A Modern Approach to the Fundamentals of Sepsis Recognition, Management and Performance Improvement

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Chris Horvat, MD MHA

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June 7, 2018

A Modern Approach to the Fundamentals of Sepsis Recognition, Management and Performance Improvement

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Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

Conflict of Interest Disclosures

Children's Hospital of Pittsburgh Young Investigator Award

Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

Outline

American College of Critical Care Medicine Clinical Practice Parameters for Hemodynamic Support of Pediatric and Neonatal Septic Shock

Critical Care Medicine June 2017 • Volume 45 • Number 6

ACCM Guidelines 2017

Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

Outline

Recognition Bundle (see AAP Trigger tool example Figure 2)

- Screen patient for septic shock using an institution trigger tool.
- Clinician assessment within 15 minutes for any patient who screens positive in the trigger tool.
- Initiate *Resuscitation Bundle* within 15 minutes for patient identified by the trigger tool whom the assessing clinician confirms suspicion of septic shock.

Resuscitation Bundle (see Algorithm Figure 3 and 4)

- Attain IV/IO access within 5 minutes.
- Appropriate fluid resuscitation begun within 30 minutes.
- Initiation of broad-spectrum empiric antibiotics within 60 minutes.
- Begin peripheral or central inotrope infusion therapy for fluid-refractory shock within 60 minutes.

Stabilization Bundle (see Algorithm Figure 3 and 4)

- Use multimodal monitoring to optimize fluid, hormonal, and cardiovascular therapies to attain hemodynamic goals.
- Confirm administration of appropriate antimicrobial therapy and source control.

Performance Bundle

- Measure adherence to Trigger, Resuscitation, and Stabilization Bundles.
- Perform root cause analysis to identify barriers to adherence.
- Provide an action plan to address identified barriers.

ACCM Guidelines 2017

Outline

1) **Historic perspective**: Foundation of resuscitation
2) **Recognition:** Augmenting clinical evaluation
3) **Resuscitation:** Guidelines for individualization
4) **Stabilization:** Bolstering clinical assessment
5) **Performance:** Collaboration and tracking

Dr. Peter Safar

Rules for Navigating Life

Rule No. 16

"When in doubt, THINK!"

Outline

1) Historic perspective: Foundation of resuscitation

2) Recognition: Augmenting clinical evaluation

3) Resuscitation: Guidelines for individualization

4) Stabilization: Bolstering clinical assessment

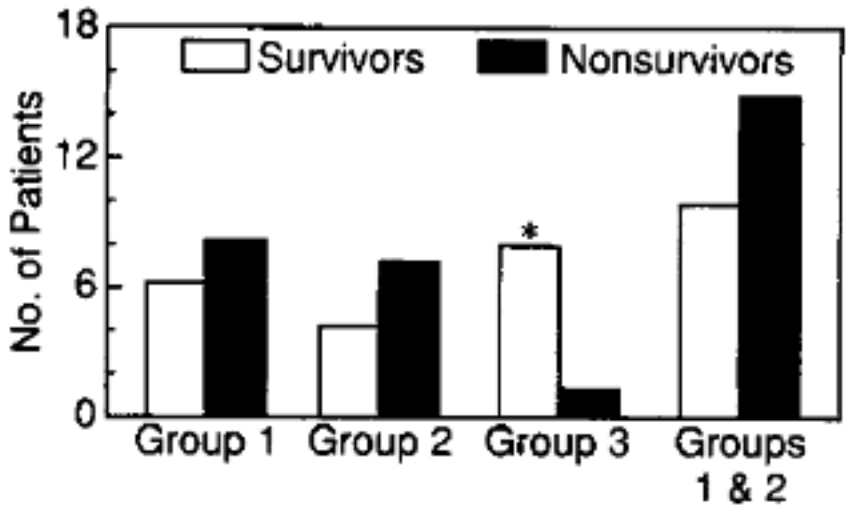
5) Performance: Collaboration and tracking

Role of Early Fluid Resuscitation in Pediatric Septic Shock

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

JAMA, September 4, 1991—Vol 266, No. 9

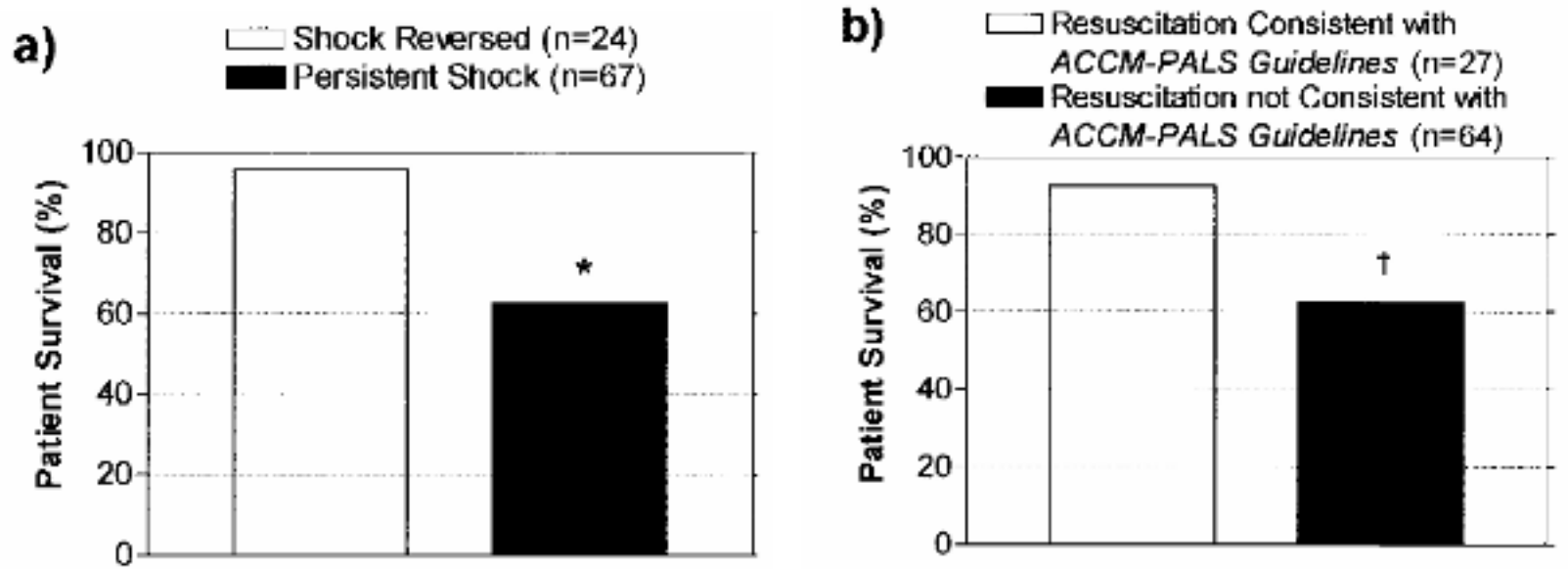
	1 h (mean ± SD)	6 h (mean ± SD)
Group 1 (n = 14; <20 mL/kg in 1 h)	11 ± 6*	71 ± 29†
Group 2 (n = 11; 20-40 mL/kg in 1 h)	32 ± 5*	108 ± 54
Group 3 (n = 9; >40 mL/kg in 1 h)	69 ± 19*	117 ± 29
All patients (n = 34)	33 + 26	95 ± 42
Survivors (n = 18)	42 ± 28‡	97 ± 49
Nonsurvivors (n = 16)	23 ± 18	94 ± 37



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*‡§

PEDIATRICS Vol. 112 No. 4 October 2003 793



Delayed Antimicrobial Therapy Increases Mortality and Organ Dysfunction Duration in Pediatric Sepsis*

Scott L. Weiss, MD[1]; Julie C. Fitzgerald, MD, PhD[1]; Fran Balamuth, MD, PhD[2]; Elizabeth R. Alpern, MD, MSCE[3]; Jane Lavelle, MD[2]; Marianne Chilutti, MS[4]; Robert Grundmeier, MD[4,5]; Vinay M. Nadkarni, MD, MS[1]; Neal J. Thomas, MD, MSc[6]

TABLE 5. PICU Mortality: Sepsis Recognition to Initial Antimicrobial Administration

Time to Initial Antibiotics (hr)	No. of Patients	% Mortality	% Difference	Unadjusted OR	95% CI
≤ 1	24	8	5	1.67	0.35–7.91
> 1	106	13			
≤ 2	55	7	10	2.43	0.74–7.99
> 2	75	17			
≤ 3	78	6	17	3.92	1.27–12.06
> 3	52	23			
≤ 4	91	8	15	3.60	1.23–10.52
> 4	39	23			

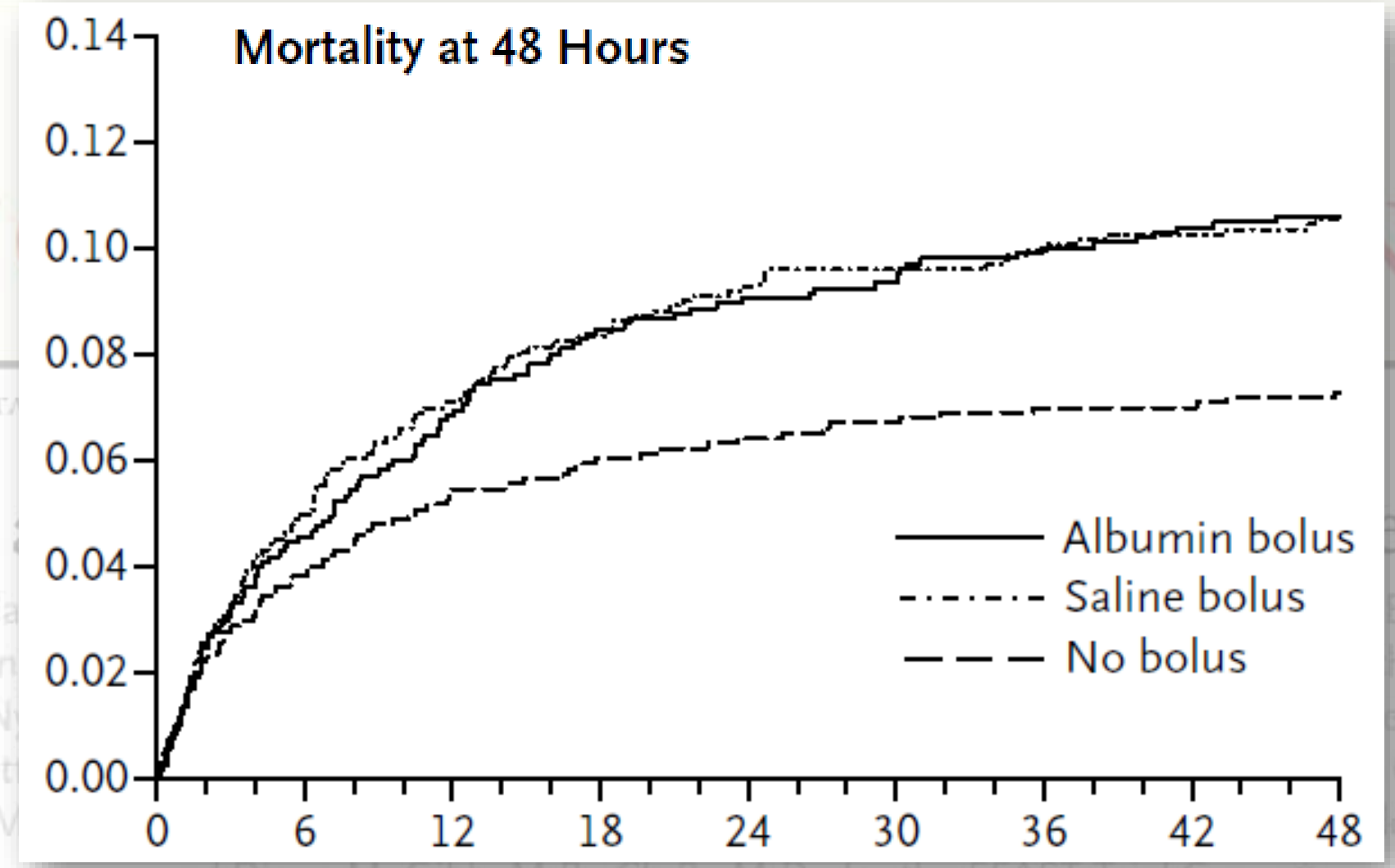
Critical Care Medicine November 2014 • Volume 42 • Number 11

The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812 JUNE 30, 2011 VOL. 364 NO. 26

Mortality after Fluid Bolus in African Children with Severe Infection

Kathryn Maitland, M.B., B.S., Ph.D., Sarah Kiguli, M.B., Ch.B., M.Med., Robert O. Opoka, M.B., Ch.B., M.Med., Charles Engoru, M.B., Ch.B., M.Med., Peter Olupot-Olupot, M.B., Ch.B., Samuel O. Akech, M.B., Ch.B., Richard Nyeko, M.B., Ch.B., M.Med., George Mtove, M.D., Hugh Reyburn, M.B., B.S., Trudie Lang, Ph.D., Bernadette Brent, M.B., B.S., Jennifer A. Evans, M.B., B.S., James K. Tibenderana, M.B., Ch.B., Ph.D., Jane Crawley, M.B., B.S., M.D., Elizabeth C. Russell, M.Sc., Michael Levin, F.Med.Sci., Ph.D., Abdel G. Babiker, Ph.D., and Diana M. Gibb, M.B., Ch.B., M.D., for the FEAST Trial Group*



The NEW ENGLAND

Table 1. (Continued.)

Variable	Albumin Bolus (N=1050)	Saline Bolus (N=1047)	No Bolus (N=1044)	Total (N=3141)
Laboratory assessments††				
Positive for malaria parasitemia — no./total no. (%)‡‡	590/1044 (57)	612/1042 (59)	591/1037 (57)	1793/3123 (57)
Hemoglobin — no./total no. (%)				
<5 g/dl	323/1024 (32)	332/1015 (33)	332/1015 (33)	987/3054 (32)
>10 g/dl	231/1024 (23)	230/1015 (23)	244/1015 (24)	705/3054 (23)

Charles Engoru, M.B., Ch.B., M.Med., Peter Olupot-Olupot, M.B., Ch.B., Samuel O. Akech, M.B., Ch.B., Richard Nyeko, M.B., Ch.B., M.Med., George Mtove, M.D., Hugh Reyburn, M.B., B.S., Trudie Lang, Ph.D., Bernadette Brent, M.B., B.S., Jennifer A. Evans, M.B., B.S., James K. Tibenderana, M.B., Ch.B., Ph.D., Jane Crawley, M.B., B.S., M.D., Elizabeth C. Russell, M.Sc., Michael Levin, F.Med.Sci., Ph.D., Abdel G. Babiker, Ph.D., and Diana M. Gibb, M.B., Ch.B., M.D., for the FEAST Trial Group*

SHOCK, Vol. 43, No. 1, pp. 68–73, 2015

FLUID OVERLOAD IN PATIENTS WITH SEVERE SEPSIS AND SEPTIC SHOCK TREATED WITH EARLY GOAL-DIRECTED THERAPY IS ASSOCIATED WITH INCREASED ACUTE NEED FOR FLUID-RELATED MEDICAL INTERVENTIONS AND HOSPITAL DEATH

Diana J. Kelm,[*†] Jared T. Perrin,[*] Rodrigo Cartin-Ceba,[*†] Ognjen Gajic,[*†] Louis Schenck,[‡] and Cassie C. Kennedy[*†]

[*]Department of Internal Medicine and Divisions of [†]Pulmonary and Critical Care and [‡]Biomedical Statistics and Informatics, Mayo Clinic, Rochester, Minnesota

Received 28 Aug 2014; first review completed 15 Sep 2014; accepted in final form 17 Sep 2014

TABLE 3. **Medical interventions and secondary outcomes in those with clinical evidence of fluid overload: univariate and multivariate analyses**

		Clinical evidence of fluid overload day 1 (n = 272)	Clinical evidence of persistent fluid overload (n = 182)
Univariate analyses		Medical interventions, OR (95% CI)	
	Thoracentesis*	3.38 (1.28–8.95)	3.10 (1.44–6.68)
	Paracentesis†	0.58 (0.19–1.77)	0.57 (0.17–1.94)
	Ultrafiltration‡	1.41 (0.66–3.02)	2.17 (1.06–4.43)
	Diuretics§	1.15 (0.71–1.86)	1.77 (1.09–2.87)
		Secondary outcomes	
	ICU LOS, mean difference, d	0.54 (−0.38 to 1.46)	0.39 (−0.51 to 1.30)
	Hospital LOS, mean difference, d	0.99 (−2.25 to 4.22)	1.55 (−1.64 to 4.74)
	30-d ICU readmission, OR (95% CI)	1.07 (0.62–1.84)	1.40 (0.839–2.34)
	Hospital mortality, OR (95% CI)	2.33 (1.34–4.05)	1.89 (1.16–3.09)
Multivariate analyses		Medical interventions, OR (95% CI)	
	Thoracentesis*‖	3.40 (1.37–10.3)	3.83 (1.74–9.15)
	Ultrafiltration‡‖		1.90 (0.90–4.19)
	Diuretics§¶‖		1.65 (1.00–2.72)
		Secondary outcomes	
	30-d ICU readmission, OR (95% CI)‖		1.61 (0.94–2.79)
	Hospital mortality, OR (95% CI)‖	2.27 (1.31–4.09)	1.92 (1.16–3.22)

Early, Goal-Directed versus Usual Care

Rivers et al. EGTD NEJM 2001

ProCESS NEJM 2014

ARISE NEJM 2014

ProMISe NEJM 2015

Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

Outline

1) Historic perspective: Foundation of resuscitation

2) Recognition: Augmenting clinical evaluation

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5) Performance: Collaboration and tracking

GET AHEAD OF SEPSIS

KNOW THE RISKS. SPOT THE SIGNS. ACT FAST.

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CRITICAL CARE MEDICINE

Implementation of Goal-Directed Therapy for Children With Suspected Sepsis in the Emergency Department

abstract

BACKGROUND: Suboptimal care for children with septic shock includes delayed recognition and inadequate fluid resuscitation.

OBJECTIVE: To describe the implementation of an emergency department (ED) protocol for the recognition of septic shock and facilitate

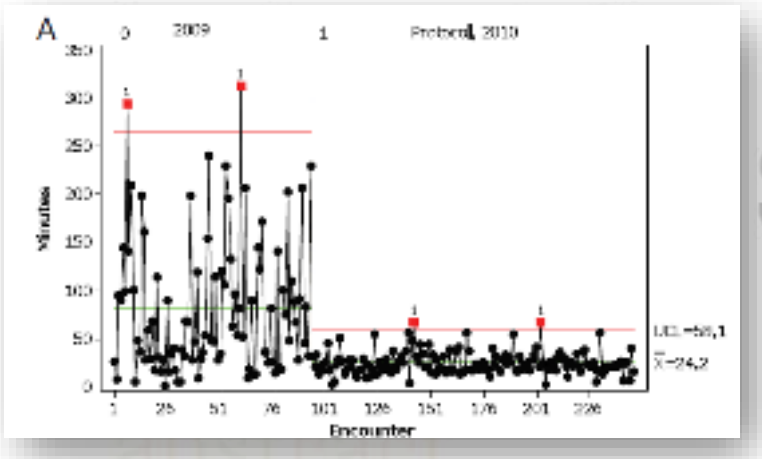
AUTHORS: Andrea T. Cruz, MD, MPH,[a,b] Andrew M. Perry, MD,[a] Eric A. Williams, MD, MS,[c] Jeanine M. Graf, MD,[c] Elizabeth R. Wuestner, MSN, RN,[d] and Binita Patel, MD[a]

Sections of [a]Emergency Medicine, [b]Infectious Diseases, and [c]Critical Care Medicine, Department of Pediatrics, Baylor College of Medicine, Houston, Texas; and [d]Emergency Department, Texas Children's Hospital, Houston, Texas

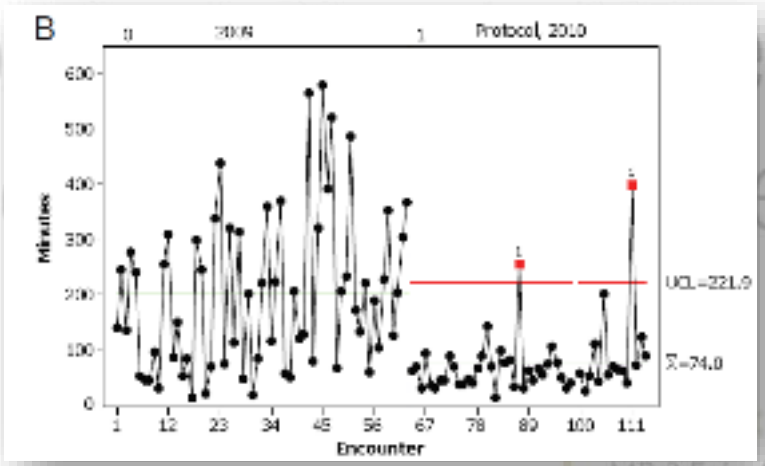
Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

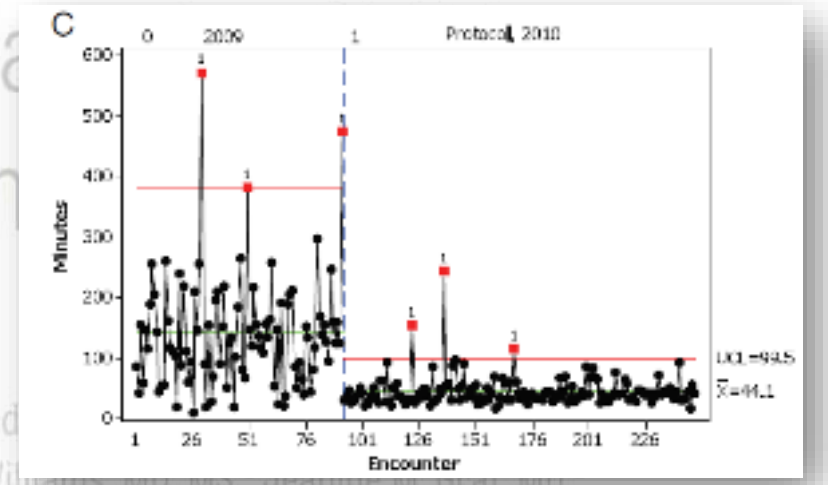
Time to 1st Bolus



Time to 3rd Bolus



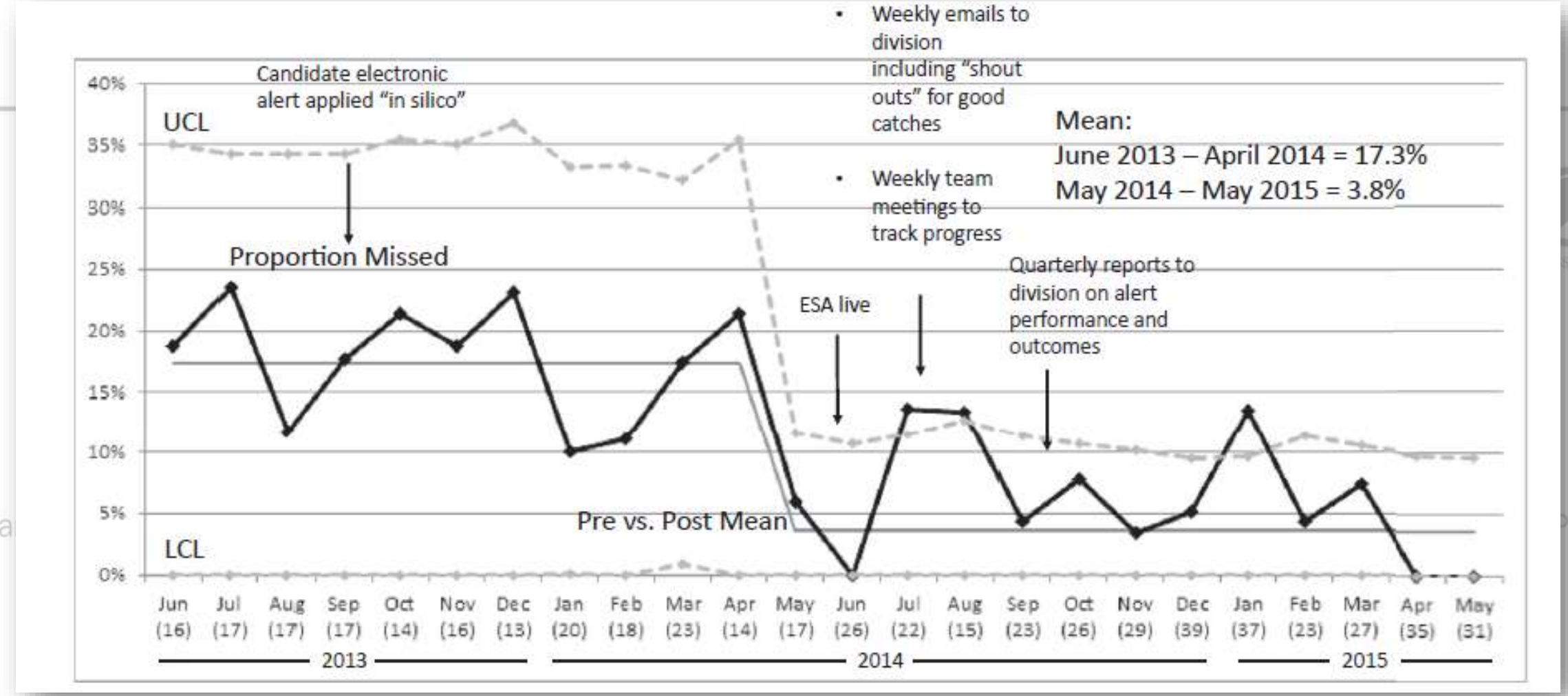
Time to Antibiotic



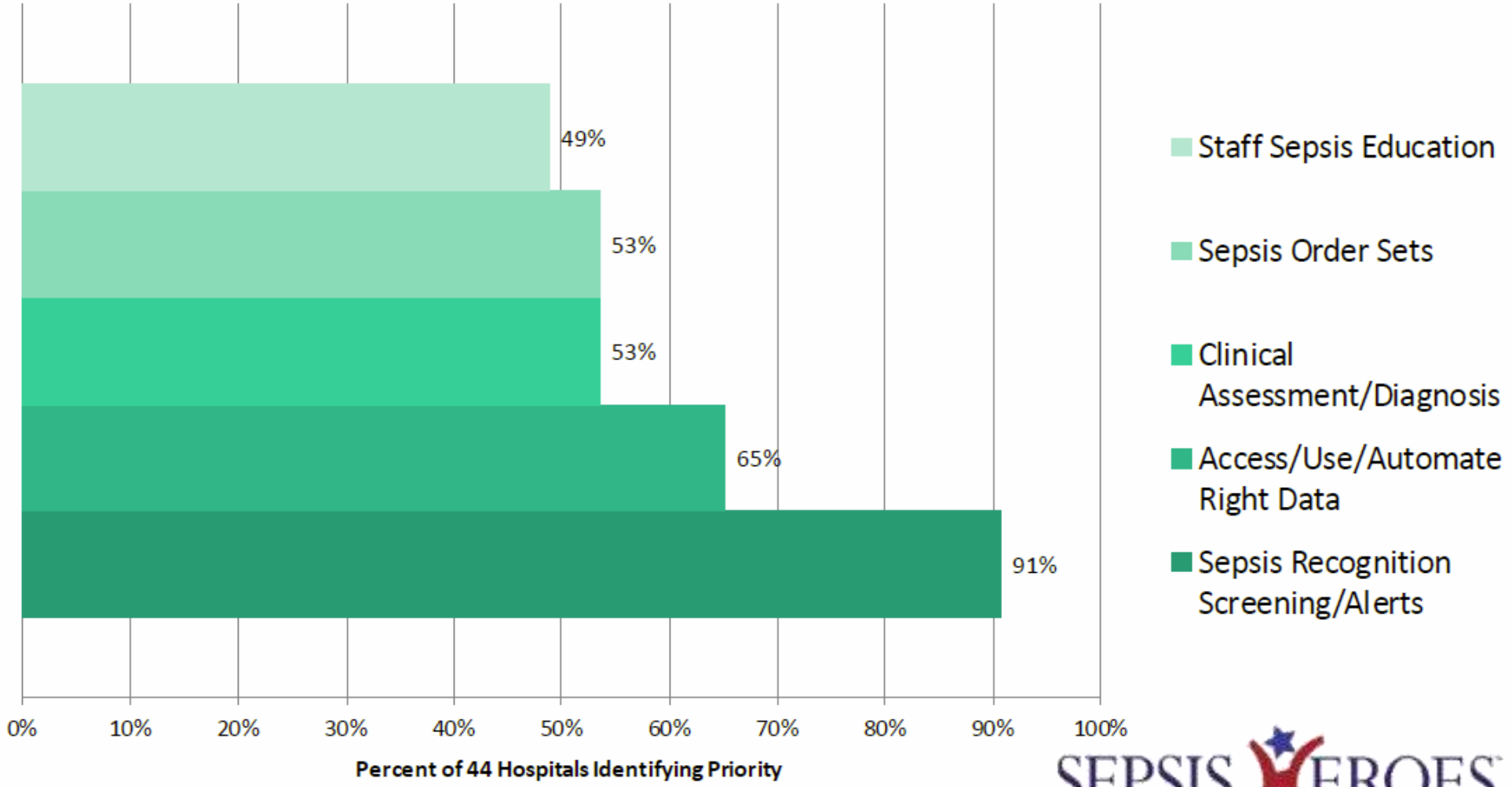
Improving Recognition of Pediatric Severe Sepsis in the Emergency Department: Contributions of a Vital Sign–Based Electronic Alert and Bedside Clinician Identification

Fran Balamuth, MD, PhD*; Elizabeth R. Alpern, MD, MSCE; Mary Kate Abbadessa, MSN, RN; Katie Hayes, BS; Aileen Schast, PhD; Jane Lavelle, MD; Julie C. Fitzgerald, MD, PhD; Scott L. Weiss, MD, MSCE; Joseph J. Zorc, MD, MSCE

*Corresponding Author. E-mail: balamuthf@email.chop.edu.


Candidate electronic alert applied "in silico"
UCL
Proportion Missed
LCL
Pre vs. Post Mean
ESA live
Quarterly reports to division on alert performance and outcomes
• Weekly emails to division including "shout outs" for good catches
• Weekly team meetings to track progress
Mean:
June 2013 – April 2014 = 17.3%
May 2014 – May 2015 = 3.8%
40%
35%
30%
25%
20%
15%
10%
5%
0%
Jun (16)
Jul (17)
Aug (17)
Sep (17)
Oct (14)
Nov (16)
Dec (13)
Jan (20)
Feb (18)
Mar (23)
Apr (14)
May (17)
Jun (26)
Jul (22)
Aug (15)
Sep (23)
Oct (26)
Nov (29)
Dec (39)
Jan (37)
Feb (23)
Mar (27)
Apr (35)
May (31)
2013
2014
2015

Top Sepsis Improvement Priorities at IPSO Hospitals in Initial 12 Months of Participation



SEPSIS HEROES

CHILDREN'S HOSPITAL ASSOCIATION

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Acute Care Pediatric Sepsis and Sepsis Shock

Clinical Effectiveness Guideline

Table 1. Criteria for positive sepsis screen. Positive screen = hypotension alone or ≥ 3 of the following 8 criteria:

1. Fever or hypothermia
2. Tachycardia
3. Tachypnea
4. Cap refill: ≥ 3 sec or < 1 sec
5. Pulse: decreased or bounding
6. Skin: mottled, flushed or petechiae/purpura
7. Mental status: depressed, highly irritable, confused
8. Presence of a high-risk medical condition:
   - Age < 1mo
   - Severe developmental delay/intellectual disability
   - Central line (Mediport, Broviac, PICC)
   - Malignancy
   - Transplant
   - Asplenia (including Sickle Cell Disease)
   - Other immunocompromised

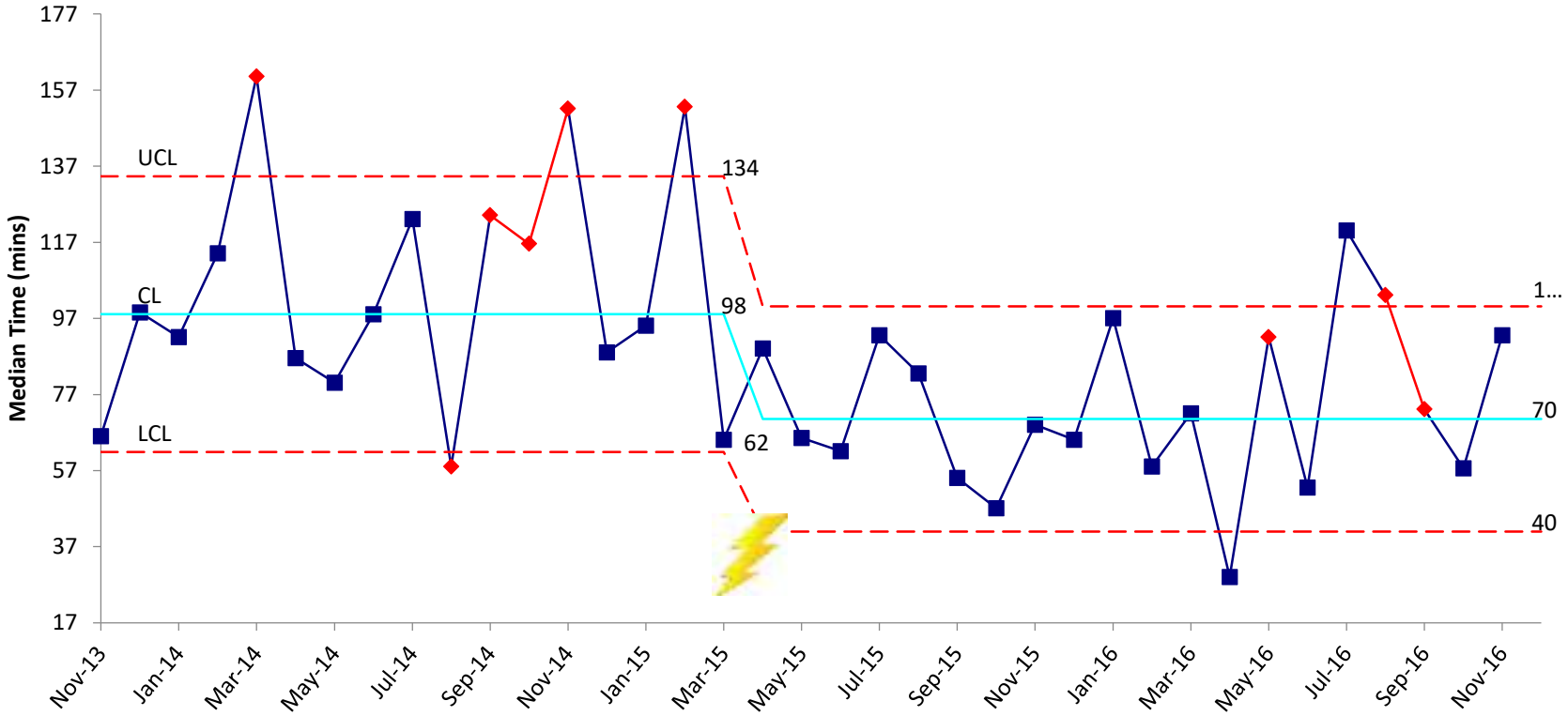
Age	Temp C	HR	RR	Systolic BP
0 d - 1 m	< 36.5 or > 38	> 205	> 60	< 60
≥ 1 m - 3 m	< 36 or > 38	> 205	> 60	< 70
≥ 3 m - 1 y	< 36 or > 38.5	> 190	> 60	< 70
1 y	< 36 or > 38.5	> 190	> 40	< 72
2 y	< 36 or > 38.5	> 140	> 40	< 74
3 y	< 36 or > 38.5	> 140	> 40	< 76
4 y	< 36 or > 38.5	> 140	> 34	< 78
5 y	< 36 or > 38.5	> 140	> 34	< 80
6 y	< 36 or > 38.5	> 140	> 30	< 82
7 y	< 36 or > 38.5	> 140	> 30	< 84
8 y	< 36 or > 38.5	> 140	> 30	< 86
9 y	< 36 or > 38.5	> 140	> 30	< 88
≥ 10 y - 13 y	< 36 or > 38.5	> 120	> 30	< 90
> 13	< 36 or > 38.5	> 110	> 20	< 90

The Lightning Bolt Makes a Difference

Median Time to Antibiotics Control Chart

Goal is 60 minutes

Bolt started in March, 2015



Nov, 2013 – Dec, 2016

Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

Outline

1) Historic perspective: Foundation of resuscitation

2) Recognition: Augmenting clinical evaluation

3) Resuscitation: Guidelines for individualization

4) Stabilization: Bolstering clinical assessment

5) Performance: Collaboration and tracking

Time to Antibiotics

The Impact of Timing of Antibiotics on Outcomes in Severe Sepsis and Septic Shock: A Systematic Review and Meta-Analysis*

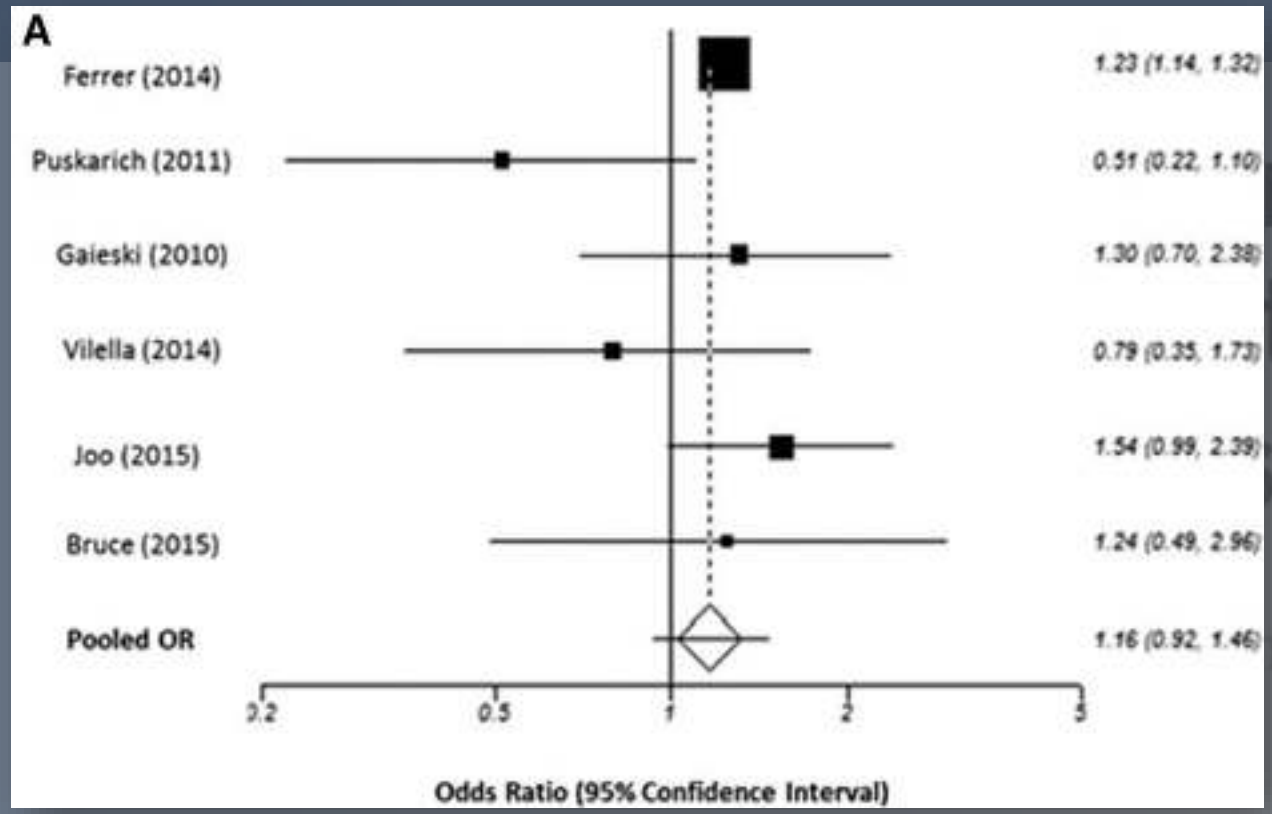
Sarah A. Sterling, MD; W. Ryan Miller, MD; Jason Pryor, MD; Michael A. Puskarich, MD; Alan E. Jones, MD

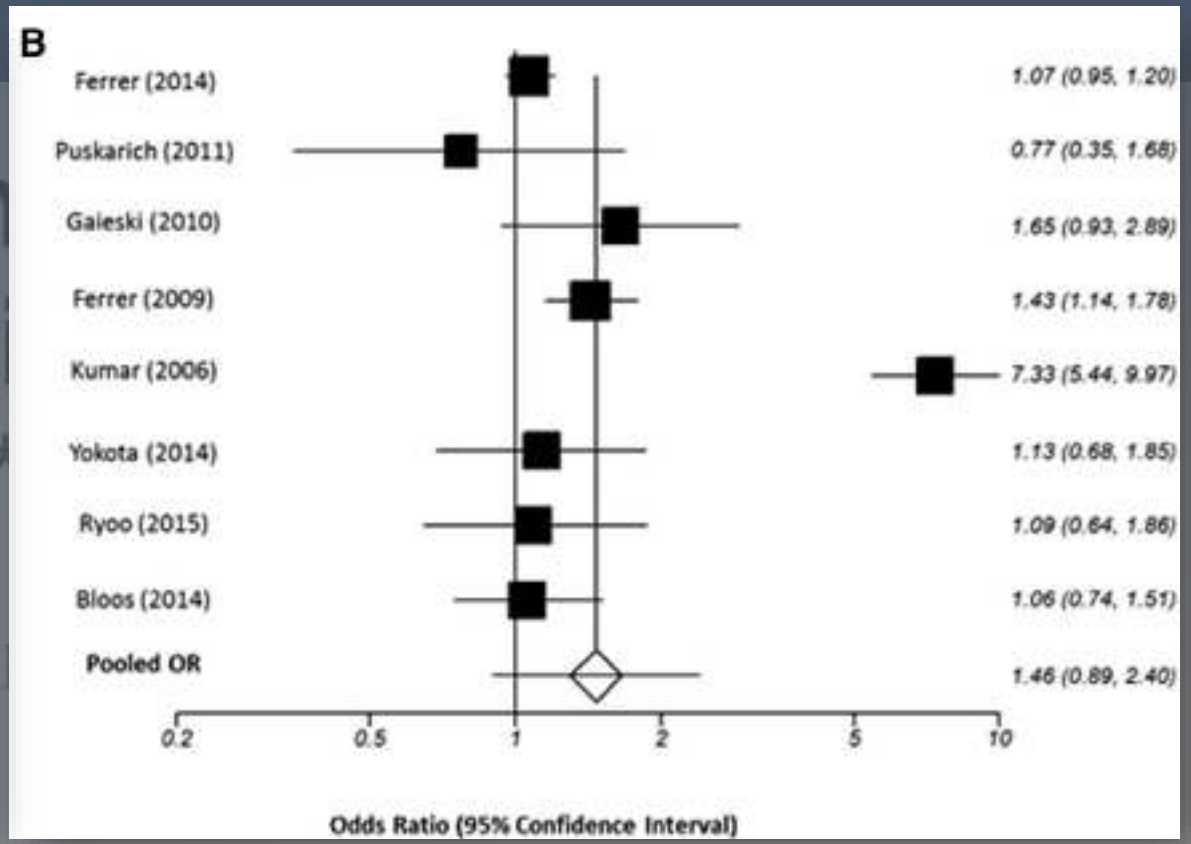
Critical Care Medicine September 2015 • Volume 43 • Number 9

Children's Hospital of Pittsburgh of UPMC

CRITICAL CARE MEDICINE

Time to Antibiotics





Yes, but…

Video Credit: Daniel Izzo. *Bacteria Growth*. https://www.youtube.com/watch?v=gEwzDydciWc.

Guidelines - Time to Antibiotics

- 2012 ESIC/SCCM Guidelines – Administer antibiotics within 1 hour
- 2015 ESIC/SCCM Update – Administer antibiotics within 3 hours
- 2016 Update – Administer antibiotics within 1 hour

Time to Antibiotics in Major Clinical Trials

Rivers et al. EGTD NEJM
- Majority within 6 hours

Kumar et al. CCM
- Median of 6 [IQR 2-15] hrs

ProCESS NEJM
- Majority within 3 ± 1.75 hrs

ARISE NEJM
- Median of 70 [38-114] min

ProMISe NEJM
- All by median of 2.5 [1.8-3.5] hrs

Credit: Michael Alison, MD; Twitter 2015

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CRITICAL CARE MEDICINE

Time to Antibiotics in Major Clinical Trials

Rivers et al. – Majority within 6 hours

Kumar et al. – Median of 6 hours

ProCESS – Majority within 3 hours

ARISE – Median of 70 minutes

ProMISe – Median of 2.5 hours

Credit: Michael Alison, MD; Twitter 2015

Factors Influencing Antibiotic Delivery

Patient and Organizational Factors Associated With Delays in Antimicrobial Therapy for Septic Shock*

Andre C. K. B. Amaral, MD[1]; Robert A. Fowler, MDCM, MS(Epi), FRCPC[1]; Ruxandra Pinto, PhD[1]; Gordon D. Rubenfeld, MD, MSc[1]; Paul Ellis, MD[2]; Brian Bookatz, MD[3]; John C. Marshall, MD, FRCSC, FACS[4]; Greg Martinka, MD[5]; Sean Keenan, MD[6]; Denny Laporta, MD[7]; Daniel Roberts, MD[8]; Anand Kumar, MD[8]; and the Cooperative Antimicrobial Therapy of Septic Shock Database Research Group

Critical Care Medicine December 2016 • Volume 44 • Number 12

Variable	Difference in Minutes to a Standard Patient	% Change in Time to Antimicrobial	p
Year of entry in the cohort, per year	−9	−3.23 (−4.22 to −2.22)	< 0.0001
Academic hospital[a]	+52	21.57 (3.13–43.34)	0.0224
Acute Physiology Score, per 5 points	+24	9.06 (6.63–11.53)	< 0.0001
Temperature, per °C	−15	−5.58 (−7.62 to −3.59)	< 0.0001
Age, per 10 yr	+15	5.94 (3.45–8.49)	< 0.0001
Pre-shock length of stay[b]			
≤ 3 d	+50	25.34 (13.79–38.07)	< 0.0001
Between 3 and 7 d	+121	61.55 (38.11–88.97)	< 0.0001
> 7 d	+130	66.25 (44.85–90.79)	< 0.0001
Immunosuppression	+18	6.92 (−1.595 to 16.16)	0.11407
Sex, male	−15	−5.41 (−11.90 to 1.56)	0.12517
Comorbidity	+85	14.15 (5.82–23.13)	0.00062
Community-acquired infection[c]	−53	−18.11 (−26.57 to −8.68)	0.00033
Hypertension	−33	−11.73 (−19.34 to −3.40)	0.00672
Transferred from[d]			
Emergency department	−47	−17.71 (−28.17 to −5.73)	0.00495
External hospital	+17	6.26 (−7.82 to 22.48)	0.40257
Medicine ward	−39	14.52 (1.32–29.45)	0.02999
Primary infection[e]			
Gastrointestinal	+18	7.64 (−6.87 to 24.42)	0.31884
Other	+35	14.66 (−0.11 to 31.66)	0.05189
Pneumonia	+45	18.69 (5.34–33.74)	0.00493
Need for source control	+19	7.425 (−3.34 to 19.39)	0.18361

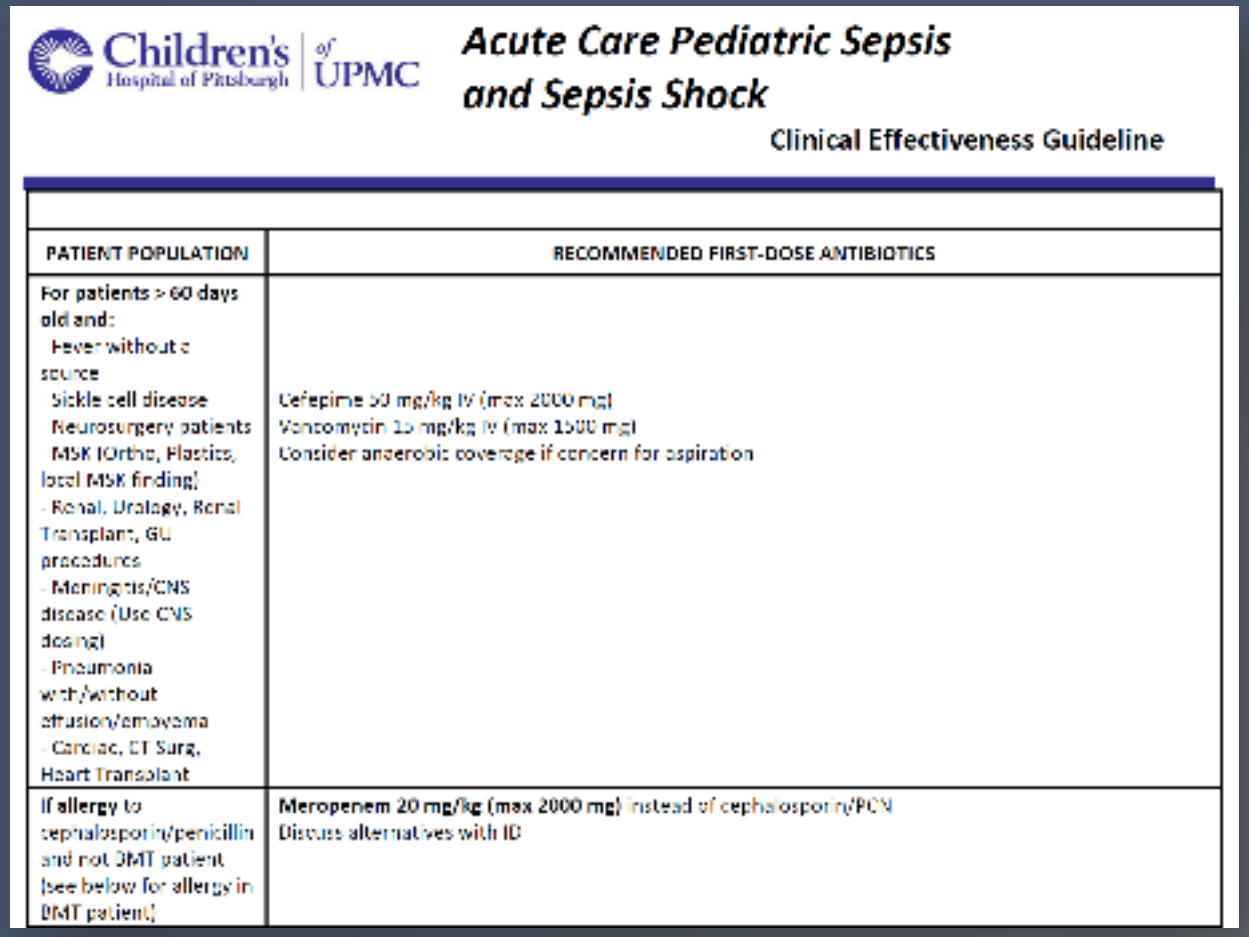
Time to Antibiotics

1. Antibiotics ordered (written, verbal or EHR)
2. Order received by pharmacy
3. Dose and indication verification
4. Order prepared
5. Transported to nursing unit/bedside
6. Infusion pump prepared
7. Antibiotic initiated (infusion completed 30 minutes later)

Time to Antibiotics (Our Old Approach)

1. Meropenem ordered (written, verbal or EHR)
   - Resident/housestaff place order while senior staff resuscitate
2. Order received by pharmacy
3. Dose and indication verification
   - Phone call to verify indication given stewardship policies
4. Order prepared
5. Transported to nursing unit/bedside via tube station
   - Antibiotic waits in the station until a nurse is able to momentarily step away from the resuscitation
   - Eventually brought to bedside and set down in order to prepare vasopressors
6. Infusion pump prepared
7. Antibiotic initiated after verification (infusion completed 30 minutes later)

Time to Antibiotics (Current Approach)



Children's Hospital of Pittsburgh of UPMC

Acute Care Pediatric Sepsis and Sepsis Shock

Clinical Effectiveness Guideline

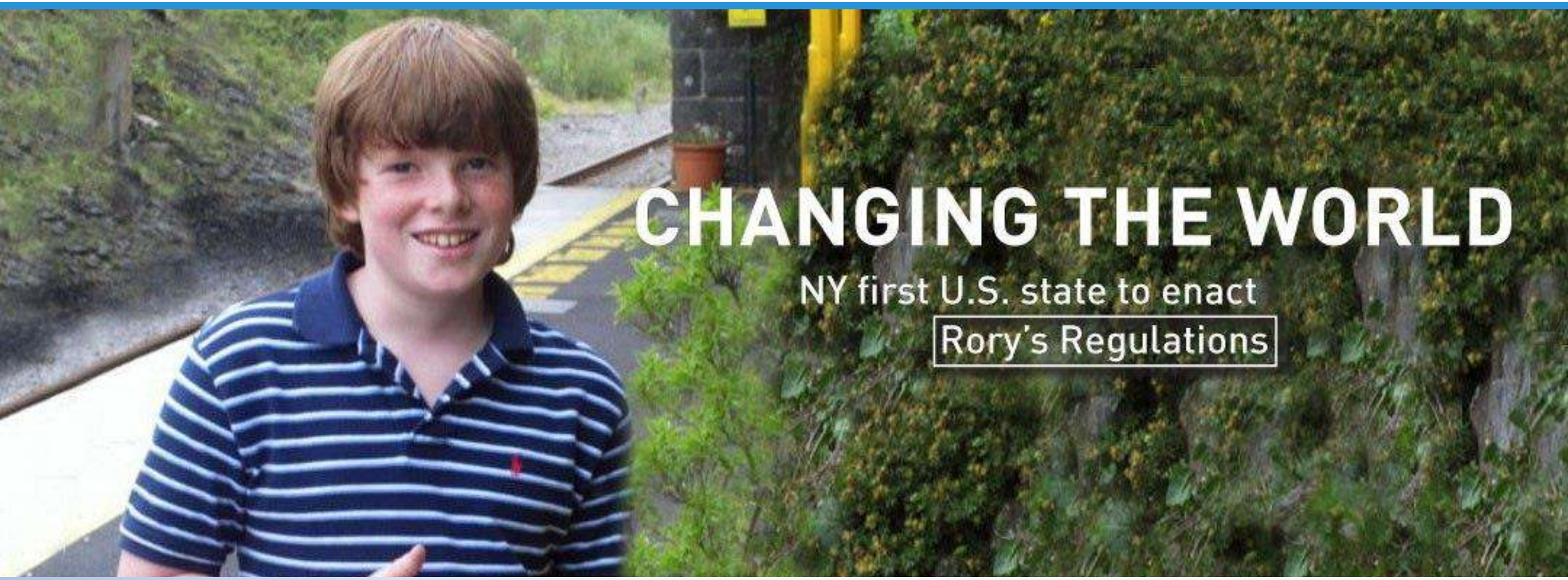
PATIENT POPULATION	RECOMMENDED FIRST-DOSE ANTIBIOTICS
For patients > 60 days old and: - Fever without a source - Sickle cell disease - Neurosurgery patients - MSK (Ortho, Plastics, local MSK finding) - Renal, Urology, Renal Transplant, GU procedures - Meningitis/CNS disease (Use CNS dosing) - Pneumonia with/without effusion/empyema - Cardiac, CT Surg, Heart Transplant	Cefepime 50 mg/kg IV (max 2000 mg) Vancomycin 15 mg/kg IV (max 1500 mg) Consider anaerobic coverage if concern for aspiration
If allergy to cephalosporin/penicillin and not BMT patient (see below for allergy in BMT patient)	**Meropenem 20 mg/kg (max 2000 mg)** instead of cephalosporin/PCN Discuss alternatives with ID

- Sepsis recognition triggers bedside huddle
- One time dose of empiric, risk-factor based antibiotic ordered
- Phone call placed to pharmacy notifying patient has sepsis
- Antibiotic delivered to bedside and prioritized for initiation

- Reduction in time to abx to median of 1 hr (Still room to improve!)

THE RORY STAUNTON FOUNDATION

FOR SEPSIS PREVENTION



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CRITICAL CARE MEDICINE

Time to Bundled Care

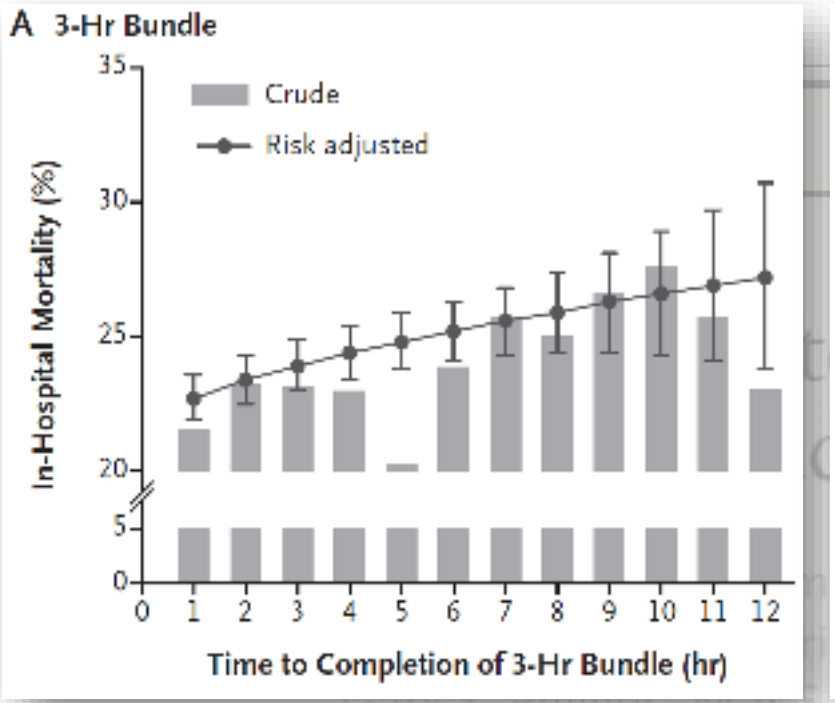
The NEW ENGLAND JOURNAL of MEDICINE

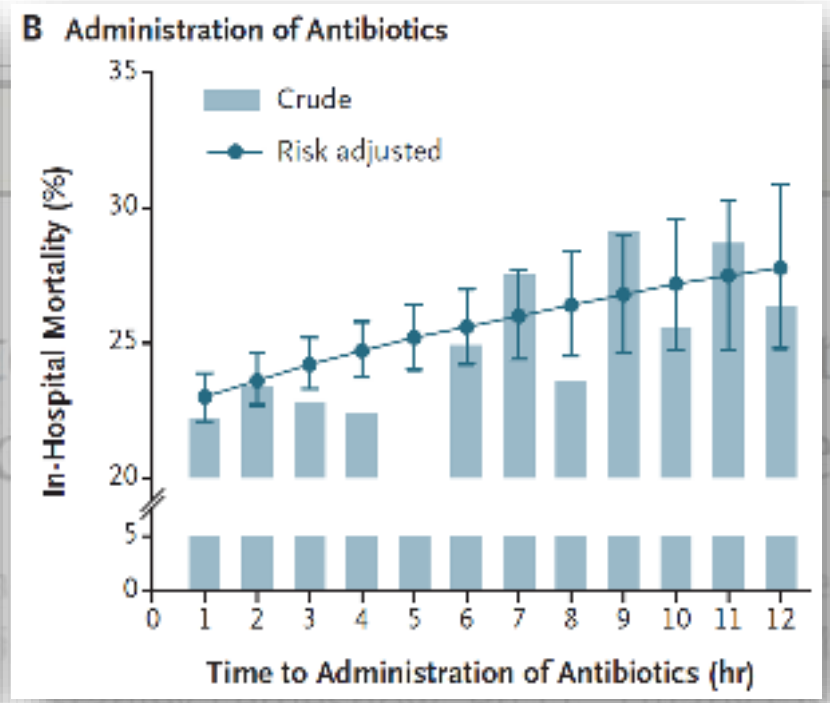
ORIGINAL ARTICLE

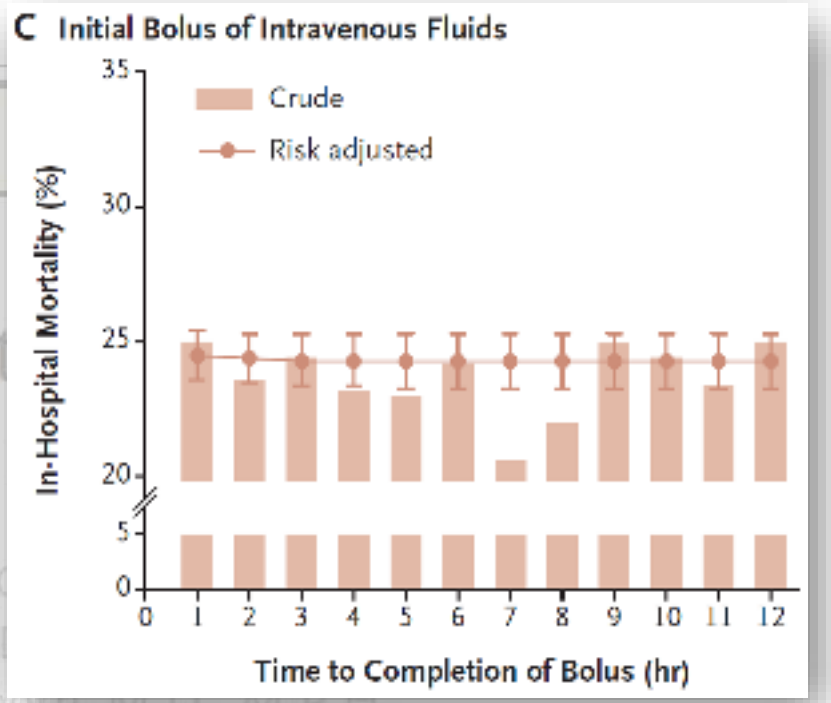
Time to Treatment and Mortality during Mandated Emergency Care for Sepsis

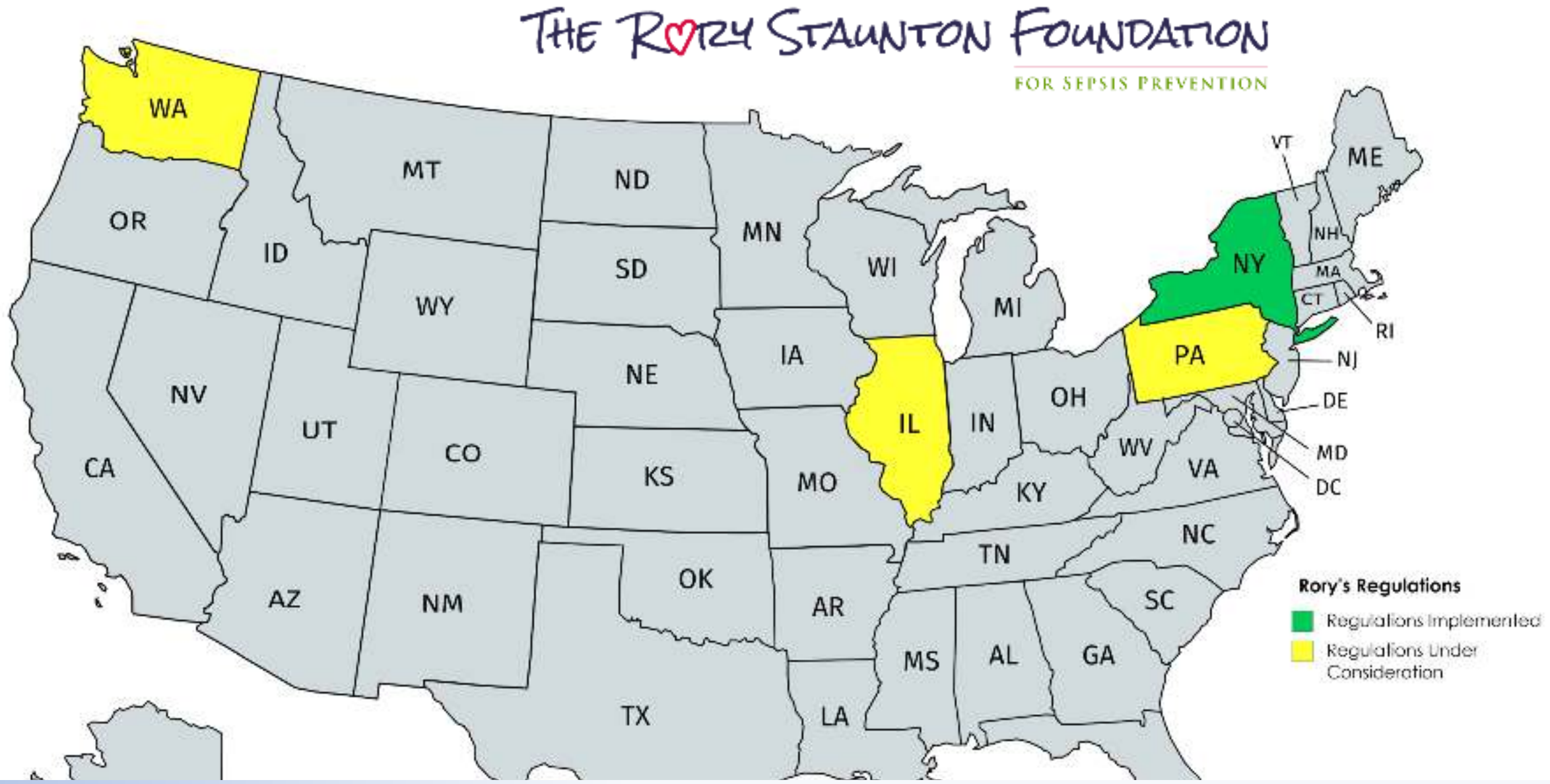
Christopher W. Seymour, M.D., Foster Gesten, M.D., Hallie C. Prescott, M.D., Marcus E. Friedrich, M.D., Theodore J. Iwashyna, M.D., Ph.D., Gary S. Phillips, M.A.S., Stanley Lemeshow, Ph.D., Tiffany Osborn, M.D., M.P.H., Kathleen M. Terry, Ph.D., and Mitchell M. Levy, M.D.

Time to Bundled Care









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CRITICAL CARE MEDICINE

This Issue | Views 704 | Citations 0 | Altmetric 37

Research Letter

October 2017

Epidemiology of Sepsis Among Ado
Community Hospital Emergency De
Implications for Rory's Regulations

Idris V. R. Evans, MD, MSc[1,2]; R. Scott Watson, MD, MPH[3]; Joseph Carcillo, MD[1,2]; et al

» Author Affiliations | Article Information

JAMA Pediatr. 2017;171(10):1011-1012. doi:10.1001/jamapediatrics.2017.1915

Table Characteristics of 899 Healthy Adolescents Presenting With 3 or More SIRS Criteria[a]

Characteristic	Patients With Sepsis (n = 158)		Patients Without Sepsis (n = 741)
	Poor Course (n = 43)	No Poor Course (n = 115)	
Time until sepsis suspected, h			
≤24	35 (81.4)	112 (97.4)	0
>24	8 (18.6)	3 (2.6)	0
Age, mean (SD), y	16 (2)	16 (2)	16 (2)
Male sex	21 (48.8)	40 (34.8)	270 (36.4)
Race			
White	26 (60.5)	81 (70.4)	531 (71.6)
Black	10 (23.3)	22 (19.1)	134 (18.1)
Other	7 (16.3)	12 (10.4)	74 (10.0)
Positive blood culture results	4 (9.3)	2 (1.7)	0
All 4 SIRS criteria in 24 h	13 (30.2)	30 (26.1)	86 (11.6)
Maximum SOFA points in 24 h			
0	14 (32.6)	70 (60.9)	507 (68.4)
1	4 (9.3)	26 (22.6)	117 (15.8)
≥2	25 (58.1)	19 (16.5)	117 (15.8)
Hospital admission	26 (60.5)	30 (26.1)	180 (24.3)
Poor course			
Admission to intensive care	25 (58.1)	0	30 (4.0)
Transfer to acute care facility or hospital	27 (62.8)	0	83 (11.1)
In-hospital mortality	1 (2.3)	0	0
Serum lactate within 24 h	9 (20.9)	3 (2.6)	0
Serum lactate, median (IQR), mg/dL	16.2 (9.0-24.3)	9.0 (8.1-17.2)	0
Mechanical ventilation[b]	18 (41.9)	0	12 (1.6)
Vasopressor use[c]	4 (9.3)	0	0
Hospital length of stay, median (IQR), d	7 (1-15)	2 (1-3)	2 (1-2)

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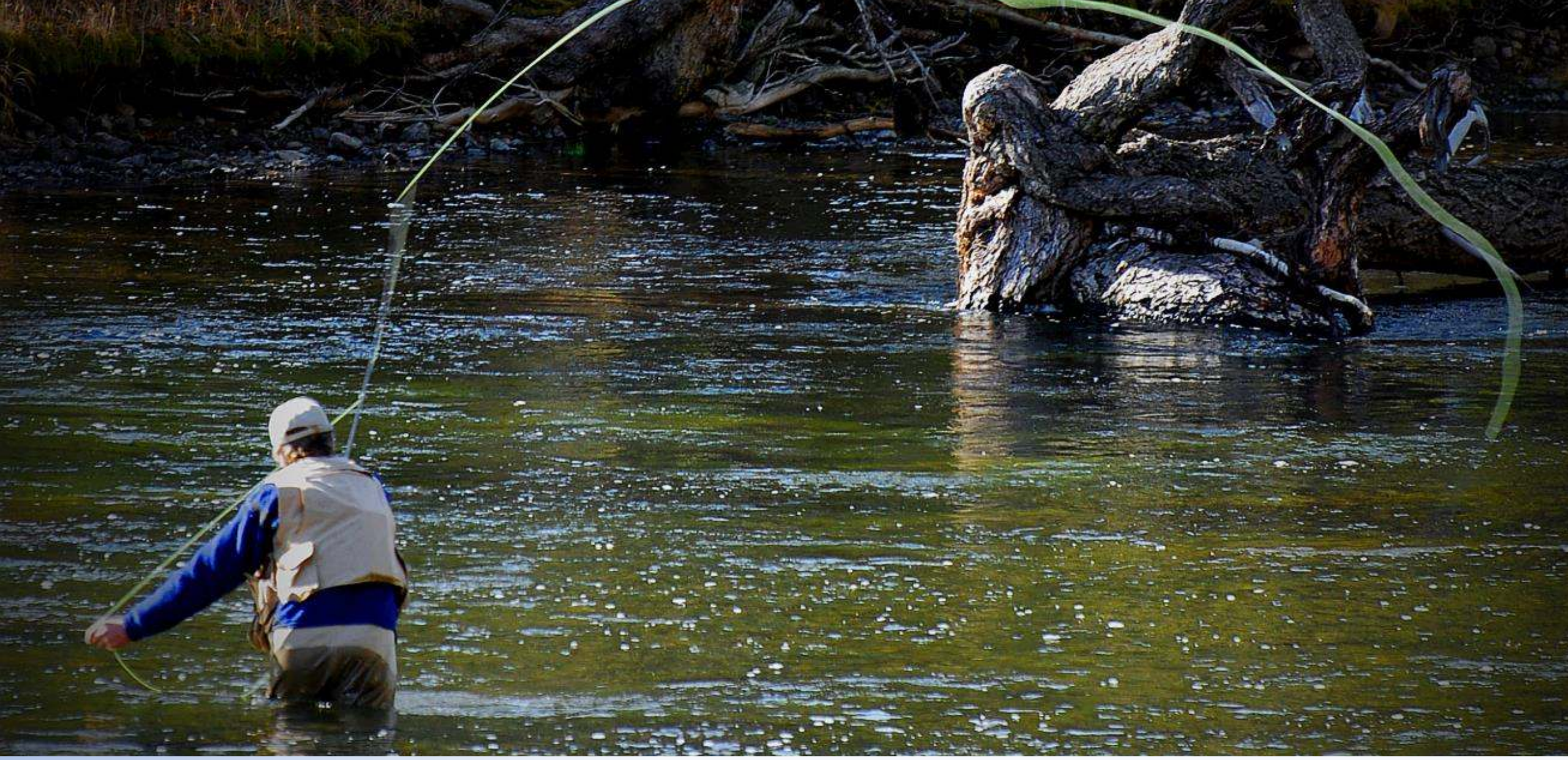

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CRITICAL CARE MEDICINE

Outline

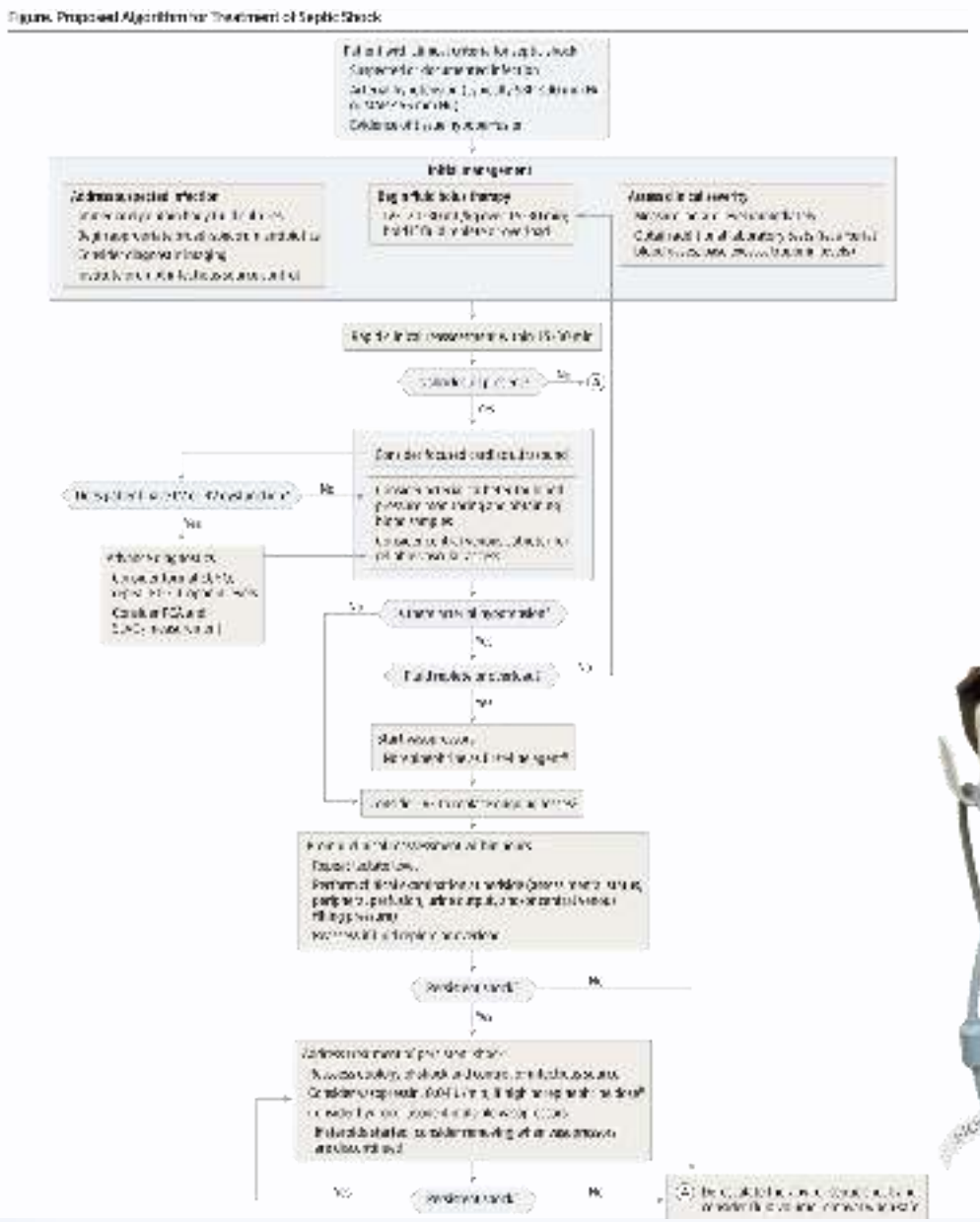
1) Historic perspective: Foundation of resuscitation
2) Recognition: Augmenting clinical evaluation
3) Resuscitation: Guidelines for individualization
4) **Stabilization: Bolstering clinical assessment**
5) **Performance:** Collaboration and tracking

Review

Septic Shock
Advances in Diagnosis and Treatment

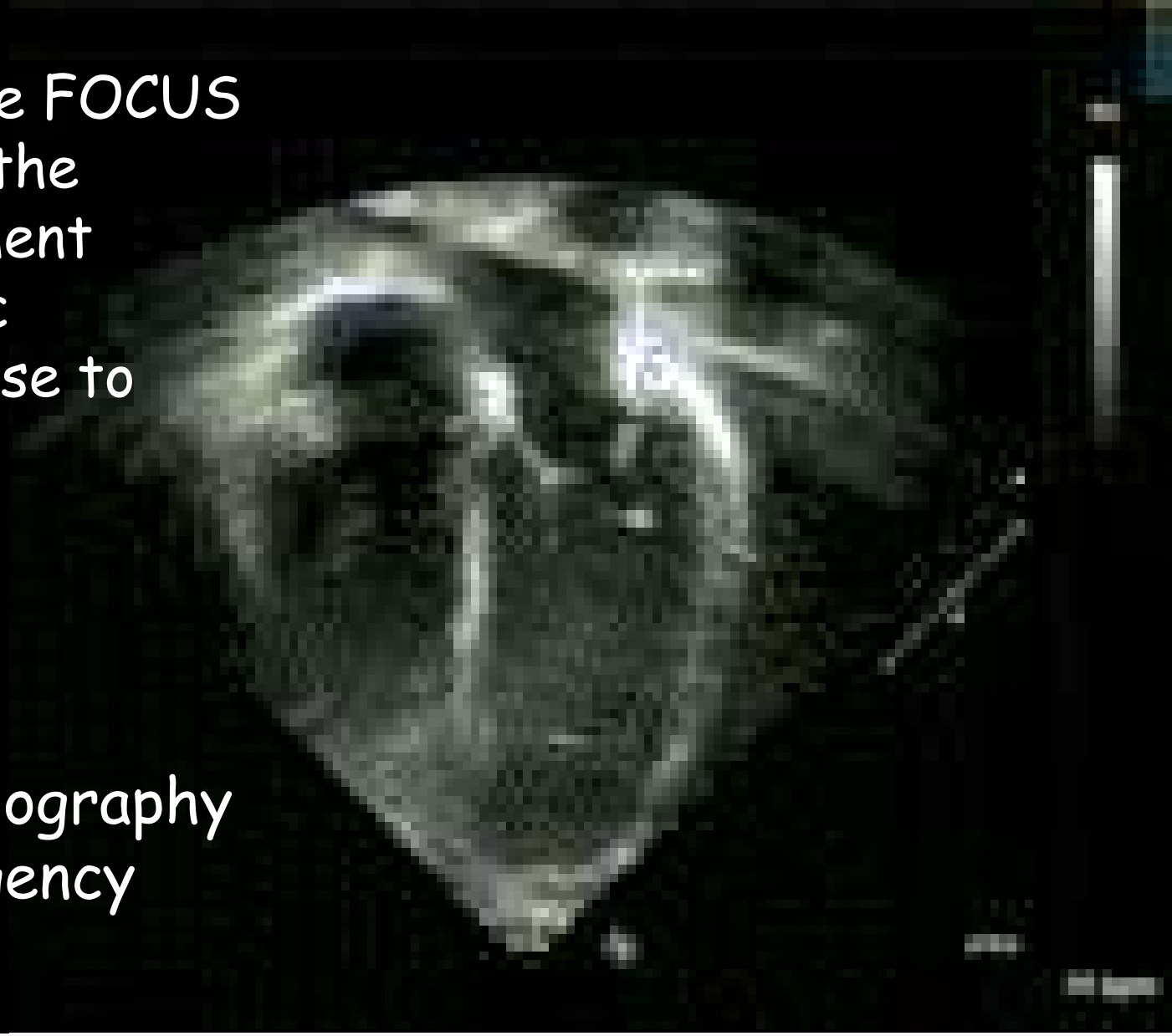
Christopher W. Seymour, MD, MSc; Matthew R. Rosengart, MD, MPH

708 JAMA August 18, 2015 Volume 314, Number 7



"In the right clinical context, [the FOCUS exam] can direct the clinician at the bedside in important next treatment interventions, optimize diagnostic efficiency, and assess the response to performed interventions"

-Labovitz et al. 2010
A Consensus Statement of the American Society of Echocardiography and American College of Emergency Physicians



Adjuvant Approaches for Sepsis Subtypes

- Noninvasive hemodynamic assessment to help guide resuscitation
  - USCOM
  - Cardiotronic ICON
  - Bedside ultrasound
- Biomarkers of organ dysfunction and inflammatory response
  - Serum cortisol measured early
    - Adjuvant hydrocortisone infusion for persistent hypotension despite vasopressors
  - Markers of tissue perfusion and oxygen utilization (Lactate, SvO2)
  - Inflammatory cascade (CRP, Procalcitonin and Ferritin)
  - ADAMTS-13 assay
    - Plasma exchange for thrombocytopenia-associated MODs

Outline

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More Children Die From Sepsis Than Cancer

1 in 100 hospitalized children are diagnosed with severe sepsis/septic shock.

@ 1 in 10 will die

@ 4,500 deaths annually

@ 45% cases are hospital-onset.

Victoria

These are US stats. Global stats are worse.

SEPSIS HEROES

CHILDREN'S HOSPITAL ASSOCIATION

SEPSIS HEROES

CHILDREN'S HOSPITAL ASSOCIATION

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CRITICAL CARE MEDICINE

Mobilize	Implement	Measure	Collaborate
Build Hospital-Wide Partnership	Standardized Bundles	Collect data monthly	Exchange what works
Engage Family Advisors	Across ED, PICU/CICU, General Care, Hem/Onc, BMT	Submit data monthly	Data transparency
Develop Structure	90 day aims and tests of change	Review monthly reports	Virtual meetings
Assess Resources and Readiness			Training events
Map Data Sources			Coaching
Plan Implementation			Workshops
Train Teams			Online discussion

SEPSIS HEROES

CHILDREN'S HOSPITAL ASSOCIATION

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Sepsis and Septic Shock Prevalence and Mortality

	Sepsis or Septic Shock Prevalence (%)	Sepsis or Septic Shock Mortality (%)
Children's Hospital of Pittsburgh EHR definitions—all sepsis	23.3	2.2
Children's Hospital of Pittsburgh EHR definitions—septic shock	2.6	15.7
Watson et al.[1]	—	10.3
Hartman et al.[2]	—	8.9
Ruth et al.[3]—both Angus criteria and ICD codes for sepsis	7.7	14.4
Ruth et al.[3]—Angus criteria	6.2	—
Ruth et al.[3]—ICD sepsis codes	3.1	—
Balamuth et al.[4]—Angus criteria	3.1	8.2
Balamuth et al.[4]—ICD sepsis codes	0.45	21.5
Weiss et al.[5]—SPROUT trial	8.2	25

ICD, International Classification of Diseases.

Cohort Characteristics

	Sepsis and Septic Shock (N = 1,433)	Sepsis (n = 1,274)	Septic Shock (n = 159)
Age (mo), median [IQR]	42 [5–131]	41.7 [3.0–135.4]	64.5 [15.6–170.8]
Female, n (%)	649 (45.3)	577 (45.3)	72 (45.3)
Length of stay (d), median [IQR]	3.9 [2.0–9.1]	3.5 [1.9–7.4]	19.9 [7.2–43.7]
Length of stay (d), mean ± SD	10.6 ± 20.6	8.8 ± 18.6	35.7 ± 43.7
Hospital mortality, n (%)	32 (2.2)	7 (0.5)	25 (15.7)
30-d Mortality, n (%)	23 (1.6)	4 (0.3)	19 (11.9)
Extracorporeal support	11 (0.8)	0 (0)	11 (6.9)

A C
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and
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Laur
Holl
Erin
Josep
Chris

Outcomes | Duration | Volume | GeoAnalytics | Custom Report Generator | How To | Definitions | All Data

Children's Hospital of Pittsburgh of UPMC — BCI

2015 | 2016 | 2017 | 2018 — Q1 Q2 Q3 Q4 — Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec — Information + — Current Selections and Filters +

Current Selections

DIAGNOSIS_NAME: 31 of 8893
IIC.Year: 2017

Search

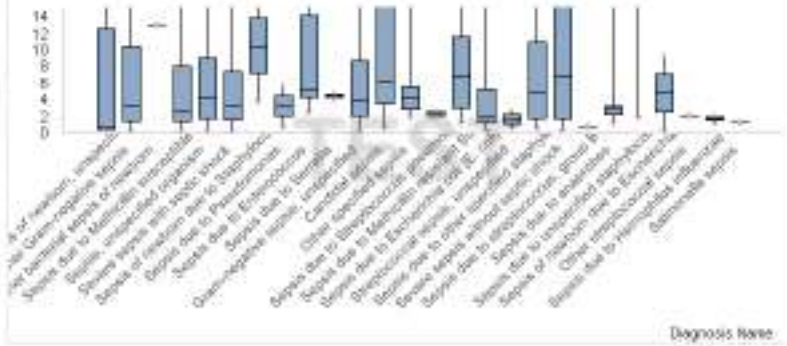
< Clear All >

Month-Year
Date
Encounter ID
Unique Patient ID
Initial Location
Final Location
Currently In House
Diagnosis Type
Diagnosis Code
Diagnosis Description

Number of Distinct Encounters: 323 **Number of Distinct ICU Encounters:487** **Number of Unique Patients:268**

Top 20 Encounters

Selections must be made for this chart to render.



Top 20 Median LOS

Please select at least one diagnosis.

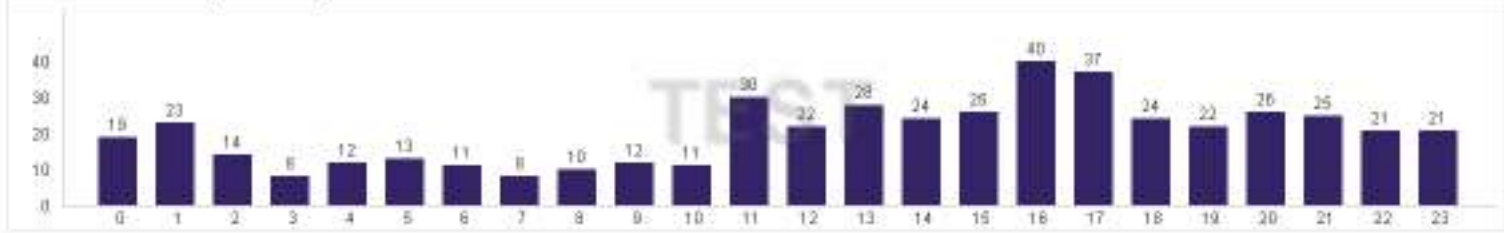
Top 20 Encounters

Final Diagnosis	# Encount...	Min LOS	Max LOS	Median L...
Sepsis, unspecified organism	52	0.40	94.16	6.89
Sepsis due to Methicillin susceptible Staphylococcus aureus	7	0.02	33.98	3.89
Sepsis due to Escherichia coli [E. coli]	5	0.71	7.94	1.57
Sepsis due to Methicillin resistant Staphylococcus aureus	5	2.51	31.82	6.98
Other Gram-negative sepsis	3	3.67	19.97	17.95
Other specified sepsis	3	1.97	4.48	3.63
Gram-negative sepsis, unspecified	2	8.02	12.69	8.81
Sepsis due to other specified staphylococcus	2	1.71	21.14	11.43
Sepsis due to Streptococcus pneumoniae	2	1.80	2.64	2.22
Sepsis of newborn due to Escherichia coli	2	8.10	9.23	8.66
Bacterial sepsis of newborn, unspecified	1	1.45	1.45	1.45
Other streptococcal sepsis	1	1.95	1.95	1.95
Salmonella sepsis	1	1.20	1.20	1.20
Sepsis due to anaerobes	1	15.74	15.74	15.74
Sepsis due to Hemophilus influenzae	1	2.01	2.01	2.01
Sepsis due to Pseudomonas	1	0.68	0.68	0.68
Severe sepsis with septic shock	1	0.46	0.46	0.46
Streptococcal sepsis, unspecified	1	0.41	0.41	0.41

Top 20 Median LOS

Final Diagnosis	Median L...	Min LOS	Max LOS
Perinatal intestinal perforation	128.73	128.73	128.73
Web of larynx	98.01	98.01	98.01
Exomphalos	78.16	78.16	78.16
RESPIRATORY DISTRESS SYNDROME IN NEWBORN	72.29	72.29	72.29
Other pneumothorax	61.16	61.16	61.16
ASPHYXIATION AND STRANGULATION	54.95	54.95	54.95
Respiratory distress syndrome of newborn	52.61	0.15	89.93
Traumatic subdural hemorrhage with loss of consciousness greater...	40.92	40.92	40.92
Malignant neoplasm of lower third of esophagus	40.34	40.34	40.34
DIAPHRAGMATIC HERNIA WITH OBSTRUCTION	39.86	39.86	39.86
Hepatorenal syndrome	33.00	33.00	33.00
Single liveborn infant, delivered by cesarean	32.25	32.25	32.25
Spastic diplegic cerebral palsy	31.99	31.99	31.99
Other transitory metabolic disturbances of newborn	31.46	31.46	31.46
OPEN FRACTURE OF VAULT OF SKULL WITH INTRACRANIAL INJUR...	29.76	29.76	29.76
Chronic hepatic failure without coma	29.06	2.29	57.13
POSTINFLAMMATORY PULMONARY FIBROSIS	28.67	28.67	28.67
Extreme immaturity of newborn, gestational age 26 completed weeks	27.83	27.83	27.83

ICU Encounter Arrival by Hour of Day



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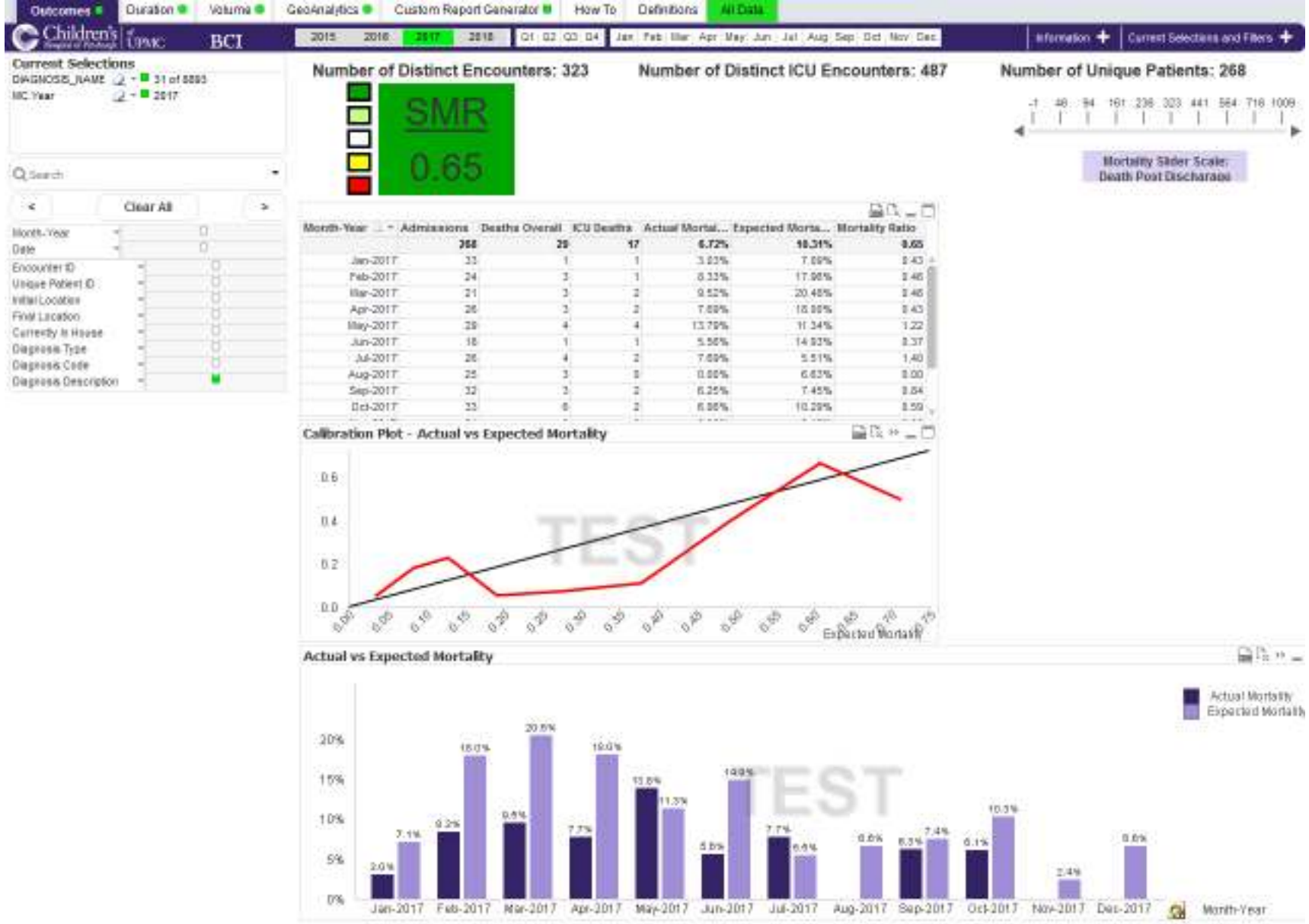
CRITICAL CARE MEDICINE



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CRITICAL CARE MEDICINE

Summary

1) **Historic perspective**: Foundation of resuscitation
2) **Recognition:** Augmenting clinical evaluation
3) **Resuscitation:** Guidelines for individualization
4) **Stabilization:** Bolstering clinical assessment
5) **Performance:** Collaboration and tracking

Image Credit: University of North Carolina at Chapel Hill School of Medicine

Thank You!

Sajel Kantawala

Gabriella Butler

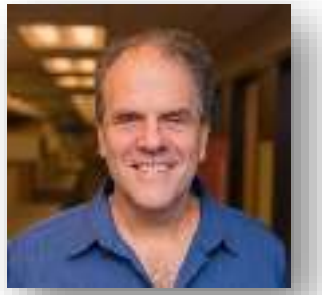
Chris Myers

Daniel Rohm

Bob Clark

Pat Kochanek

Suresh Srinivasan



Joe Carcillo

<u>Not Pictured:</u>

Thomas Brown
Kelly Bricker
Janice Daugherty
Sue Park
Denee Marasco
Kristi Russo

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CRITICAL CARE MEDICINE

Thank You

Questions?

EUROPEAN UNION

European Social Fund

INVESTING IN YOUR FUTURE

Christopher.Horvat@chp.edu

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