** (DDAVP) 0.3 mcg/kg IV (enhances platelet adhesion, clot formation)

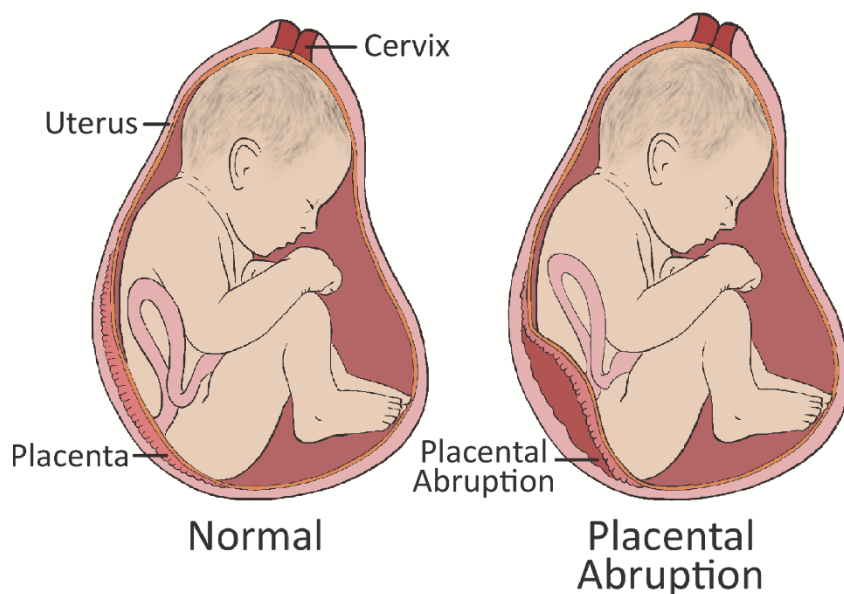
10. Manage seizures

- a. Prophylaxis for GCS ≤ 8
 - i. **Levetiracetam** 20 mg/kg IV
- b. If seizure
 - i. Emergent control therapy
 1. **Lorazepam**: 4 mg IV (Peds: 0.1 mg/kg)
 2. **Midazolam**: 10 mg IM/IV (Peds: 0.2 mg/kg)
 3. **Diazepam**: 10 mg IV (Peds: 0.15 mg/kg)
 - ii. Urgent control therapy
 1. **Levetiracetam**: 40-60 mg/kg IV (max 4500 mg)
 2. **Fosphenytoin**: 20 mg/kg IV (max 1500 mg & max 150 mg/min infusion rate)
 3. **Phenytoin**: 20 mg/kg (max 1500 mg & max 50 mg/min infusion rate)
 4. **Valproic Acid**: 30-40 mg/kg IV (max 3000 mg)
 - iii. W/Refractory seizures
 1. **Midazolam**: 0.2 mg/kg IV bolus, followed by infusion 0.05-2 mg/kg/hr IV
 2. **Ketamine**: 1-2.5 mg/kg/hr IV
 3. **Propofol**: 1-2 mg/kg IV bolus, followed by infusion 5-50 mcg/kg/min IV
 4. **Phenobarbital**: 5-15 mg/kg IV bolus, followed by infusion 1-2 mg/kg/day IV

ABRUPTIO PLACENTA

PATHOPHYSIOLOGY:

Blunt/penetrating trauma or spontaneously → disrupts the connections of the placenta with the uterine wall → PAIN → bleeding → fetal demise → mother hypotension and shock → death



ASSESSMENT:

Vaginal bleeding (only in 80% of cases), abdominal/ back pain, shock, uterine tenderness, loss of fetal heart tones or slowing fetal heart tones

MANAGEMENT:

1. Provide supportive and general care.
 - a. Tilt left or right lateral 15 degrees if > 20 weeks gestation
 - b. Aggressive fluid resuscitation (target >0.5 mL/kg/hr)
 - c. Transport to a facility capable of performing Cesarean section.
2. Assess any blood loss (must be quantifiable).
3. W/dehydration/hypovolemia: **Isotonic crystalloid**: 20 mL/kg (target UOP

0.5-1 mL/kg/hr)

4. Control pain
 - a. **Fentanyl**: 50-100 mcg IV (0.5-1.5 mcg/kg)
 - b. **Morphine**: 2-6 mg IV (0.05-0.1 mg/kg)
5. W/anemia (from bleeding)
 - a. **Whole blood** 1-2 units (type O- or cross/matched)
 - b. **PRBCs/platelets/FFP** 1:1:1 (type O- or cross/matched) x 1-2
 - c. **PRBCs** 1-2 units (type O- or cross/matched)
 - d. **TXA** 1-2 g/100 mL over 10 min
 - e. **Calcium gluconate** 2-3 grams or **calcium chloride** 1 gram for each 3 units of PRBCs or whole blood
6. W/hypo-coagulability (from bleeding)
 - a. **FFP or liquid plasma** (1-2 units)
 - b. **Kcentra** 1500 units IV
 - c. **Cryoprecipitate** (Fibrinogen, Factors VIII & XIII)
 - i. 5-10 units (aka 1-2 pools) via infusion of 2-5 mL/min (usual dose 50-200 mL)
 - ii. 1 unit ↑ fibrinogen by 7-10 mg/dL
7. W/ anticoagulation therapy or delayed clotting:
 - a. Heparin or Enoxaparin related: **Protamine** 50 mg
 - b. Aspirin or antiplatelet therapy related: **Desmopressin** (DDAVP) 0.3 mcg/kg IV (enhances platelet adhesion, clot formation)

CONGENITAL HEART DISEASE, ACYANOTIC LESIONS

PATHOPHYSIOLOGY:

Multiple etiologies - defect causes one or multiple structural lesions → alternate blood flow paths → left-to-right shunting of blood → increased pulmonary blood flow and pressure. Presents like CHF with volume overload, pulmonary congestion, and reduced systemic perfusion.

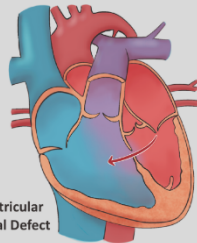


Atrial Septal Defect

ATRIAL SEPTAL DEFECT
Left to Right shunt, opening between Atria.

TREATMENT
Size dependent

- Small- Self resolving.
- Medium/Large- Surgical repair.
- For symptom management think heart failure

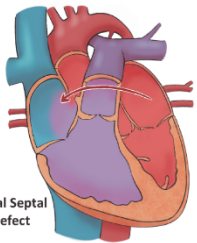


Ventricular Septal Defect

VENTRICULAR SEPTAL DEFECT (VSD)
Left to Right shunt, opening between Ventricles.

TREATMENT

- Surgical Repair
- For symptom management, think heart failure, treat with Diuretics and ACE inhibitors.

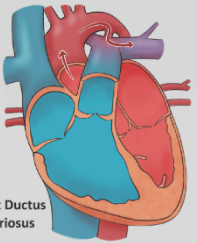


Atrial Septal Defect

COARCTATION OF THE AORTA
Narrowing of the Aorta causing increased afterload (in the Left Ventricle) and decreased peripheral blood flow.

TREATMENT

- Repair via angioplasty, cath, and stent.



Patent Ductus Arteriosus

PATENT DUCTUS ARTERIOSUS (PDA)
Left to Right shunt, causing increased workload on the left heart and increased pulmonary blood flow.

TREATMENT

- Heart failure management
- Surgical repair
- Administer Prostaglandin (PG) inhibitors for preterm neonates.

ASSESSMENT:

Cardiovascular: Tachycardia; Weak pulses; Pathologic murmur; Hyperdynamic precordium; Hepatomegaly. Respiratory: Tachypnea; Dyspnea; Retractions; Respiratory distress; Pulmonary edema. General: Poor weight gain; Feeding difficulties; Excessive sweating; Irritability. ABG: Metabolic acidosis due to systemic hypoperfusion. Chest X-ray: Enlarged heart; Pulmonary congestion. **Pre- and Post-Ductal SpO₂:** Normal with no cyanosis; significant differential (>10%) or signs of PPHN suggest underlying lesion or heart failure.

Saturation Finding	Likely Condition
No difference (<3%)	Normal oxygenation
Pre-ductal > Post-ductal (>10%)	PPHN, aortic coarctation, interrupted arch
Pre-ductal < Post-ductal (>10%) (reversed)	TGA, coarctation with PDA
Both <85%	Severe cyanotic heart disease, pulmonary disease, shock
Saturation Finding	Likely Condition

MANAGEMENT:

1. Provide supportive and general care
2. Maintain **STABLE**
3. Monitor closely for signs of CHF exacerbation or metabolic derangements.
4. Limit fluid intake to 50-60 mL/kg/day.
5. Reduce Pulmonary Congestion:
 - a. **Furosemide:** 0.5-1 mg/kg/dose IV/IM
 - b. **Bumetanide:** 0.01–0.05 mg/kg IV q6-24hr
 - c. **Chlorothiazide:** 5-10 mg/kg IV q12hr

6. W/Poor perfusion/hypotension/shock
 - a. **Fluids:**
 - i. **Isotonic Crystalloids:** 10-20 mL/kg slow IVP
 - ii. **Blood** (PRBCs or Whole blood): 10-20 mL/kg slow IVP
 - b. **Vasopressors:**
 - i. **Dopamine:** 5-20 mcg/kg/min
 - ii. **Epinephrine:** 0.01-1 mcg/kg/min
 - iii. **Norepinephrine:** 0.01-2 mcg/kg/min
 - c. **Inotropes:**
 - i. **Digoxin:**
 1. 30-50 mcg/kg for total 24 hour dose
 2. Give half initially
 3. Give 1 quarter in 8 hours and last quarter 8 hours after that
 - ii. **Dobutamine** 2-20 mcg/kg/min
 - iii. **Milrinone:** 0.125-0.75 mcg/kg/min
 - d. **W/persistent/refractory hypotension:**
 - i. **Hydrocortisone:** 1-2 mg/kg
 - ii. **Calcium gluconate:** 30-60 mg/kg slow IVP **OR Calcium chloride:** 10 to 20 mg/kg
7. W/coarctation of the aorta
 - a. These patients often need preload, start with 10ml/kg NS bolus
 - b. Utilize low dose Epinephrine 0.03 mcg/kg/min then add vasopressin (**NOT Dopamine**)
 - c. For bradycardia use push dose Epinephrine over Atropine
8. W/Sepsis:
 - a. Fluids, Dopamine, and/or Epinephrine as above
 - b. Always consider sepsis if the patient has gone home and been readmitted
 - c. Common broad-spectrum antibiotic choices include:
 - i. **Ampicillin** 100 mg/kg + **Gentamicin** 5 mg/kg
 - ii. Other 3rd generation cephalosporin
 1. < 40 weeks: **Cefotaxime** 50 mg/kg
 2. >40 weeks: **Ceftriaxone** 50 mg/kg

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ABOUT THE AUTHORS & CONTRIBUTORS

ABOUT CHARLIE: AUTHOR

Swearingen, or Charlie as he will have you call him, was born and raised on the Mississippi Gulf Coast by his parents, Gene and Jan Swearingen. As an amputee due to a birth defect of his lower legs, he was fitted for prosthetics in his first year of life, but that did not stop Charlie chasing down countless accolades and achievements. In 1995, he graduated from Millsaps College in Jackson, MS and not long after began paramedic school at the University of Mississippi Medical Center's (UMC) School of Health-Related Professions across the street from his alma mater in Jackson (Millsaps College). Three years later he was hired as a flight paramedic on the prestigious helicopter, AirCare, the flagship of UMC's helicopter transport program. Within a few months, hurricane



Katrina provided a backdrop to use his new skills and new role to help the many victims of his home state. While at UMC and AirCare, he published several peer-reviewed articles in the field of air medical transport and began a PhD in physiology. He started a critical care education company,

Meducation Specialists, in 2007 and has innovated this field with the first fully online and IBSC critical care certification program, choose your own adventure simulation games, among others. Swearingen was pulled away from Mississippi, UMC, and AirCare in 2010 as USA volleyball invited him to train full time as a US national volleyball player with hopes of an Olympic berth in 2012- a goal he had been actively working towards since 2007. Finally, in 2016, Charlie represented the United States and USA Volleyball at the Rio Summer games. Currently, Charlie runs his company, is the lead critical care educator for North American Rescue, engages in collaborations with other critical care education teams around the globe including training special forces operators in the military, donates time to the Chive Charities (where he is a board member), and delivers an occasional motivational speech. He currently lives with his wife, Marge, and 2 daughters, Isla and Avery), in Brandon, MS where he plans to finish his PhD and continues to train with USA volleyball. He has recently reunited with AirCare and is back to flying the sick or injured in Mississippi full time.

ABOUT SCOTT: AUTHOR

Scott Heller began his journey into medicine in 2010 when his mother, an experienced NICU Flight Nurse, advised him to find a career he could be passionate about. After discovering his love of medicine, he quickly found his way to EMS, graduating from paramedic school in 2013 and completing his bachelor's degree in Health Education (EMS emphasis) from the University of Utah in 2014. As is not uncommon in EMS, Scott got a lot of experience quickly, sometimes working up to three jobs at a time. In those early years he worked as a ground medic, ski patroller, EMS educator, medical supervisor, pediatric clinic technician, Level I emergency department paramedic, and an advanced practice educator.



In 2019, Scott began working as a multidisciplinary Flight Paramedic for MedX AirOne and, after the standard 1-2 years of imposter syndrome, finally felt like he could sit back and be a confident flight medic.... Then he met Charlie. Scott will be the first to tell you he's the last person he ever expected to write a book, but Charlie has a way of helping people see their potential and pushing them to live up to it. At the end of a long 96-hour shift, they sat down to enjoy a bonfire and the better half of a bottle of bourbon and suddenly, they were co-authors. After spending the better part of three years researching and writing, Scott and Charlie are excited to bring you a book that they truly believe would have benefited their early and continued growth in the critical care world.

ABOUT MICHAEL: PHARMACIST, REVIEWER, CONTRIBUTOR

Ever since he can remember, Michael has been fascinated by the human body and its complexity. Initially, he thought this passion meant becoming a physician. However after getting a job as a pharmacy technician in a retail pharmacy after college, he found his path. It was incredible to witness the effects medications had on people's lives and he couldn't wait to learn more about these fascinating molecules. Michael is a proud Buckeye and attended The Ohio State University College of Pharmacy graduating Summa Cum Laude. As he progressed throughout pharmacy school, he was



inspired to become an inpatient clinical pharmacy specialist. Michael began his pharmacy residency training at Harvard University's flagship institution, Massachusetts General Hospital where he developed his love for critical care practice treating the sickest and most complex patients. He was fortunate to complete his second-year critical care pharmacy residency at Mass General working side by side with the best minds in critical care

medicine. After residency, Michael had to escape the snow and began his career as a nocturnal Emergency Medicine/Critical Care Pharmacist at the University of Mississippi Medical Center. Every night, he is responsible for clinical coverage of 4 different intensive care units plus the emergency department, rapid/code blue response and trauma activations treating and learning from a diverse array of the sickest and complex critically ill patients in the country. Here in the middle of the night, Charlie was shadowing Michael and they “blued” a patient in GNR septic shock and immediately a friendship was formed. Michael enjoys bedside teaching where concepts are engrained and has won two best guest lecturer awards from the Emergency Medicine residency program. Michael lives in Brandon, Mississippi with his wife Lauren and son Baker. He enjoys hiking with his camera, scuba diving, playing tennis and pickleball. Michael hopes you can use the information in the book to thread the needle of critical illness and turn around your patient when the stakes are the highest.

ABOUT HILLARY: ILLUSTRATOR

Hillary (Aery) has led an eclectic life, earning a bachelor’s degree in communication and working across several industries. Including the bicycling industry, public relations, the Home Builders Association, and event management. In 2019, while visiting Cambodia, she meet a comic artist who inspired her to explore working in art and illustration. Since then, she has pursued her love of illustration and worked to build her career. After bouncing from the West Coast to the East Coast she and her son settled in Utah to be close to family. You will often find her enjoying a cup of coffee cuddled up with her son, watching anime, surrounded by their two cats and dog.

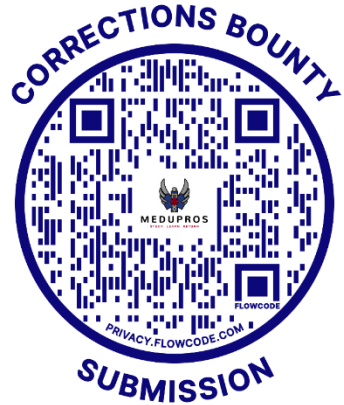


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