



# Pediatric Shock

National Pediatric Nighttime Curriculum

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# Pre-Topic Questions

1. Why is it important to identify the stage of shock?
2. Why is it important to identify the type of shock?



# Learning Objectives

- Define shock
- Know the stages of shock
- Know the classifications of shock and generate differential diagnosis of etiology
- Know the initial management of shock



# What is shock?

- Inadequate perfusion to meet tissue demands. A progressive process.
  - Occurs in 2% of hospitalized patients.
  - Mortality 10% in children (without MODS), vs. 30-40% in adults. <sup>1,2</sup>
- In other words, a systemic reduction in tissue perfusion → decreased tissue O<sub>2</sub> delivery.
  - A shift to less-efficient anaerobic metabolism, leading to lactic acidosis, occurs.
- Initially, effects are reversible. Eventually:
  - Cell membrane ion pump dysfunction
  - Cellular edema, leakage of cells' contents
  - Inadequate regulation of intracellular pH
  - → Cell death, organ failure, cardiac arrest, and death.



# Stages of Shock

*A progressive process: Intervene early*

- **Compensated Shock:** Cardiac output (HR x SV) and systemic vascular resistance (peripheral vasoconstriction) work to keep BP within normal.
  - On exam: Tachycardia; decreased pulses & cool extremities in cold shock; flushing and bounding pulses in warm shock; oliguria; labs may show mild lactic acidosis
  
- **Hypotensive (Uncompensated) Shock:** Compensatory mechanisms are overwhelmed.
  - On exam: As above, plus hypotension, altered mental status; labs may show increased lactic acidosis
  - Generally quick progression to cardiac arrest.
  
- **Irreversible Shock:** Irreversible organ damage, cardiac arrest, death occur.



# Classifications of Shock

## ■ Hypovolemic Shock

- Decreased preload due to internal or external losses.

## ■ Distributive Shock

- Decrease in SVR, with abnormal distribution of blood flow → functional hypovolemia, decreased preload.
- Typically, NL or ↑ CO.

## ■ Cardiogenic Shock

- “Pump failure.” ↓ CO, systolic function.

## ■ Obstructive Shock

- Outflow from left or right side of heart physically obstructed.

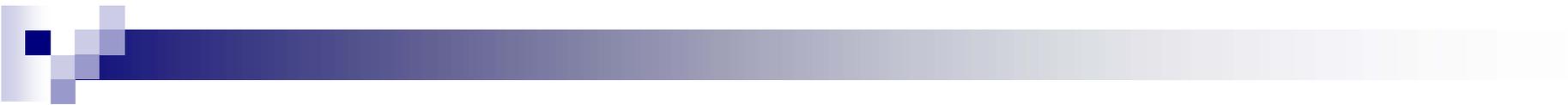
# Physiologic profiles of shock states

Type of Shock	Preload (PCWP)	Cardiac Output	Afterload (SVR)	Tissue Perfusion (Mixed venous sat)
Hypovolemic	↓ ↓	↓	↑	↓
Distributive	↓ Or =	↑ Or =	↓ ↓	↑
Cardiogenic	↑ ↑	↓*	↑ ↑	↓
Obstructive	↑ ↑	↓	↑	↓



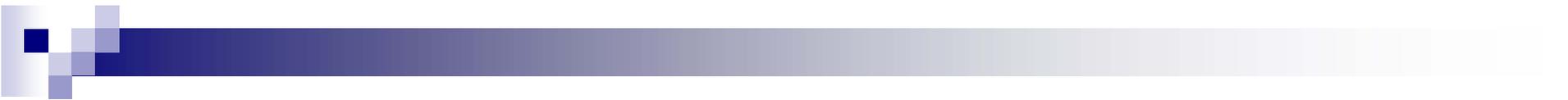
# Case 1

- 15-year-old previously well boy is freshly from the PICU, POD #3 from partial small bowel resection after multiple gunshot wounds to the abdomen. The nurse pages because his HR has increased in the last hour from 90 to 130, despite pain score of 1/10 on morphine drip. On exam, he is afebrile, HR is 140, BP 80/50. Cap refill is >3 seconds in his cool extremities and pulses are 1+.
- What is your assessment?
- What is the stage of shock?
- What is the classification of shock?
- What is your initial management?



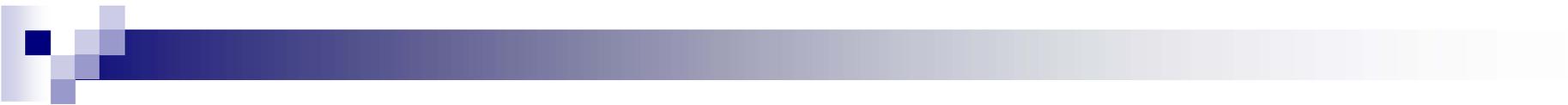
# Shock: General initial management

- **Children benefit from goal-directed therapy to improve physiologic indicators within first 6 hrs of presentation.** <sup>1,2</sup>
  - Early reversal of shock associated with 57% decrease in mortality and morbidity regardless of underlying etiology.
    - Observational study of 1422 children with shock transferred from community hospitals to tertiary care pediatric facility. <sup>3</sup>
  - Mortality 6% in children not in shock on admission to PICU versus 19% for those in shock on arrival.
    - Observational study of 136 children with septic shock. <sup>4</sup>



# Shock Evaluation

- **Answer early, continue to re-evaluate: *Does patient need a higher level of care?***
  
- What is your institution's policy about when to call a:
  - PICU consult?
  - Rapid Response? (if available)
  - Pediatric Code Blue (Code White)?
  - Remember:
    - It is better to de-escalate a Code than emergently escalate a PICU consult/Rapid Response.



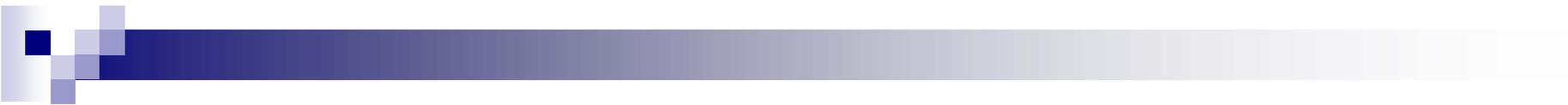
# General initial management

- Overall goal: Normalization of BP and tissue perfusion.
- Physiologic indicators that should be targeted include:<sup>1</sup>
  - **Blood pressure:** Normal (defined in next slide).
  - Quality of central and peripheral **pulses:** Strong, distal pulses equal to central pulses.
  - **Skin perfusion:** Warm, with capillary refill 1-2 seconds.
  - **Mental status:** Normal.
  - **Urine output:** >1 mL/kg per hour, once effective circulating volume is restored.



# Shock: Evaluation pearls

- **Tachycardia?** - Non-specific early finding. Investigate further.
- **Skin changes?** - Typically, prolonged cap refill (vasoconstriction) with compensated shock. Flash refill with early distributive shock **and** with irreversible shock.
- **Impaired mental status?** - Defining mental status as accurately as possible (GCS) is key to monitoring progression. Assess for yourself -- don't rely on other providers.
- **Oliguria?** - Watch for decreased GFR; re-order meds accordingly.
- **Hypotension?** - Late finding. Don't accept from others that BP is "normal." **Widened pulse pressure** (>40 mmHg)? - May be present in distributive shock, aortic insufficiency, AVMs, Cushing's reaction



# Case 2

- 6-year-old previously well girl is admitted to your ward directly from clinic with fever, bloody diarrhea x 1 day. She's had no urine x 24 hrs and is becoming harder to awaken. On exam, her HR is 150, BP 72/30, temp 103. She's sleepy but arousable. She's flushed with capillary refill <1 second.
- What is your assessment?
- What is the stage of shock?
- What is the classification of shock?
- What is your differential for the etiology?
- What is your initial management? If a higher level of care is needed, how would you obtain it?



# Goal-directed algorithm <sup>1-3</sup>

- Algorithm is based on consensus recommendations for septic shock in children, mostly extrapolated from adult data.
- May initially be applied to any patient in shock, regardless of etiology.
  - Exact etiology must be sought to identify which patients may not respond and to tailor therapy.



# Management: Goal-directed algorithm

## ■ First 5-15 min:

- **ABCs (and D's: dextrose, disability)**
  - Attach CRM, change vital sign measurements to appropriate interval (q 15 min), alert nurses of concerns.
  
- **Identify life-threatening conditions and establish access.**
  - Place 2 large bore PIVs if possible; ensure established lines are working.
  - If no IV access and uncompensated, PALS says go for I/O immediately.
  
- **Give 20 ml/kg crystalloid over 5-10 min.**
  - Begin w/ 5-10 ml/kg if suspect cardiogenic shock, DKA.
  
- **Give epinephrine if suspect anaphylactic shock.**
  - 0.01 mg/kg 1:1,000 solution IM (max 0.5 mg); repeat as necessary q 15 min.



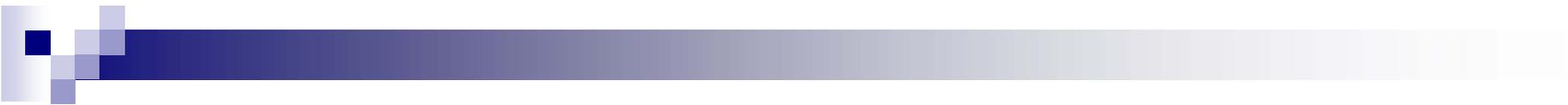
# Management: Goal-directed algorithm

## ■ **First 15-30 min:**

- **Identify abnormal glucose, Ca, electrolytes.**
- **Administer abx** for those in suspected septic shock.
  - Broad coverage for most likely pathogens
- **Administer dopamine** in suspected cardiogenic shock.
- **Continue to give up to 60 ml/kg crystalloid** in 20 ml/kg boluses, then consider PRBCs. Monitor for overload.

## ■ **Continually:**

- Monitor ABCs.
- Monitor physiologic goals pre, post intervention.



# Case 3

- 4-month-old boy ex-term, previously well boy presents to ED with decreased desire to feed x 2 days with 2 times daily emesis, following what sounds like viral URI. Urine output has been 3 wet diapers daily. He is afebrile with HR 180; BP has not been obtained. He has a weak cry, is mottled with 3-second capillary refill, pulses 1+ in all extremities. Liver is palpable 4 cm below RCM. S4 is present without murmur.
- What is your assessment?
- What is the stage of shock?
- What is the classification of shock?
- What is your differential for the etiology?
- What is your initial management?



# Highlights for specific classes, etiologies<sup>1</sup>

## ■ Hypovolemic shock

- Give colloid after crystalloid if capillary leak, hypoalbuminemia.
- Do not delay PRBCs if suspect hemorrhage.

## ■ Septic shock

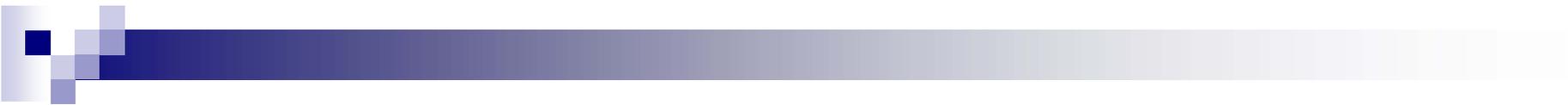
- If not improved after 60 ml/kg crystalloid, consider pressors.
- Dopamine (5-15 mcg/kg/min STAT to the bedside) is first-line.
  - Norepinephrine if warm shock (vasodilated).
  - Epinephrine if cold shock (vasoconstricted).
  - Consider dexamethasone.

## ■ Cardiogenic shock

- Consider in any patient worsening with fluid therapy.
- Dopamine first-line agent.
  - Consider milrinone if diastolic dysfunction, dobutamine if increased SVR leading to organ dysfunction.

## ■ Obstructive shock

- Causes of obstructive shock require specific interventions
- Chest tube for tension pneumothorax; removal of fluid for tamponade; PGE for ductal-dependent lesions.



# Take-Home Points

- **Shock is a progressive process.**

- Intervene early.

- **Identifying the stage and classification of shock is important.**

- Stage: Compensated, uncompensated, or irreversible?
- Classification: Hypovolemic, distributive, cardiogenic, or obstructive?

- **Management should be directed at normalizing tissue perfusion and blood pressure.**

- Consider using the consensus-based goal-directed algorithm for shock management.



# References

- Bilkovski, RN, Rivers, EP, Horst HM. Targeted resuscitation strategies after injury. *Curr Opin Crit Care* 2004; 10:529.
- Bone, RC. Toward an epidemiology and natural history of SIRS (systemic inflammatory response syndrome). *JAMA* 1992; 268:3452.
- Carcillo, JA, Fields, AI. Clinical practice parameters for hemodynamic support of pediatric and neonatal patients in septic shock. *Crit Care Med* 2002; 30:1365.
- Carcillo, JA, Kuch, BA, Han, YY, et al. Mortality and functional morbidity after use of PALS/APLS by community physicians. *Pediatrics* 2009;124:500.
- Inwald, DP, Tasker, RC, Peters, MJ, Nadel, S. Emergency management of children with severe sepsis in the United Kingdom: the results of the Paediatric Intensive Care Society sepsis audit. *Arch Dis Child* 2009;94:348.
- Fisher JD. Et al. Clinical spectrum of shock in the pediatric emergency department. *Pediatr Emerg Care*. 2010 Sep;26(9):622-5.
- Kache, Saraswati; Frankel, Lorry. *Nelson's Pediatrics: 18th edition*, chapter 68.
- Watson, RS, Carcillo, JA, Linde-Zwirble, WT, et al. The epidemiology of severe sepsis in children in the United States. *Am J Respir Crit Care Med* 2003; 167:695.
- Pediatric Advanced Life Support Provider Manual*. Ralston, M, et al (Eds), American Heart Association, Subcommittee on Pediatric Resuscitation, Dallas 2006. p.61.
- Rivers, E, Nguyen, B, Havstad, S, et al. Early goal-directed therapy in the treatment of severe sepsis and septic shock. *N Engl J Med* 2001; 345:1368.
- Up To Date, 2010. Initial management of shock in children; Physiology and classification of shock in children.