Pediatric Shock and Sepsis

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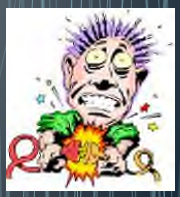

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Objectives

- Define and describe shock
- Outline management principles
- Discuss goals of fluid resuscitation
- Review Surviving Sepsis campaign with 2016 and 2018 guidelines
- Describe the physiologic effects of vasopressors and inotropic agents

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Disclosures

- I have no financial interests to disclose

Renown CHILDREN'S HOSPITAL

University of Nevada, Reno School of Medicine

REMSA

MEDNAX NATIONAL MEDICAL GROUP

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Renown PICU Contact Info

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- Renown PICU attending (direct): (775) 982-8143
- Renown Transfer Center (775) 982-2210
- My email: kdeeter@renown.org

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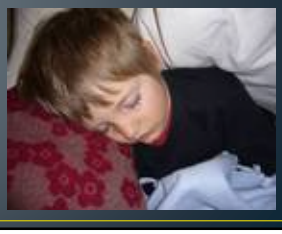
Any day in Any Town

- EMS called for a 2 year old at home with history of poor PO intake and lethargy. He has had fever off and on with diarrhea and emesis 4 days ago. Mother has been pushing him to drink water, but she has noted decreased urine output.

- What do you do first?
- Are you worried?
- What is your biggest concern?



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Assessment

- Vitals:
  - T 102 F
  - HR 172
  - RR 35
  - BP 85/30
  - Sat 98% on room air
- Leave at home with Tylenol?
- Bring in immediately?

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"Hypoperfusion can be present in the absence of significant hypotension."

--somebody wise

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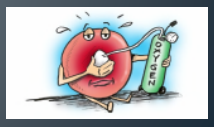
Definition

- **Shock** = Inadequate organ perfusion to meet the tissue's oxygenation demand
- Signs include:
  - Mental status changes
  - Oliguria
  - Tachycardia
  - Tachypnea
  - Lactic Acidosis



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Recognition

- Your patient is in extremis – tachycardic, hypovolemic, obtunded
- How long do you have to manage this?
- Many things must be done at once
- Your patient needs help…. NOW!

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Categories of Shock

- HYPOVOLEMIC
- DISTRIBUTIVE
- CARDIOGENIC
- OBSTRUCTIVE

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Hypovolemic Shock

- ***Causes***
  - hemorrhage
  - vomiting
  - diarrhea
  - dehydration
  - burns
  - Sepsis (cold shock)
- ***Signs***
  - ⇩ cardiac output
  - ⇧ SVR

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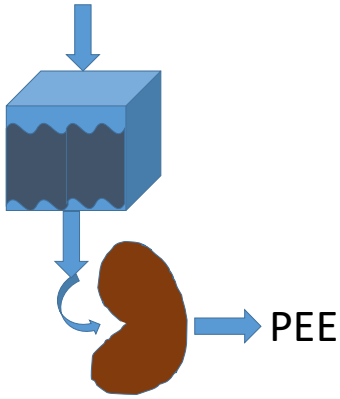
Homeostasis



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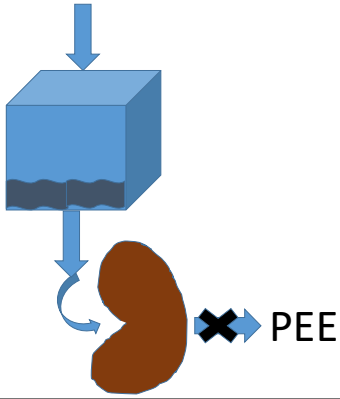
Hypovolemia



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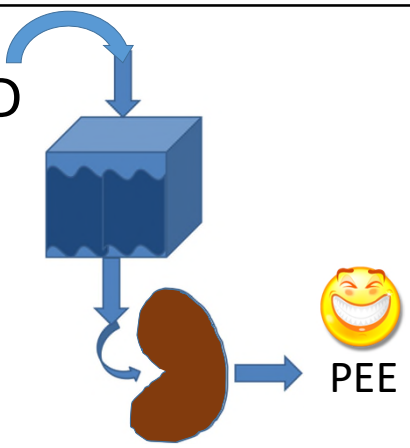
FLUID



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Distributive Shock

- ***Causes***
  - Sepsis (warm shock)
  - Anaphylaxis
  - Acute adrenal insufficiency
  - Neurogenic (spinal shock)
- ***Signs***
  - ± cardiac output
  - ⇩SVR

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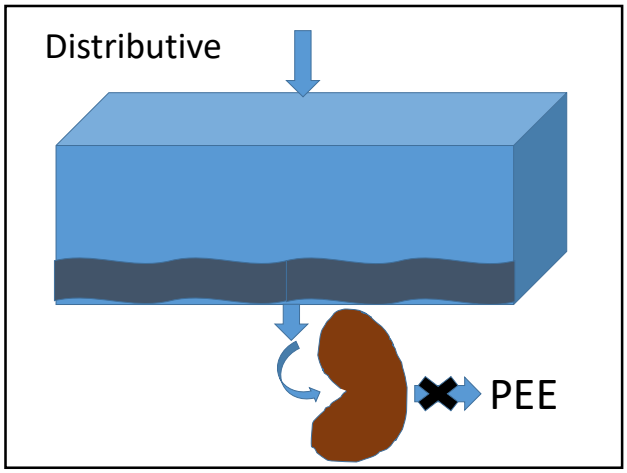

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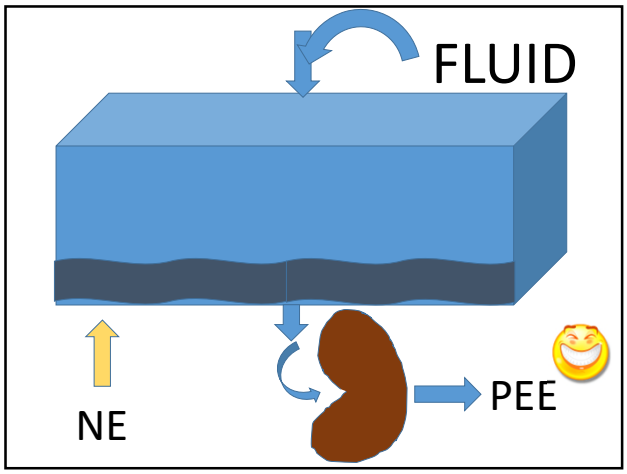

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Cardiogenic Shock

- ***Cause***
  - Defect in cardiac function
    - Myocarditis
    - Pericarditis
    - Endocarditis
  - Arrhythmia
  - Trauma
- ***Signs***
  - ⇩ cardiac output
  - ⇧ SVR
  - Cardiomegaly on Xray
  - Gallop
  - Hepatomegaly
  - Crackles

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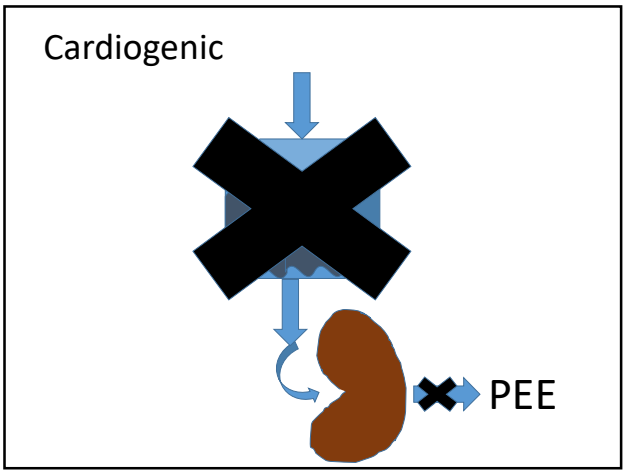

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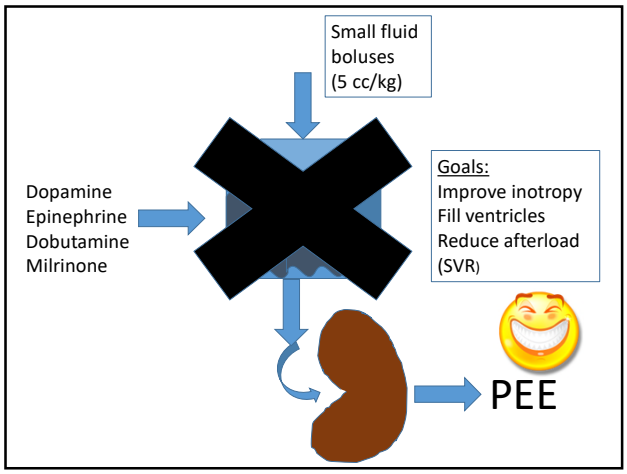

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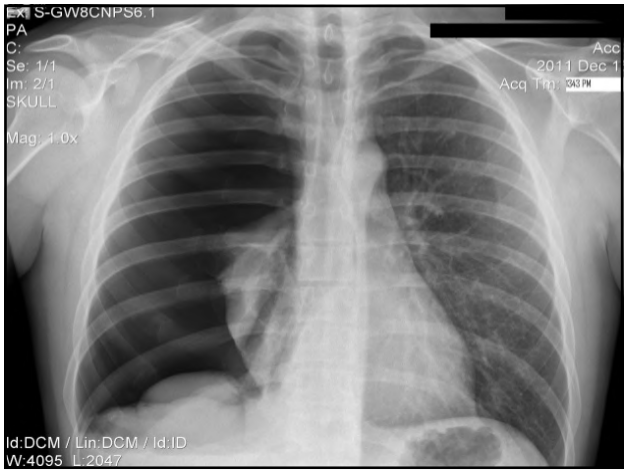

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Obstructive Shock

- ***Causes***
  - Cardiac tamponade
  - Tension pneumothorax
  - Pulmonary embolus
  - Ductal-dependent cardiac anomaly
- ***Signs***
  - ⇩ cardiac output
  - ⇧ SVR
  - Tracheal shift
  - Diminished breath sounds
  - Muffled heart sounds
  - Narrow pulse pressure
  - Hypoxia
  - JVD

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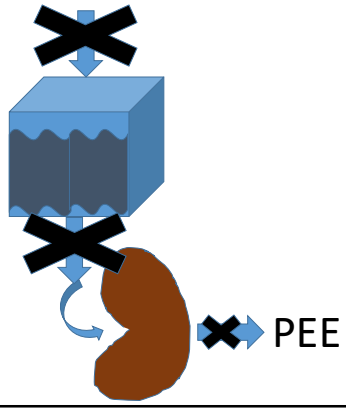
Obstructive



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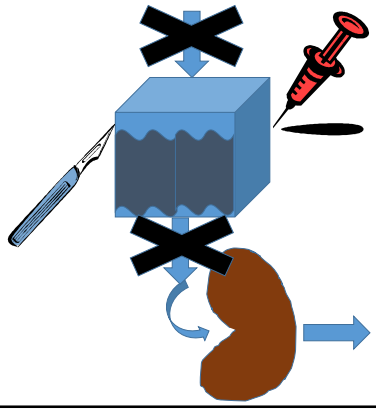
Fix it fast!



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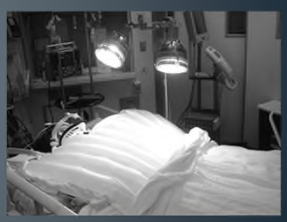
Surviving Sepsis Campaign

A global program to:

- Reduce mortality rates
- Improve standards of care
- Secure adequate funding



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Surviving Sepsis

- Sepsis is the leading cause of death in the non-coronary ICU.
- Affects 1 – 1.5 million Americans each year
- Results in more than 200,000 deaths in USA each year
- The mortality rate associated with sepsis is near 30%

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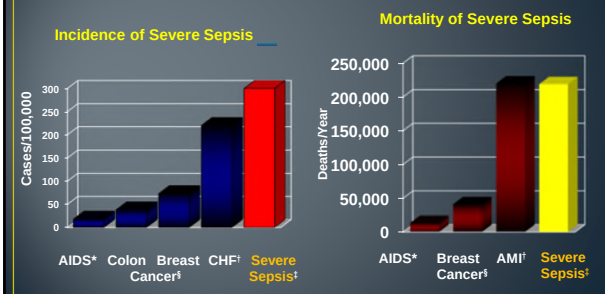
Comparison With Other Major Diseases



†National Center for Health Statistics, 2001. §American Cancer Society, 2001. *American Heart Association. 2000. ‡Angus DC et al. *Crit Care Med.* 2001;29(7):1303-1310.

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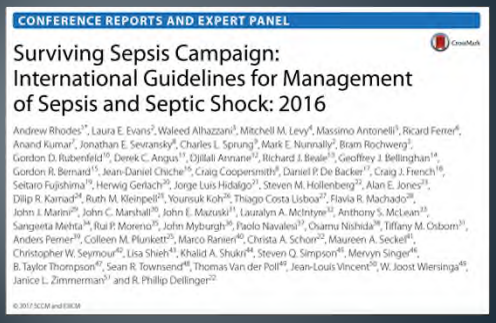
Latest updates…


CONFERENCE REPORTS AND EXPERT PANEL

Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016

Andrew Rhodes[1*], Laura E. Evans[2], Waleed Alhazzani[3], Mitchell M. Levy[4], Massimo Antonelli[5], Ricard Ferrer[6], Anand Kumar[7], Jonathan E. Sevransky[8], Charles L. Sprung[9], Mark E. Nunnally[10], Bram Rochwerg[11], Gordon D. Rubenfeld[12], Derek C. Angus[13], Djillali Annane[14], Richard J. Beale[15], Geoffrey J. Bellinghan[16], Gordon R. Bernard[17], Jean-Daniel Chiche[18], Craig Coopersmith[19], Daniel P. De Backer[17], Craig J. French[18], Seitaro Fujishima[20], Herwig Gerlach[20], Jorge Luis Hidalgo[21], Steven M. Hollenberg[22], Alan E. Jones[23], Dilip R. Karnad[24], Ruth M. Kleinpell[25], Yoonsuk Koh[26], Thiago Costa Lisboa[27], Flavia R. Machado[28], John J. Marini[29], John C. Marshall[30], John E. Mazuski[31], Lauralyn A. McIntyre[32], Anthony S. McLean[33], Sangeeta Mehta[34], Rui P. Moreno[35], John Myburgh[36], Paolo Navalesi[37], Osamu Nishida[38], Tiffany M. Osborn[39], Anders Perner[40], Colleen M. Plunkett[25], Marco Ranieri[40], Christa A. Schorr[22], Maureen A. Seckel[41], Christopher W. Seymour[42], Lisa Shieh[43], Khalid A. Shukri[44], Steven Q. Simpson[45], Mervyn Singer[46], B. Taylor Thompson[47], Sean R. Townsend[48], Thomas Van der Poll[49], Jean-Louis Vincent[50], W. Joost Wiersinga[49], Janice L. Zimmerman[51] and R. Phillip Dellinger[22]

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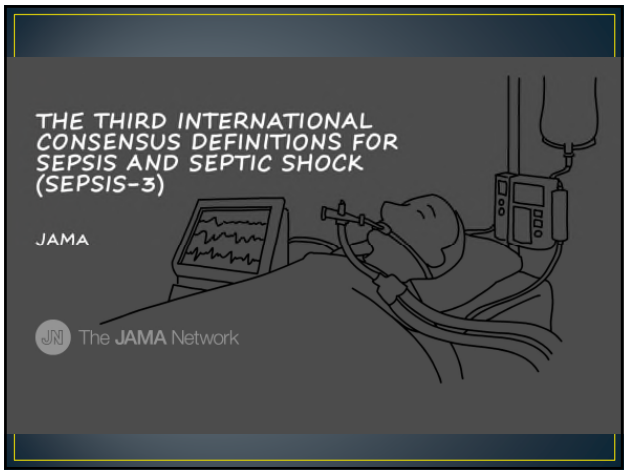

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Surviving Sepsis 2018 Update

- Measure lactate level. Remeasure if initial lactate is >2 mmol/L.
- Obtain blood cultures prior to administration of antibiotics.
- Administer broad-spectrum antibiotics.
- Begin rapid administration of 30ml/kg crystalloid for hypotension or lactate ≥4 mmol/L.
- Apply vasopressors if patient is hypotensive during or after fluid resuscitation to maintain MAP ≥65 mm Hg.

*"Time zero" or "time of presentation" is defined as the time of triage in the Emergency Department or, if presenting from another care venue, from the earliest chart annotation consistent with all elements of sepsis (formerly severe sepsis) or septic shock ascertained through chart review.

Figure 1. Hour-1 Surviving Sepsis Campaign Bundle of Care.*

Levy et al CCM 2018

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Changes to Defining Sepsis

Box 1. SIRS (Systemic Inflammatory Response Syndrome)

Two or more of:
- Temperature >38°C or <36°C
- Heart rate >90/min
- Respiratory rate >20/min or $Paco_2$ <32 mm Hg (4.3 kPa)
- White blood cell count >12 000/mm³ or <4000/mm³ or >10% immature bands

Sepsis Severe Sepsis

Sepsis and Septic Shock

- Non specific pro-inflammatory response
- Aid in identifying infection and anatomical source

Third International Consensus Definitions for Sepsis and Septic Shock. JAMA 2016

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Definitions – 2016 ELIMINATES "SIRS"

- **Sepsis** = Life threatening organ dysfunction caused by dysregulated host response to infection
- **Septic Shock** = Subset of sepsis with circulatory and cellular/metabolic dysfunction associated with higher risk of mortality
  - Persistent hypotension requiring vasopressors to maintain normal MAP and lactate > 2 despite adequate volume resuscitation.

JAMA. 2016;315(8):801-810. doi:10.1001/jama.2016.0287

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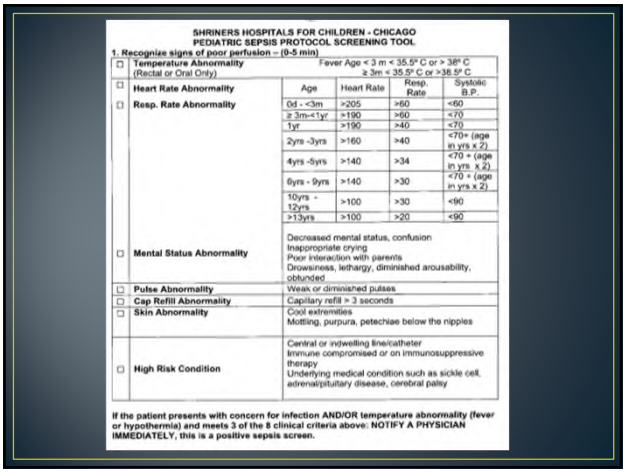

SHRINERS HOSPITALS FOR CHILDREN - CHICAGO
PEDIATRIC SEPSIS PROTOCOL SCREENING TOOL

1. Recognize signs of poor perfusion – (0-5 min)

☐	Temperature Abnormality (Rectal or Oral Only)	Fever Age < 3 m < 35.5° C or > 38° C ≥ 3m < 35.5° C or >38.5° C			
☐	Heart Rate Abnormality	Age	Heart Rate	Resp. Rate	Systolic B.P.
☐	Resp. Rate Abnormality	0d - <3m	>205	>60	<60
		≥ 3m-<1yr	>190	>60	<70
		1yr	>190	>40	<70
		2yrs -3yrs	>160	>40	<70+ (age in yrs x 2)
		4yrs -5yrs	>140	>34	<70 + (age in yrs x 2)
		6yrs - 9yrs	>140	>30	<70 + (age in yrs x 2)
		10yrs - 12yrs	>100	>30	<90
		>13yrs	>100	>20	<90
☐	Mental Status Abnormality	Decreased mental status, confusion Inappropriate crying Poor interaction with parents Drowsiness, lethargy, diminished arousability, obtunded			
☐	Pulse Abnormality	Weak or diminished pulses			
☐	Cap Refill Abnormality	Capillary refill > 3 seconds			
☐	Skin Abnormality	Cool extremities Mottling, purpura, petechiae below the nipples			
☐	High Risk Condition	Central or indwelling line/catheter Immune compromised or on immunosuppressive therapy Underlying medical condition such as sickle cell, adrenal/pituitary disease, cerebral palsy			

If the patient presents with concern for infection AND/OR temperature abnormality (fever or hypothermia) and meets 3 of the 8 clinical criteria above: NOTIFY A PHYSICIAN IMMEDIATELY, this is a positive sepsis screen.

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Surviving Sepsis

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Goals of Shock Resuscitation

- Restore blood pressure
- Normalize systemic perfusion
- Preserve organ function

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How do we do this?

- Source Control
- Early Antibiotics
- Fluid therapy
- Vasoactive agents
- Follow lactate

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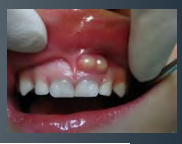
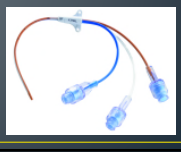
Source Control

- Identify cause and anatomic diagnosis
- Intervene as soon as medically and logistically practical





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Early antibiotics

- ASAP = Within 1 hour
- IV empiric, broad-spectrum
- For septic shock, use at least two combination antibiotics
- Narrow once pathogen known
- 7-10 days, use procalcitonin to determin end point

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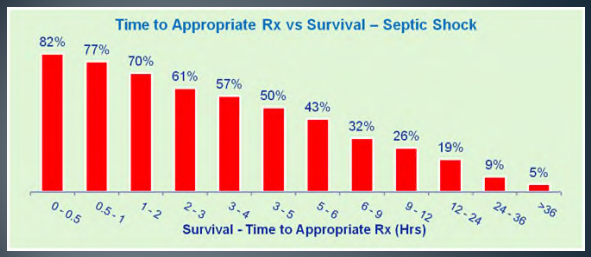

Kumar et al. Chest. 2009 Nov;136(5):1237-48).

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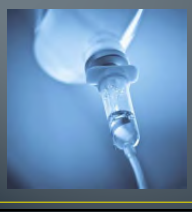
Fluid Therapy

- 30 ml/kg of NS, LR or combination
- Hyperchloremia may prolong acidosis, consider balanced fluids
- Consider albumin when patient requiring significant amount of fluids
- Avoid hypervolemia



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Vasopressor Agents?

- Augment contractility, after preload established, thus improving cardiac output.
- Risk tachycardia and increased myocardial oxygen consumption if used too soon
- Most require CVL placement (if any α-effects)
- Rationale: increased cardiac output improves global perfusion

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Norepinephrine

- Potent α-adrenergic vasopressor
- Some β-adrenergic, inotropic, chronotropic
- Dose 0.05-1.0 mcg/kg/min
- First line agent for warm shock

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Epinephrine

- α- and β-adrenergic effects
- potent inotrope and chronotrope
- dose 0.05-1.5 mcg/kg/min
- increases myocardial oxygen consumption and SVR
- First line agent for cold shock – keep low dose

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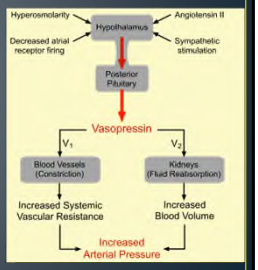
Vasopressin

- Acts on V1 and V2 receptors
- Potent vasopressor
- dose 0.0001 – 0.00005 units/kg/min



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Dopamine

- Low dose (0.5 - 2 μg/kg/min) = dopaminergic
- Moderate dose (3-10 μg/kg/min) = β-effects
- High dose (> 10 μg/kg/min) = α-effects
- Falling out of favor, catecholamine depletion
- SIDE EFFECTS
  - tachycardia
  - > 20 μg/kg/min Δ to norepinephrine

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Dobutamine

- β-agonist
- 5 - 20 mcg/kg/min
- potent inotrope, variable chronotrope
- vasodilator
- caution in hypotension (inadequate volume) may precipitate tachycardia or worsen hypotension

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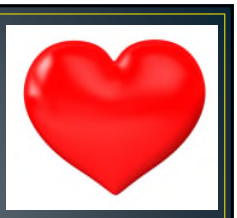
Milrinone



- Phosphodiesterase inhibitor:
  - Inotrope (helps squeeze)
  - Vasodilator (decreases afterload)
  - Lusitropy (ventricular relaxation)
- Do not use in acute setting – may be carefully added for cardiogenic or septic shock in ICU
- Dose 0.25 – 0.75 mcg/kg/min drip (after load)

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Vasopressors

- 1st line = NOREPINEPHRINE
- 2nd line = Vasopressin (up to 0.03 U/min) or epinephrine
- Consider dopamine if bradycardic and low risk of tachyarrhythmias
- Consider dobutamine if persistent hypotension despite fluid and vasopressors
- Phenylephine NO LONGER recommended

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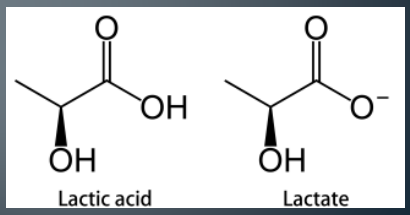
Follow lactate

- On presentation – concern if > 4
- (but repeat if > 2)
- Again within 6 hours
- Just do it



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Sepsis treatment

- Source Control
- Early Antibiotics
- Fluid therapy
- Vasoactive agents
- Follow lactate
- And Bundle…

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Surviving Sepsis Three- hour bundle

- Measure lactate
- Obtain blood cultures
- Bolus 30 ml/kg crystalloid for hypotension or lactate > 4
  - *** don't wait for kids to become hypotensive – give fluid! ***
  - New literature recommends mixing NS and LR or just giving LR as bolus

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Six-hour bundle

- If persistent hypotension despite adequate volume, consider addition of vasopressors
- Frequently re-assess volume status and tissue perfusion for those with persistent hypotension and or initial lactate ≥ 4
- Normalization of lactate (recheck within 6 hours)

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Final Thoughts

- Recognize compensated shock quickly- have a high index of suspicion, remember tachycardia is first sign. Hypotension is late and ominous.
- Gain access quickly- if necessary use an IO.
- Administer adequate amounts of fluid rapidly. Remember ongoing losses. Check patient between every bolus.
- Correct electrolytes and glucose problems quickly.
- If the patient is not responding the way you think he should, broaden your differential, think about different types of shock.

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Less than 8… intubate…

- RSI = pushing fast acting drugs slowly (not pushing drugs rapidly)
- Goal = no bagging… no puking…
- NO Etomidate
  - suppresses adrenal function = bad for sepsis
- My favorites:
  - Ketamine 1 mg/kg
  - (Fentanyl 2 micrograms/kg (SLOW push))
  - Rocuronium 1-2 mg/kg

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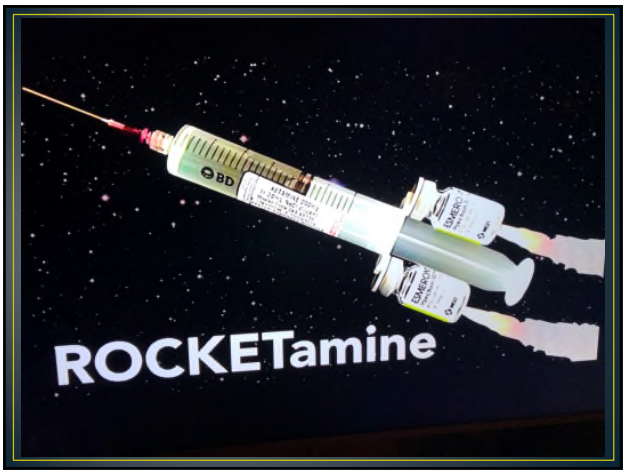

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And then there was COVID19…

- And **MIS-C (Multisystem Inflammatory Syndrome in Children)**
- Typically starts about 1 month after COVID exposure
- Autoimmune reaction to the infection
- Look for:
  - Fever
  - GI symptoms
  - Rash
  - Dehydration
  - Neuro symptoms
  - Heart failure

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Thank you!!!

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