Confronting Complexity and Improving Sepsis Care: Resilience and Human Factors

Texas Children’s Hospital
UNC Hospitals/North Carolina Children’s Hospital

March 8, 2016, 9:30 – 10:45 AM
Confronting Complexity and Improving Sepsis Care: Resilience and Human Factors

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Texas Children’s Hospital

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Associate Chief Medical Officer for Quality (UNC Hospitals)

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Lead Clinical Pharmacist Specialist, Emergency Medicine

March 8, 2016, 9:30 – 10:45 AM
Learning Objectives

1. Understand complex barriers to effective pediatric sepsis care created by diagnostic uncertainty, nonlinear and often rapid disease progression, and multiple care environments

2. Identify strategies, resources, and leadership support needed for implementation of a successful sepsis care improvement program
Personality styles

1. “Tell me exactly what I need to do.”
2. “You can’t possibly tell me what I need to do because I know more than you.”
3. “I know a team-based approach will be best for all.”
4. “I like seashells.”
Pediatric Sepsis: How we got here

Eric A. Williams, MD, MS, MMM, FAAP, FCCM
Texas Children’s Hospital
Baylor College of Medicine
DO₂ and VO₂
Sequential physiologic interactions in pediatric cardiogenic and septic shock

JOSEPH A. CARCILLO, MD; MURRAY M. POLLACK, MD; ALAN I. FIELDS, MD

Fig. 2. VO₂ vs. DO₂ physiologic interaction curves for the septic and cardiogenic shock populations in early and middle stages. Symbol same as in Fig. 1.

Carcillo et al Crit Care Med 17:1 1989
“DO₂ appears to be the major determinant of VO₂. Since both populations show similar relationships, we suggest that therapeutic regimens which increase cardiac output and DO₂ should optimize VO₂ equally in these forms of pediatric circulatory failure.”

Carcillo et al Crit Care Med 17:1 1989
Early fluid resuscitation

$\text{DO}_2$ and $\text{VO}_2$
Role of Early Fluid Resuscitation in Pediatric Septic Shock

Joseph A. Carcillo, MD; Alan L. Davis, MD; Arno Zaritsky, MD

<table>
<thead>
<tr>
<th>Group</th>
<th>1 h (mean ± SD)</th>
<th>6 h (mean ± SD)</th>
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</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
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<tr>
<td>(n = 14; &lt;20 mL/kg in 1 h)</td>
<td>11 ± 6*</td>
<td>71 ± 29†</td>
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<td>Group 2</td>
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<tr>
<td>(n = 11; 20-40 mL/kg in 1 h)</td>
<td>32 ± 5*</td>
<td>108 ± 54</td>
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<tr>
<td>Group 3</td>
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<td></td>
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<tr>
<td>(n = 9; &gt;40 mL/kg in 1 h)</td>
<td>69 ± 19*</td>
<td>117 ± 29</td>
</tr>
<tr>
<td>All patients</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 34)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Survivors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 18)</td>
<td>33 ± 26</td>
<td>95 ± 42</td>
</tr>
<tr>
<td>Nonsurvivors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n = 16)</td>
<td>42 ± 28†</td>
<td>97 ± 49</td>
</tr>
</tbody>
</table>

Carcillo et al JAMA 266:9 1991
“Our study found that rapid fluid resuscitation using volumes in excess of 40 ml/kg in the first hour following emergency department presentation was associated with an improved outcome in this group of children with septic shock.”
Early fluid resuscitation

DO₂ and VO₂

Fluid-Refractory Septic shock

QUALITY AND SAFETY IN CHILDREN’S HEALTH CONFERENCE
Hemodynamic Support in Fluid-refractory Pediatric Septic Shock

Gary Ceneviva, MD‡; J. Alan Paschall, MD||‡; Frank Maffei, MD‡; and Joseph A. Carcillo, MD, FAAP*‡§

| TABLE 3. CI (L/min/m²) and SVRI (dyne/sec/cm⁵) in Groups I, II, and III After Fluid Resuscitation, Initial Therapy Adjustment, and 48 Hours |
|---|---|---|
|               | After Fluid Resuscitation | After Initial Therapy Adjustment | 48 Hours |
| **Group I (n = 29)** |
| CI          | 3.06 ± .26               | 3.3 ± .16*               | 4.0 ± .2** |
| SVRI       | 1794 ± 176               | 1758 ± 158*              | 1178 ± 65** |
| **Group II (n = 10)** |
| CI          | 8.51 ± 1.1               | 6.3 ± .75                | 5.06 ± .41** |
| SVRI       | 622 ± 184                | 919 ± 99                 | 1090 ± 91** |
| **Group III (n = 11)** |
| CI          | 3.93 ± .28               | 4.37 ± .26               | 5.07 ± .29** |
| SVRI       | 922 ± 87                 | 904 ± 65                 | 1089 ± 92 |

Ceneviva et al *Pediatrics* 102:2 1998
“Unlike adults, children with fluid-refractory shock are frequently hypodynamic and respond to inotrope and vasodilator therapy.”

“Attention to maintenance of cardiac output may be of greater importance to improved survival in children with fluid-refractory shock.”

Early fluid resuscitation

ACCM/PALS Guideline 2002

DO$_2$ and VO$_2$

Fluid-Refractory Septic shock

QUALITY AND SAFETY IN CHILDREN’S HEALTH CONFERENCE
Clinical practice parameters for hemodynamic support of pediatric and neonatal patients in septic shock

Table 2. Definitions of shock

- Cold or warm shock: Decreased perfusion including decreased mental status, capillary refill >2 secs (cold shock) or flash capillary refill (warm shock), diminished (cold shock) or bounding (warm shock) peripheral pulses, mottled cool extremities (cold shock), or decreased urine output <1 mL/kg/hr
- Fluid-refractory/dopamine-resistant shock: Shock persists despite ≥60 mL/kg fluid resuscitation in first hour and dopamine infusion to 10 μg/kg/min
- Catecholamine resistant shock: Shock persists despite use of catecholamines epinephrine or norepinephrine
- Refractory shock: Shock persists despite goal-directed use of inotropic agents, vasopressors, vasodilators, and maintenance of metabolic (glucose and calcium) and hormonal (thyroid and hydrocortisone) homeostasis
Carcillo et al Crit Care Med 30:6 2002
“Conclusion: American College of Critical Care Medicine adult guidelines for hemodynamic support of septic shock have little application to the management of pediatric or neonatal septic shock. Studies are required to determine whether the American College of Critical Care Medicine guidelines for hemodynamic support of pediatric and neonatal septic shock will be implemented and associated with improved outcome.”
Early Reversal of Pediatric-Neonatal Septic Shock by Community Physicians Is Associated With Improved Outcome

Yong Y. Han, MD*§; Joseph A. Carcillo, MD*‡§; Michelle A. Dragotta, RN§; Debra M. Bills, RN§; R. Scott Watson, MD, MPH*‡§; Mark E. Westerman, RT§; and Richard A. Orr, MD*‡§

• Retrospective
• Single center pediatric transport database
• 9 years, 6196 transports, 186 with sepsis, 91 with septic shock

Han et al., Pediatrics 112: 2003
Shock reversal from community hospital MD’s resulted in better survival

Multiple logistic regression analyses revealed time-dependent relationships between persistent shock and delayed ACCM-PALS-directed resuscitation with poor outcome (adjusting for PRISM Score).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mortality Odds Ratio</th>
<th>95% Confidence Interval</th>
</tr>
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<tr>
<td>Duration of persistent shock (per 1-hour increment)</td>
<td>2.29</td>
<td>1.19 – 4.44</td>
</tr>
<tr>
<td>Delay in resuscitation consistent with ACCM-PALS Guidelines (per 1-hour increment)</td>
<td>1.53</td>
<td>1.08 – 2.16</td>
</tr>
</tbody>
</table>

Han et al., *Pediatrics* 112: 2003

Improved survival by 38%
Number Needed to Treat = 3.3
Early fluid resuscitation

ACCM/PALS Guideline 2002

DO₂ and VO₂

Fluid-Refractory Septic shock

Sepsis Definitions 2005

QUALITY AND SAFETY IN CHILDREN'S HEALTH CONFERENCE
International pediatric sepsis consensus conference: Definitions for sepsis and organ dysfunction in pediatrics

Brahm Goldstein, MD; Brett Giroir, MD; Adrienne Randolph, MD; and the Members of the International Consensus Conference on Pediatric Sepsis
Table 2. Definitions of systemic inflammatory response syndrome (SIRS), infection, sepsis, severe sepsis, and septic shock

**SIRS**

The presence of at least two of the following four criteria, one of which must be abnormal temperature or leukocyte count:

- Core temperature of >38.5°C or <36°C.
- Tachycardia, defined as a mean heart rate >2 SD above normal for age in the absence of external stimulus, chronic drugs, or painful stimuli; or otherwise unexplained persistent elevation over a 0.5- to 4-hr time period OR for children <1 yr old: bradycardia, defined as a mean heart rate <10th percentile for age in the absence of external vagal stimulus, β-blocker drugs, or congenital heart disease; or otherwise unexplained persistent depression over a 0.5-hr time period.
- Mean respiratory rate >2 SD above normal for age or mechanical ventilation for an acute process not related to underlying neuromuscular disease or the receipt of general anesthesia.
- Leukocyte count elevated or depressed for age (not secondary to chemotherapy-induced leukopenia) or >10% immature neutrophils.

**Infection**

A suspected or proven (by positive culture, tissue stain, or polymerase chain reaction test) infection caused by any pathogen OR a clinical syndrome associated with a high probability of infection. Evidence of infection includes positive findings on clinical exam, imaging, or laboratory tests (e.g., white blood cells in a normally sterile body fluid, perforated viscus, chest radiograph consistent with pneumonia, petechial or purpuric rash, or purpura fulminans).

**Sepsis**

SIRS in the presence of or as a result of suspected or proven infection.

**Severe sepsis**

Sepsis plus one of the following: cardiovascular organ dysfunction OR acute respiratory distress syndrome OR two or more other organ dysfunctions. Organ dysfunctions are defined in Table 4.

**Septic shock**

Sepsis and cardiovascular organ dysfunction as defined in Table 4.
“The definition of septic shock remains problematic. As children will often maintain their blood pressure until they are severely ill, there is no requirement for systemic hypotension to make the diagnosis of septic shock as there is in adults. Shock may occur long before hypotension occurs in children.”

Goldstein et al., Ped Crit Care Med 6:1 2005
Early fluid resuscitation

ACCM/PALS Guideline 2002

ACCM/PALS Guideline Update 2009

DO$_2$ and VO$_2$

Fluid-Refractory Septic shock

Sepsis Definitions 2005

QUALITY AND SAFETY IN CHILDREN’S HEALTH CONFERENCE
Clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock: 2007 update from the American College of Critical Care Medicine

Joe Brierley, MD; Joseph A. Carcillo, MD; Karen Choong, MD; Tim Cornell, MD; Allan DeCaen, MD; Andreas Deymann, MD; Allan Doctor, MD; Alan Davis, MD; John Duff, MD; Marc-Andre Dugas, MD; Alan Duncan, MD; Barry Evans, MD; Jonathan Feldman, MD; Kathryn Felmet, MD; Gene Fisher, MD; Larry Frankel, MD; Howard Jeffries, MD; Bruce Greenwald, MD; Juan Gutierrez, MD; Mark Hall, MD; Yong Y. Han, MD; James Hanson, MD; Jan Hazlezet, MD; Lynn Hernan, MD; Jane Kiff, MD; Niranjan Kisson, MD; Alexander Kon, MD; Jose Izazusta, MD; John Lin, MD; Angie Lorts, MD; Michelle Mariscalco, MD; Renuka Mehta, MD; Simon Nadel, MD; Trung Nguyen, MD; Carol Nicholson, MD; Mark Peters, MD; Regina Okhuyzen-Cawley, MD; Tom Poulton, MD; Monica Relves, MD; Agustin Rodriguez, MD; Ranna Rozenfeld, MD; Eduardo Schnitzler, MD; Tom Shanley, MD; Sara Skache, MD; Peter Skippen, MD; Adalberto Torres, MD; Bettina von Dessauer, MD; Jacki Weigarten, MD; Timothy Yeh, MD; Arno Zaritsky, MD; Bonnie Stojadinovic, MD; Jerry Zimmerman, MD; Aaron Zucker, MD

Brierley et al., Crit Care Med 37:2 2009
“The continued emphasis is directed to 1) first hour fluid resuscitation and inotrope drug therapy and 2) subsequent ICU hemodynamic support directed to goals of $S_{cv}O_2$ and CI.”

“Because mortality went up with delay in time to inotrope drug use, the 2007 update now recommends use of peripheral inotropes (not vasopressors) until central access is attained.”
Implementation of Goal-Directed Therapy for Children With Suspected Sepsis in the Emergency Department

An Emergency Department Septic Shock Protocol and Care Guideline for Children Initiated at Triage

Adherence to PALS Sepsis Guidelines and Hospital Length of Stay

Larsen et al., Pediatrics 127:e1585 2011
Paul et al., Pediatrics 130:e273 2012
Cruz et al., Pediatrics 127:e758 2011

QUALITY AND SAFETY IN CHILDREN’S HEALTH CONFERENCE
Implementation of Goal-Directed Therapy for Children With Suspected Sepsis in the Emergency Department

BACKGROUND: Delayed diagnosis of sepsis in the emergency department (ED) predisposes patients to severe sepsis.

OBJECTIVE: To evaluate the implementation of goal-directed therapy in the ED of a tertiary care children's hospital.

METHODS: A retrospective chart review of patients with suspected sepsis seen in the ED from January 2010 to December 2010 was conducted. The primary outcome was the rate of adherence to goal-directed therapy in the ED.

RESULTS: A total of 127 patients were included in the study. The rate of adherence to goal-directed therapy was 75%. Patients who received goal-directed therapy had a lower mortality rate compared to those who did not receive it.

CONCLUSIONS: Goal-directed therapy may improve outcomes for children with suspected sepsis in the ED.

Larsen et al., Pediatrics 127:e1585 2011
Paul et al., Pediatrics 130:e273 2012
Cruz et al., Pediatrics 127:e758 2011

R. Phillip Dellinger, MD1; Mitchell M. Levy, MD2; Andrew Rhodes, MB BS3; Djillali Annane, MD4; Herwig Gerlach, MD, PhD5; Steven M. Opal, MD6; Jonathan E. Sevransky, MD7; Charles L. Sprung, MD8; Ivor S. Douglas, MD9; Roman Jaeschke, MD10; Tiffany M. Osborn, MD, MPH11; Mark E. Nunnally, MD12; Sean R. Townsend, MD13; Konrad Reinhart, MD14; Ruth M. Kleinpell, PhD, RN-CS15; Derek C. Angus, MD, MPH16; Clifford S. Deutschman, MD, MS17; Flavia R. Machado, MD, PhD18; Gordon D. Rubenfeld, MD19; Steven A. Webb, MB BS, PhD20; Richard J. Beale, MB BS21; Jean-Louis Vincent, MD, PhD22; Rui Moreno, MD, PhD23; and the Surviving Sepsis Campaign Guidelines Committee including the Pediatric Subgroup*
# Surviving Sepsis Campaign: International

## Initial Resuscitation and Infection Issues

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## Hemodynamic Support and Adjunctive Therapy

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Surviving Sepsis Campaign: International Guidelines

INITIAL RESUSCITATION AND INFECTION ISSUES

A. Initial Management
B. Early Goals of Resuscitation
C. Early Goal-Directed Therapy
D. Early Follow-Up
E. Early Identification of Sepsis
F. Early Diagnosis of Sepsis
G. Early Commencement of Antimicrobial Therapy
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O. Mechanical Ventilation of Sepsis-Induced Respiratory Distress Syndrome
P. Sedation, Analgesia, and Neuromuscular Blockade in Sepsis
Q. Glucose Control
R. Renal Replacement Therapy
S. Bicarbonate Therapy
T. Deep Vein Thrombosis Prophylaxis
U. Stress Ulcer Prophylaxis
V. Nutrition
W. Setting Goals of Care

QUALITY AND SAFETY IN CHILDREN'S HEALTH CONFERENCE
SURVIVING SEPSIS CAMPAIGN BUNDLES

TO BE COMPLETED WITHIN 3 HOURS:
1) Measure lactate level
2) Obtain blood cultures prior to administration of antibiotics
3) Administer broad spectrum antibiotics
4) Administer 30 mL/kg crystalloid for hypotension or lactate ≥4mmol/L

TO BE COMPLETED WITHIN 6 HOURS:
5) Apply vasopressors (for hypotension that does not respond to initial fluid resuscitation) to maintain a mean arterial pressure (MAP) ≥ 65 mm Hg
6) In the event of persistent arterial hypotension despite volume resuscitation (septic shock) or initial lactate ≥4 mmol/L (36 mg/dL):
   - Measure central venous pressure (CVP)*
   - Measure central venous oxygen saturation (Scvo₂)*
7) Remeasure lactate if initial lactate was elevated*

*Targets for quantitative resuscitation included in the guidelines are CVP of ≥8 mm Hg, Scvo₂ of ≥70%, and normalization of lactate.
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</tbody>
</table>
Follow American College of Critical Care Medicine-Pediatric Life Support (ACCM-PALS) guidelines for the management of septic shock.
Early fluid resuscitation

ACCM/PALS Guideline 2002

ACCM/PALS Guideline Update 2009

Surviving Sepsis 2012

DO₂ and VO₂

Fluid-Refractory Septic shock

Sepsis Definitions 2005

QI and Implementation

PROCESS, ARISE, PROMISE

QUALITY AND SAFETY IN CHILDREN'S HEALTH CONFERENCE
A Randomized Trial of Protocol-Based Care for Early Septic Shock

The ProCESS Investigators*
Goal-Directed Resuscitation for Patients with Early Septic Shock

The ARISE Investigators and the ANZICS Clinical Trials Group*

PROCESS Investigators *NEJM 370:18 2014
ARISE Investigators *NEJM 371:16 2014
Trial of Early, Goal-Directed Resuscitation for Septic Shock

Paul R. Mouncey, M.Sc., Tiffany M. Osborn, M.D., G. Sarah Power, M.Sc.,
David A. Harrison, Ph.D., M. Zia Sadiq, Ph.D., Richard D. Grieve, Ph.D.,
Rahi Jahan, B.A., Sheila E. Harvey, Ph.D., Derek Bell, M.D., Julian F. Bion, M.D.,
Timothy J. Coats, M.D., Mervyn Singer, M.D., J. Duncan Young, D.M.,
and Kathryn M. Rowan, Ph.D., for the ProMISe Trial Investigators*
“Optimization of CVP and ScVO$_2$ were not required to produce improved outcomes in septic shock.”
DO$_2$ and VO$_2$

Fluid-Refactory Septic shock

Sepsis Definitions 2005

QI and Implementation

PROCESS, ARISE, PROMISE

CHA IPSO
The Surviving Sepsis Campaign bundles and outcome: results from the International Multicentre Prevalence Study on Sepsis (the IMPReSS study)
“Compliance remained independently associated with improvements in hospital mortality for both the 3-h bundle and the 6-h bundle.”

Rhodes et al., *Int Care Med* 41 2015
Stage 1
2011-2012
Data capture and sharing
• Using that information to track key clinical conditions

Stage 2
2014
Advance clinical processes
• More rigorous health information exchange (HIE)

Stage 3
2016
Improved outcomes
• Decision support for national high-priority conditions

www.healthit.gov/providers-professionals/meaningful-use-definition-objectives
Early fluid resuscitation

ACCM/PALS Guideline 2002

ACCM/PALS Guideline Update 2009

Surviving Sepsis 2012

AAP Collaborative

IMPRESS

Paper to Digital and Meaningful Use

DO₂ and VO₂

Fluid-Refractory Septic shock

Sepsis Definitions 2005

QI and Implementation

PROCESS, ARISE, PROMISE

CHA IPSO

ACCM/PALS Guideline Update 2016

QUALITY AND SAFETY IN CHILDREN’S HEALTH CONFERENCE
Governor Cuomo Announces New York State to Lead the Nation in Fighting Sepsis the #1 Killer in Hospitals and Make Major Improvements in Pediatric Care

https://www.governor.ny.gov/news
The medical staff shall be responsible for the collection, use, and reporting of quality measures related to the recognition and treatment of severe sepsis for purposes of internal quality improvement and hospital reporting to the Department. Such measures shall include, but not be limited to, data sufficient to evaluate each hospital’s adherence rate to its own sepsis protocols, including adherence to timeframes and implementation of all protocol components for adults and children.
The medical staff shall be responsible for the collection, use, and reporting of quality measures related to the recognition and treatment of severe sepsis for purposes of internal quality improvement and hospital reporting to the Department. Such measures shall include, but not limited to, data sufficient to evaluate each hospital’s adherence rate to its own sepsis protocols, including adherence to timeframes and implementation of all protocol components for adults and children.
Cases, Stories, and How We Practice Hands-on Skills

Tina Schade Willis, MD
Leah Hatfield, PharmD, BCPS
North Carolina Children’s Hospital
Case #1 Pre Code Sepsis Program

19:23 – Registration in ED
19:28 – VS HR 167, RR 26, T 38.3, 100% RA;
   Toddler male with Leukemia and Recent Chemotherapy
   Decreased activity, home temp 39.3, Central Line
19:48 - Rocephin after CBC, Blood Culture
   Less than 1 hour after presentation
Case #1 Pre Code Sepsis Program

20:00 - Cefepime added
21:19 - 20 ml/kg NS to run over 1 hour ordered
23:28 - VS HR 167 BP 77/30 RR 22 T 38.4 sats 98% RA admitted to wards
Arrival to wards VS HR 167 BP 63/33 T 38.3 “appears ill”
Next few hours receives 20 ml/kg boluses X 3 over 1 hour each and rapid response called
Initial VBG 05:15 7.22/41/44/ -10.1 Lactate 3.9 Hgb 7.4
Case #1 Pre Code Sepsis Program

In ICU from 05:15 – late morning/early afternoon

- Broadened abx coverage and antifungal coverage
- High dose steroids
- Intubation (brief cardiac arrest)
- 150 ml/kg total fluid resuscitation
- Dopamine and Epinephrine
- Acute Abdomen opened by Pediatric Surgery in PICU – necrotic cecum found
- Second Cardiac Arrest
- VA ECMO
- Survival to Discharge and currently doing well
Morning Clinic Visit: toddler 3 months after stem cell transplant. Central Line. Complaint of fever. 
VS T 38.2, HR 173, RR 36, BP 128/67, O2 sat 97% RA Weight 10 kg
“quiet, complains of being cold”
• Broad Spectrum Antibiotics administered within 30 minutes, blood culture and CBC were drawn first
• 20 ml/kg given over 1 hour at 9 am, another 20 ml/kg over the next hour 10 am, started on O2 in clinic at 11 am
• Admit to wards
Case #2 Pre Code Sepsis Program

• Patient arrival to wards between 12-1 pm
• RN staff from wards called PICU Charge RN that patient might need RRT
• Instead Code called 30 min later
• Code team arrival 1:30pm CPR in progress and PRBC infusing on pump through CVL
• Code team intubated patient, hand pushed blood with syringe through CVL and also hand pushed blood through IO placed by code team after which had return of spontaneous circulation
• Initial Lactate >21 pH 6.9
• Patient transferred to PICU – died mid afternoon from overwhelming septic shock
Case #3 Post Code Sepsis Program

0853 – Pt. and mother arrive in ED
0855 – Triage nurse notes “mother reports that pt. had Tmax of 106.5 and HR in 200s” and immediately notifies physician and nurse to take pt. back.
0855 - ED physician note written
    Max temp prior to arrival reported as 106.5, HR 170-200s, Rhonchi and wheezes documented in all lung fields
    Infection suspected and code sepsis initiated
0900 - Pt. placed on full cardiac monitoring
0908 - First set of vitals in ED; HR 170, RR 42, Temp 36.3 temporal Sats 89% on 2 L NC
Case #3 Post Code Sepsis Program

0911 - MD ordered ceftriaxone and vancomycin and called pharmacist who started preparing abx
0917 – Blood culture drawn
0920 – VBG and lactate drawn (lactate 2.2)
0922 – first 20ml/kg NS bolus given over 11 min
0931 – IV ceftriaxone given
0943 – second 20 ml/kg NS bolus given over 14 min
1005 – IV vancomycin administered
END OF FIRST HOUR – all completed with only 1 IV obtained
More Cases to Learn From Post Code Sepsis

- 6 year old sickle cell simple sepsis patient with antibiotics and fluids administered in ED and stable VS on transfer to wards; developed severe sepsis after admission
- Burn PICU patient – tachypnea and rigors otherwise normal VS – in ICU “code sepsis”
- Short Stay Unit teenager with ESRD, anuria, and “code sepsis”
- Toddler with pneumonia and severe sepsis presented to on campus clinic “code sepsis” in the clinic
- Adult patient with electronic screening tool alert but team did not feel sepsis was diagnosis, therefore diagnosis and antibiotic delay
Think about your patient locations

- ED versus inpatient and ICU’s – where are your antibiotics located and who can get to them quickly?
- Mixed adult and pediatric care areas – can you use premixed bags of antibiotics and pull out peds doses?
- Outpatient clinic areas – what is your response and resources?
- How and when should you practice caring for septic shock patients?

Themes for success

- Team based approach works best – empowerment is key!
- Standardize but encourage inclusion of clinical judgment
- Challenges of immediate antibiotic access and which to administer first, pushed, run together
- Giving fluids rapidly and assessing responses to fluids take training
- Hands on practice & simulation
IV Push Antibiotics*

<table>
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<tr>
<th>Antibiotic</th>
<th>Rate of Administration</th>
<th>Considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ampicillin</td>
<td>3-5 min</td>
<td>Max rate 100 mg/min; NOT compatible with gentamicin</td>
</tr>
<tr>
<td>Cefotaxime</td>
<td>1-5 min</td>
<td></td>
</tr>
<tr>
<td>Ceftriaxone</td>
<td>1-3 min</td>
<td>Do not administer with calcium products; NOT compatible with vancomycin</td>
</tr>
<tr>
<td>Ceftazidime</td>
<td>1-3 min</td>
<td></td>
</tr>
<tr>
<td>Cefepime</td>
<td>3-5 min</td>
<td>Compatible with vancomycin</td>
</tr>
<tr>
<td>Daptomycin</td>
<td>2-4 min</td>
<td></td>
</tr>
<tr>
<td>Gentamicin</td>
<td>3-5 min</td>
<td>NOT compatible with ampicillin</td>
</tr>
<tr>
<td>Meropenem</td>
<td>3-5 min</td>
<td></td>
</tr>
<tr>
<td>Tobramycin</td>
<td>3-5 min</td>
<td></td>
</tr>
</tbody>
</table>

* Data often based upon evidence based medicine in adults
Please do NOT resuscitate a pediatric patient in SHOCK with an infusion pump

Premixed Medication Bags
Simulation sepsis training in situ small scale

Hem/Onc Clinic

Inpatient Wards RN emergency preparedness and resident training
Incorporate Sepsis into mature programs such as mock codes
Didactic training residents and new hire ED nurse training

Simulation classroom setting include pharmacy team training

Sepsis training in classroom
Large scale multi-site in-situ sepsis simulation

Presentation to affiliated community ED

Recognition and initial bundle
Large scale multi-site in-situ sepsis simulation

Initial Bundle Treatment

Practice with EHR tools
Large scale multi-site in-situ sepsis simulation

Decision for Transfer to Higher Level of Care and Handoff

Arranging for Transport with Pediatric Critical Care Transport Team
Large scale multi-site in-situ sepsis simulation

Septic Shock Practice

Transport to Higher Level of Care
Large scale multi-site in-situ sepsis simulation

Handoff to PICU – escalates to ECMO on standby

Multidisciplinary Debriefing at all sites including Face Time
Resilience as a Framework

Eric A. Williams, MD, MS, MMM, FAAP, FCCM
Texas Children’s Hospital
Baylor College of Medicine
Questionable Beliefs

We work in a well-designed system.
We understand what is actually going on.
We always fix the correct problems.
<table>
<thead>
<tr>
<th></th>
<th>Tractable system</th>
<th>Intractable system</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Number of details</strong></td>
<td>Description are simple with few details</td>
<td>Description are elaborate with many details</td>
</tr>
<tr>
<td><strong>Comprehensibility</strong></td>
<td>Principles of functioning are known</td>
<td>Principles of functioning are partly unknown</td>
</tr>
<tr>
<td><strong>Stability</strong></td>
<td>System does not change while being described</td>
<td>System changes before description is completed</td>
</tr>
<tr>
<td><strong>Relation to other systems</strong></td>
<td>Independence</td>
<td>Interdependence</td>
</tr>
</tbody>
</table>
High Reliability

- Preoccupation with failure
- Sensitivity to operations
- Reluctance to simplify
- Deference to expertise
- Resilience

Weick and Sutcliffe, Managing the Unexpected, Wiley
Rigid in execution when the system is known and highly adaptable when the system is less understood.
Resilience

“The intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances so that it can sustain required operations under both expected and unexpected conditions.”

Hollnagel E et al, Resilience Engineering, Ashgate Press
Resilient Health Care

“The intrinsic ability of THE HEALTH CARE SYSTEM to adjust its functioning prior to, during, or following changes and disturbances so that it can sustain required operations under both expected and unexpected conditions.”

Hollnagel E et al, Resilience Engineering, Ashgate Press
Safety

Safety I: Safety can be achieved by first finding and eliminating causes of adverse events.

What goes wrong.

Safety II: Safety is the ability to succeed under varying conditions, so that the number of intended outcomes is as high as possible.

What goes right.

Hollnagel E et al, Resilience Engineering, Ashgate Press
QUALITY AND SAFETY IN CHILDREN’S HEALTH CONFERENCE
Outcomes

- Failed to follow a policy
- Suboptimal communication
Questionable Beliefs

We DO NOT work in a well-designed system
We HAVE A LIMITED UNDERSTANDING of what is actually going on
We OFTEN fix the WRONG problems
A New Way of Examining Safety

Safety I = absence of things going wrong
Safety II = presence of every day successful functioning
Getting to Safety II

Explicitly assume that systems work because people are able to adjust what they do to match the conditions of work.

Performance Variability:
   Acknowledge the presence
   Monitor
   Control
Human Factors in the Delivery of Sepsis Care: Confronting Nursing Workload

Stephanie A. Davenport, BS, RN, CPN
Texas Children’s Hospital
Factors that drive complexity in the system

- Complexity of human physiology and variety of disease
- Historical primacy of healthcare work as a human activity
- Explosion of biotechnology and medical knowledge
- Scale of the endeavor itself
Human factors

Work in a sociotechnical system
Human Factors Engineering

- Human Roles in Systems
- Aspects of Human Information Processing
- Technology
- Operational Environment

Human Roles in Systems

• Decision-maker
• Monitor
• Information Processor
• Closed-loop controller
• Information encoder and storer
• Discriminator, pattern recognizer
• Ingenious problem solver

Aspects of Human Information Processing

- **Input**
  - Attention
  - Sensation

- **Mediation**
  - Perception
  - Cognition

- **Output**
  - Response

- **Response to environment**
- **Motivation**
- **Adaptation**
- **Error**

Technology

- Monitors
- Interactive Monitors
- Medication Scanners
- Smart Phones
- Alarms
Operational environment

- Shift-work
- Patient load
- Time
- Alarms
- Licensure
- Policy & Procedure

- Relational & task oriented
- Procedures:
  - Diaper changes/baths
  - Codes/CPR
  - De-escalating patient and family emotions
  - Documentation
SELF-CARE AND PRESERVATION
Why is this so very hard?

Work is underspecified.
Start | Treat Sepsis | Finish
Treat Sepsis

Start: Recognize decreased mental status and perfusion. Begin high flow O₂. Establish IV/IO access.

Initial resuscitation: Push boluses of 20 cc/kg isotonic saline or colloid up to & over 60 cc/kg until perfusion improves or unless rates or heptotomically develop. Correct hypoglycemia & hypercalcemia. Begin antibiotics.

If shock not reversed:

Fluid refractory shock: Begin inotrope IV/IO. Use atropine/epinephrine IV/IO/IM to obtain central access & airway if needed. Reverse cold shock by titrating central dopamine or, if resistant, titrate central norepinephrine

If shock not reversed:

Catecholamine resistant shock: Begin hydrocortisone if at risk for absolute adrenal insufficiency.

If 2nd inotrope start isotropes.

Dose range: dopamine up to 10 mcg/kg/min, epinephrine 0.05-0.1 mcg/kg/min.

50 min

Monitor CVP in PICU, attain normal MAP-CVP & Svo₂ > 70%.

Cold shock with normal blood pressure: 1. Titrate fluid & epinephrine, Svo₂ > 70%, Hgb > 10g/dL. 2. If Svo₂ still < 70% Add vasodilator with volume loading (nitrovasodilators, milrinone, inotrope, & others). Consider levosimendan

Cold shock with low blood pressure: 1. Titrate fluid & epinephrine, Svo₂ > 70%, Hgb > 10g/dL. 2. If still hypotensive consider norepinephrine

If shock not reversed:

Warm shock with low blood pressure: 1. Titrate fluid & norepinephrine, Svo₂ > 70%. 2. If still hypotensive consider vasopressin, terlipressin or angiotensin

If Svo₂ still < 70% consider low dose epinephrine

Persistent catecholamine resistant shock: Rule out and correct periarticular effusion, pneumothorax, & intra-abdominal pressure > 12 mm Hg.

Consider pulmonary artery, PICCO, or PACT catheter, &/or doppler ultrasound to guide fluid, inotrope, vasopressor, vasodilator and hormonal therapies. Goal CI > 3.5kL x 6.0 L/min/m²

If shock not reversed:

Refractory shock: ECMO
The Messy Details: Insights From the Study of Technical Work in Healthcare

• System of care at different levels adapts to exploit new capabilities and to work around complexities.
• Technical work is based on:
  • Knowledge of illness and response
  • How to get things done.
  • Where things will happen.
  • What is likely to happen.
  • How to make what is needed happen.
• Operators create success in work through their efforts to manage the messy details.
• As they confront evolving situations they constantly adapt their performance.
• These adaptations become the everyday nature of work.

Nemeth et al., IEEE Trans Syst Man Cyber 34:6 2004
Recognize decreased mental status and perfusion. Begin high flow $O_2$. Establish IV/IO access.

**Initial resuscitation:** Push boluses of 20 cc/kg isotonic saline or colloid up to & over 60 cc/kg until perfusion improves or unless renal or hepatopulmonary develop.
Correct hypoglycemia & hypocalcemia. Begin antibiotics.

**Shock not reversed?**

**Fluid refractory shock:** Begin isotonic IV/IO; use norepinephrine IV/IO/IM to obtain central access & airway if needed. Reverse cold shock by intravenous dopamine or, if resistant, intravenous central epinephrine.

**Shock not reversed?**

**Catecholamine resistant shock:** Begin hydrocortisone if at risk for absolute adrenal insufficiency.

Monitor CVP in PICU, attain normal MAP-CVP & ScvO₂ > 70%.

**Cold shock with normal blood pressure:**
1. Titrate fluid & epinephrine, ScvO₂ > 70%, Hgb > 8 g/dL.
2. If ScvO₂ still < 70% Add vasodilator with volume loading (nitrovasodilator, milrinone, inotropic, & others)
Consider levosimendan

**Cold shock with low blood pressure:**
1. Titrate fluid & epinephrine, ScvO₂ > 70%, Hgb > 10 g/dL.
2. If still hypotensive consider norepinephrine
3. If ScvO₂ still < 70% consider dobutamine, milrinone, enoximone or levosimendan

**Warm shock with low blood pressure:**
1. Titrate fluid & norepinephrine, ScvO₂ > 70%,
2. If still hypotensive consider vasopressor or argatroban
3. If ScvO₂ still < 70% consider low dose epinephrine

**Persistent catecholamine resistant shock:** Rule out and correct pericardial effusion, pneumothorax, & intra-abdominal pressure >12 mmHg.
Consider pulmonary artery, PICCO, or FátO₂ catheter, &/or doppler ultrasound to guide fluid, isotone, vasopressor, vasodilator & hormonal therapies.
Goal C.I. > 3.5 & < 6.0 L/min/m²

**Shock not reversed?**

**Refractory shock:** ECMO
Socio-Technical Interaction

Humans interacting within this system
Hardwiring Adaptability

• Nurses are constantly adapting – we just need to understand it!

• Good design expands the ability to adapt & can help tame complexity

• The system should allow for ANY human to step into the workflow and adapt and thrive – therefore meeting and exceeding basic human needs.

What does the theoretical to physical construct look like?

Messy Details → Adapt → Learn
Conclusion

• Scale of this endeavor itself dwarfs all other activities in which human factors professions have been engaged

• Once we come to understand the human behavior of nurses in relation to their workload we can properly design human-automation interactions.
Thank you for attending

• Presentations:
  www.childrenshospitals.org

• Presenter contact information:

<table>
<thead>
<tr>
<th>Texas Children’s Hospital</th>
<th>UNC Hospitals/North Carolina Children’s Hospital</th>
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</thead>
<tbody>
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<td>Stephanie Davenport, BS, BME, RN, CPN</td>
<td>Leah Hatfield, PharmD, BCPS</td>
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