

# Sepsis



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Accounting for more than \$20 billion  
(5.2%) of total US hospital costs in 2011



The reported incidence of sepsis is increasing, likely reflecting aging populations with more comorbidities, greater recognition,



Sepsis is a leading cause of mortality and critical illness worldwide.

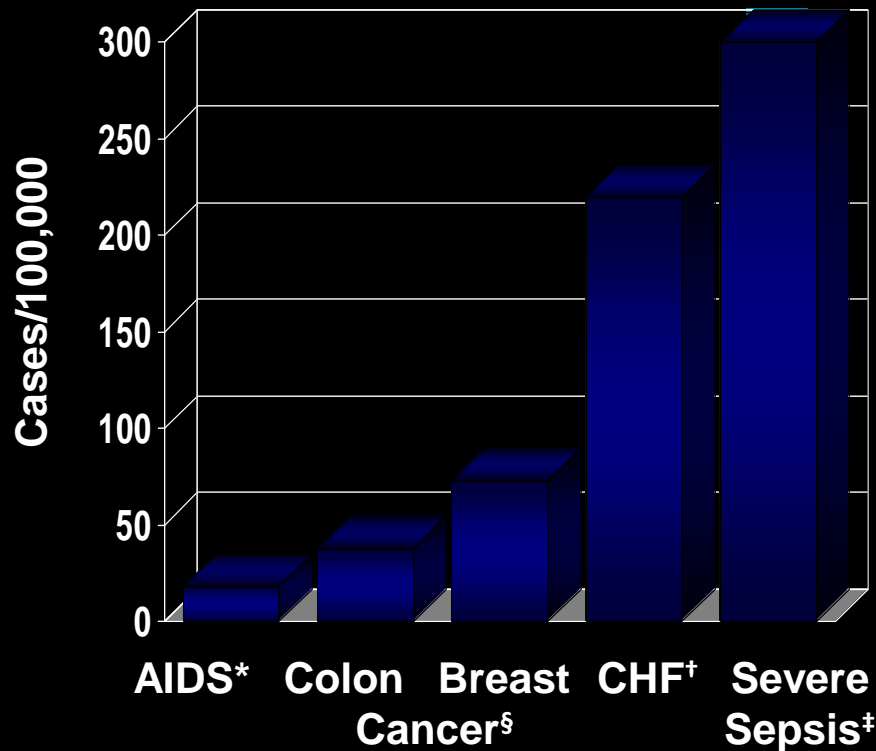


long-term physical, psychological, and cognitive  
disabilities with significant health care and  
social implications

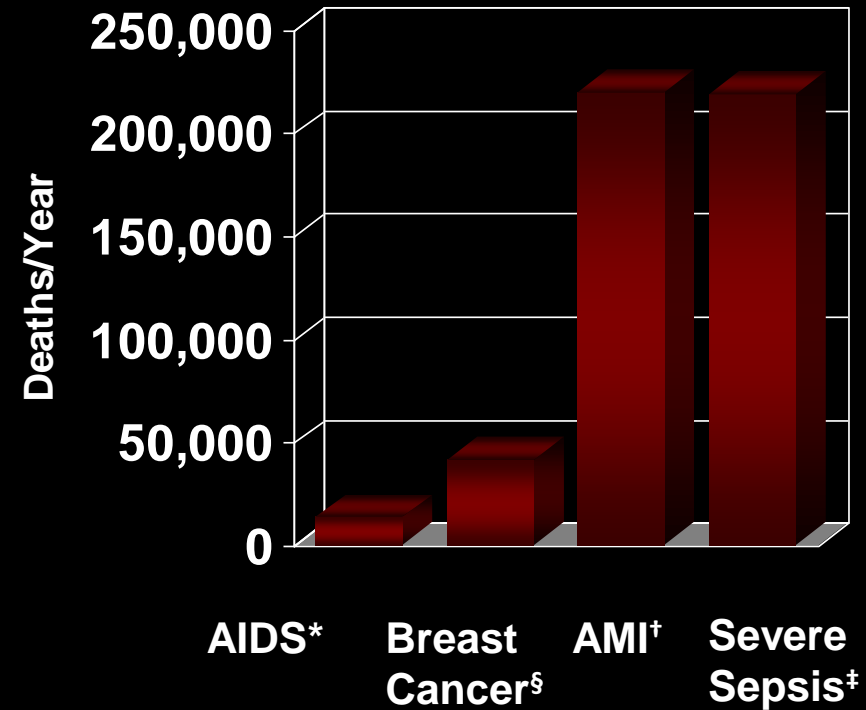


# Comparison With Other Major Diseases

## Incidence of Severe Sepsis



## Mortality of Severe Sepsis



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

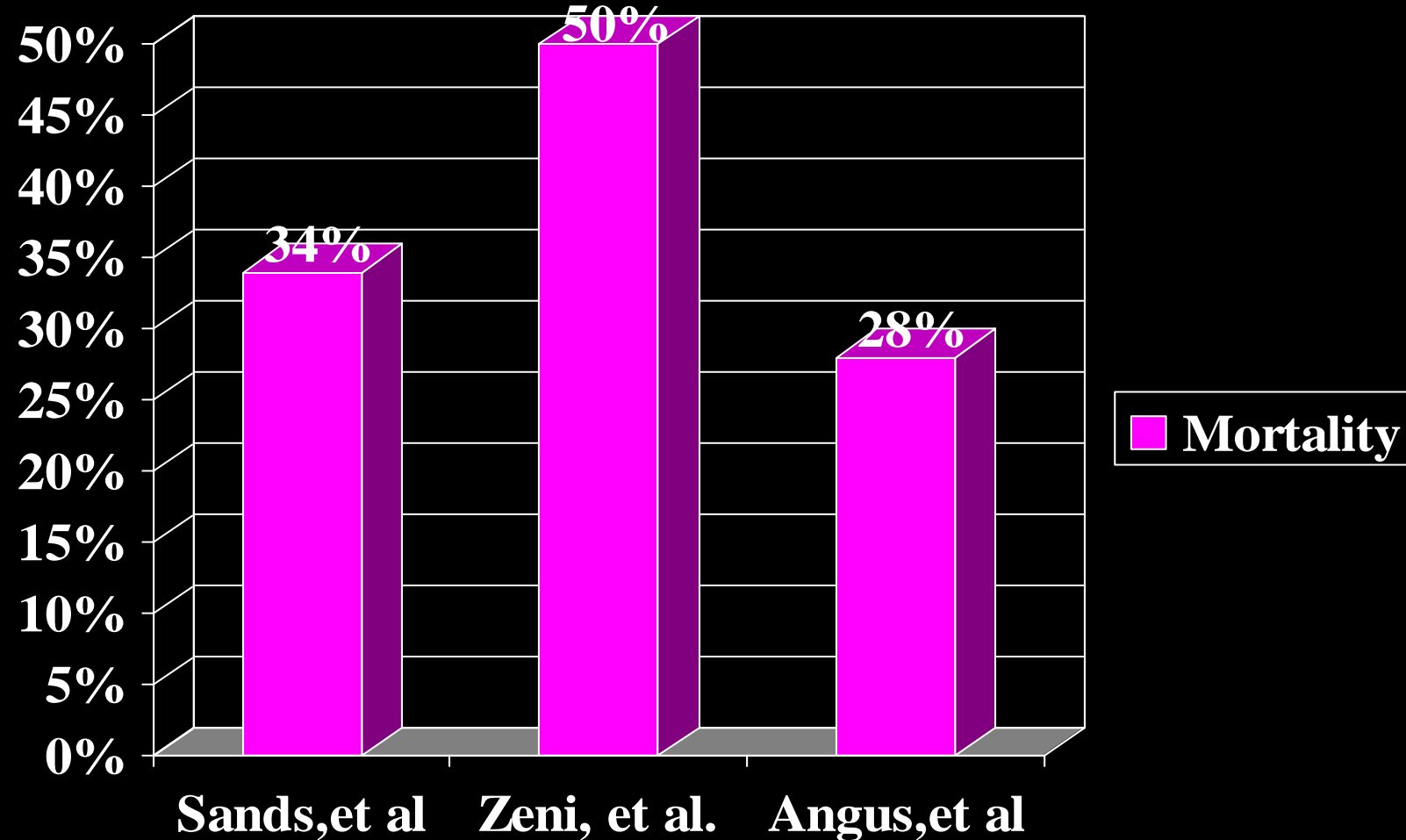


# Sepsis, Mortality Rates

- Overall = 30% - 50%
- By syndrome definition:
  - Sepsis = 16%
  - Septic shock = 46%

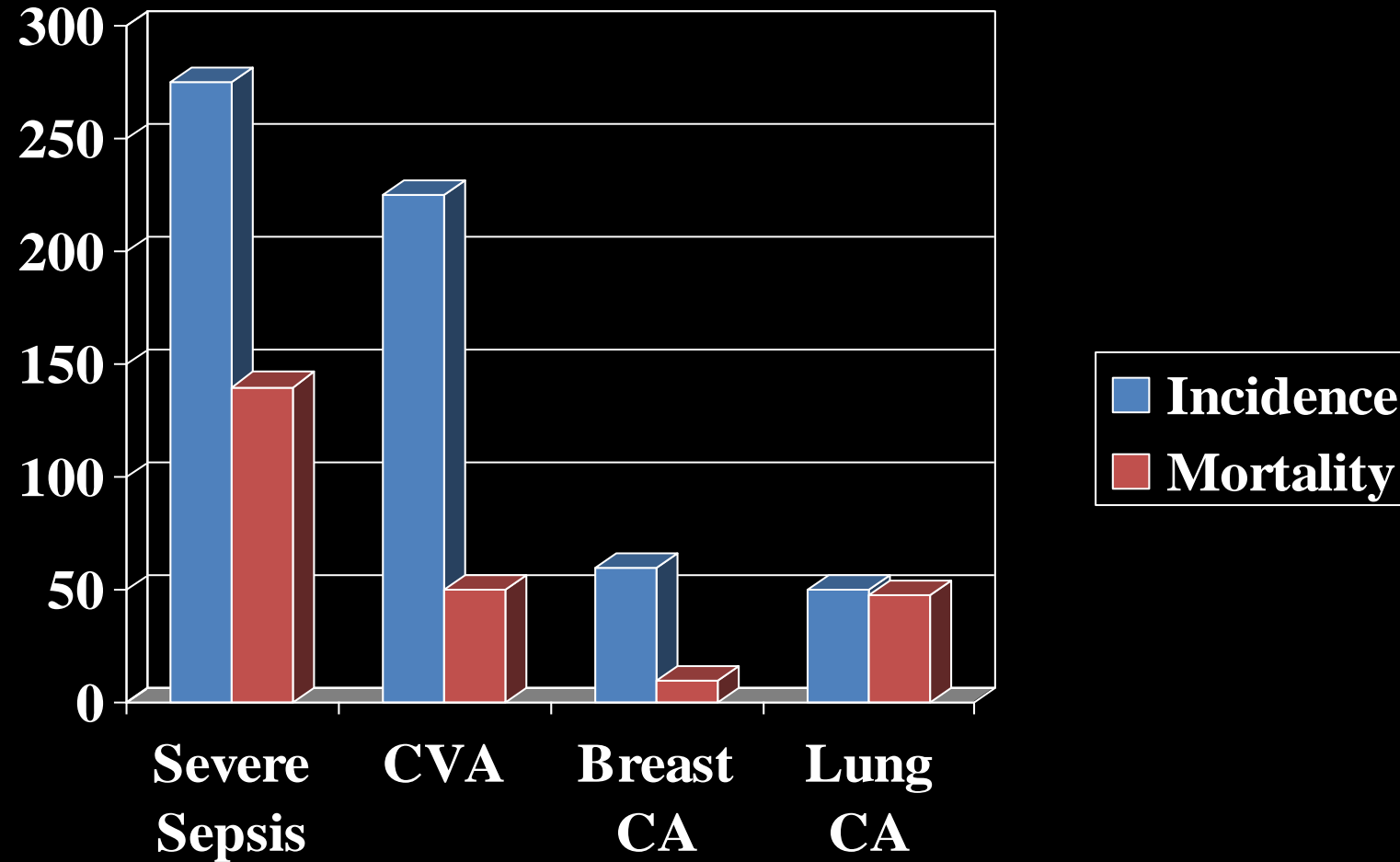


# Severe Sepsis is deadly

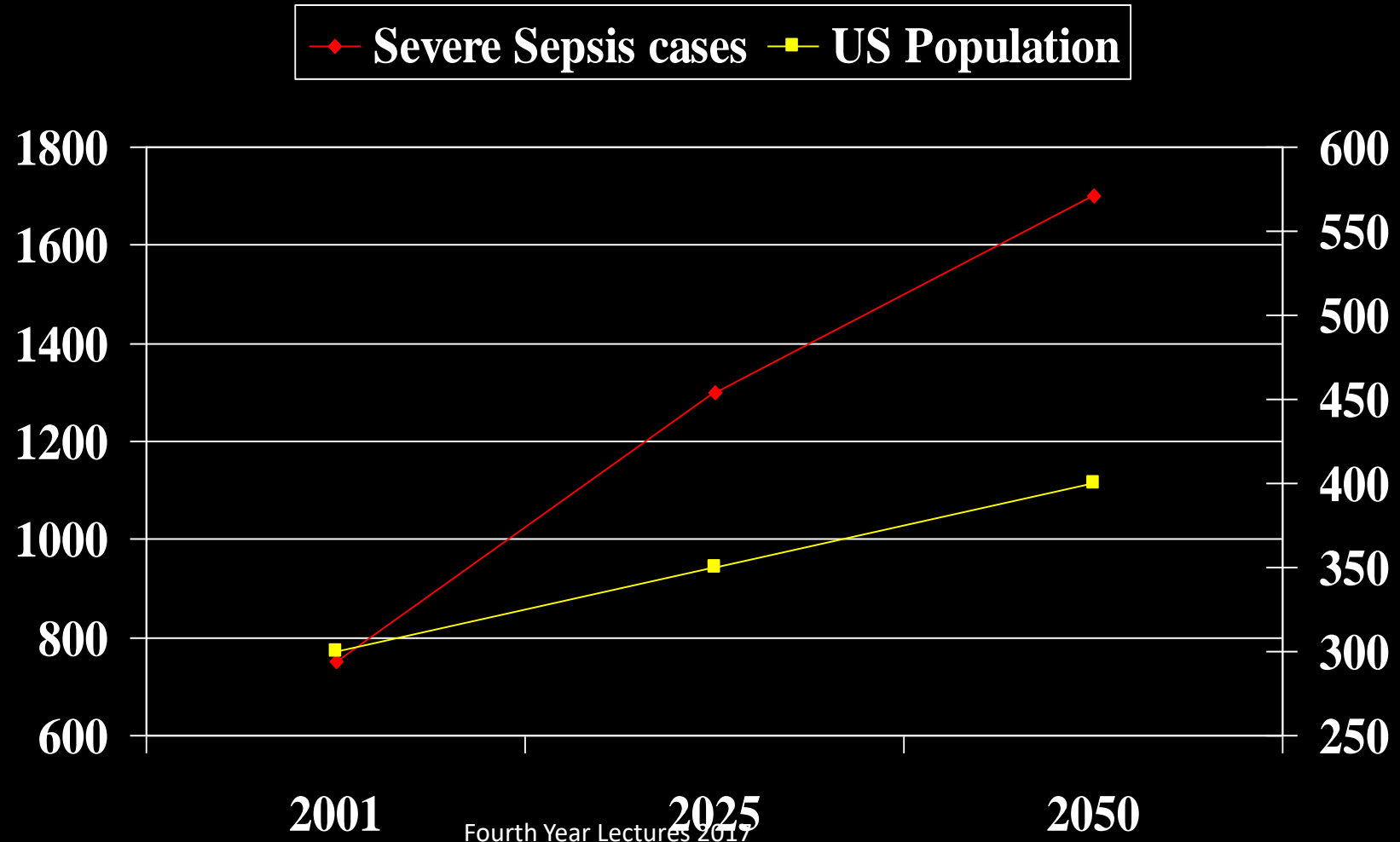


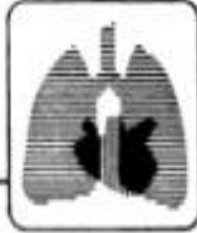


# Severe Sepsis is Common



# Severe Sepsis is increasing in incidence





## accp/sccm consensus conference

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### Definitions for Sepsis and Organ Failure and Guidelines for the Use of Innovative Therapies in Sepsis

#### THE ACCP/SCCM CONSENSUS CONFERENCE COMMITTEE:

*Roger C. Bone, M.D., F.C.C.P., Chairman*

*Robert A. Balk, M.D., F.C.C.P.*

*Frank B. Cerra, M.D.*

*R. Phillip Dellinger, M.D., F.C.C.P.*

*Alan M. Fein, M.D., F.C.C.P.*

*William A. Knaus, M.D.*

*Roland M. H. Schein, M.D.*

*William J. Sibbald, M.D., F.C.C.P.*

### 2001 SCCM/ESICM/ACCP/ATS/SIS International Sepsis Definitions Conference

*Mitchell M. Levy, MD, FCCP; Mitchell P. Fink, MD, FCCP; John C. Marshall, MD; Edward Abraham, MD; Derek Angus, MD, MPH, FCCP; Deborah Cook, MD, FCCP; Jonathan Cohen, MD; Steven M. Opal, MD; Jean-Louis Vincent, MD, FCCP, PhD; Graham Hamsay, MD; For the International Sepsis Definitions Conference*



# Terminology

## ■ Systemic Inflammatory Response Syndrome (SIRS)

- Temp > 38 or < 36
- HR > 90
- RR > 20 or PaCO<sub>2</sub> < 32
- WBC > 12 or < 4 or Bands > 10%

TWO out of four criteria  
acute change from baseline

## ■ Sepsis

- The systemic inflammatory response to infection.

## ■ Severe Sepsis

- Organ dysfunction secondary to Sepsis.
- e.g. hypoperfusion, hypotension, acute lung injury, encephalopathy, acute kidney injury, coagulopathy.

## ■ Septic Shock

- Hypotension secondary to Sepsis that is resistant to adequate fluid administration and associated with hypoperfusion.



# **The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)**

**The Sepsis Definitions Task Force**



## The Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)

Mervyn Singer, MD, FRCP, Clifford S. Deutschman, MD, MS, Christopher Warren Seymour, MD, MSc, Manu Shankar-Hari, MSc, MD, FFICM, Djillali Annane, MD, PhD, Michael Bauer, MD, Ronaldo Bellomo, MD, Gordon R. Bernard, MD, Jean-Daniel Chiche, MD, PhD, Craig M. Coopersmith, MD, Richard S. Hotchkiss, MD, Mitchell M. Levy, MD, John C. Marshall, MD, Greg S. Martin, MD, MSc, Steven M. Opal, MD, Gordon D. Rubenfeld, MD, MS, Tom van der Poll, MD, PhD, Juan-Louis Vincent, MD, PhD, Derek C. Angus, MD, MPH

**IMPORTANCE:** Definitions of sepsis and septic shock were last revised in 2001. Considerable advances have since been made into the pathobiology (changes in organ function, morphology, cell biology, biochemistry, immunology, and circulation), management, and epidemiology of sepsis, suggesting the need for reexamination.

**OBJECTIVE:** To evaluate and, as needed, update definitions for sepsis and septic shock.

**PROCESS:** A task force (n = 19) with expertise in sepsis pathobiology, clinical trials, and epidemiology was convened by the Society of Critical Care Medicine and the European Society of Intensive Care Medicine. Definitions and clinical criteria were generated through meetings, Delphi processes, analysis of electronic health record databases, and voting, followed by circulation to international professional societies, requesting peer review and endorsement (by 31 societies listed in the Acknowledgment).

**KEY FINDINGS FROM EVIDENCE SYNTHESIS:** Limitations of previous definitions included an excessive focus on inflammation, the misleading model that sepsis follows a continuum through severe sepsis to shock, and inadequate specificity and sensitivity of the systemic inflammatory response syndrome (SIRS) criteria. Multiple definitions and terminologies are currently in use for sepsis, septic shock, and organ dysfunction, leading to discrepancies in reported incidence and observed mortality. The task force concluded the term severe sepsis was redundant.

**RECOMMENDATIONS:** Sepsis should be defined as life-threatening organ dysfunction caused by a dysregulated host response to infection. For clinical operationalization, organ dysfunction can be represented by an increase in the Sequential [Sepsis-related] Organ Failure Assessment (SOFA) score of 2 points or more, which is associated with an in-hospital mortality greater than 10%. Septic shock should be defined as a subset of sepsis in which particularly profound circulatory, cellular, and metabolic abnormalities are associated with a greater risk of mortality than with sepsis alone. Patients with septic shock can be clinically identified by a vasopressor requirement to maintain a mean arterial pressure of 65 mm Hg or greater and serum lactate level greater than 2 mmol/L (≥18 mg/dL) in the absence of hypovolemia. This combination is associated with hospital mortality rates greater than 40%. In out-of-hospital, emergency department, or general hospital ward settings, adult patients with suspected infection can be rapidly identified as being more likely to have poor outcomes typical of sepsis if they have at least 2 of the following clinical criteria that together constitute a new bedside clinical score termed quickSOFA (qSOFA): respiratory rate of 22/min or greater, altered mentation, or systolic blood pressure of 100 mm Hg or less.

**CONCLUSIONS AND RELEVANCE:** These updated definitions and clinical criteria should replace previous definitions, offer greater consistency for epidemiologic studies and clinical trials, and facilitate earlier recognition and more timely management of patients with sepsis or at risk of developing sepsis.

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

Editorial page 757

Author Video Interview, Author Audio Interview, and JAMA Report Video at [jama.com](http://jama.com)

Related articles pages 762 and 775

CME Quiz at [jamanetwork.com](http://jamanetwork.com) and CME Questions page 816

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**Group Information:** The Sepsis Definitions Task Force members are the authors listed above.

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# The Document

Singer M, Deutschman CS, Seymour CW, Shankar-Hari M et al.

## Third International Consensus Definitions for Sepsis and Septic Shock (Sepsis-3)

JAMA 2016; 315: 801-10

# The Definition of Sepsis

**Sepsis is life-threatening organ dysfunction caused by a dysregulated host response to infection**



# The Definition of Septic Shock

□ What tangibly differentiates septic shock from sepsis ?

□ MORTALITY

Septic shock is “really bad” sepsis

**Septic shock is a subset of sepsis in which profound circulatory, cellular and metabolic abnormalities are associated with a greater risk of mortality than with sepsis alone**





# Clinical criteria for sepsis



# SOFA Score

Variables/Points	1	2	3	4
Neurological Coma Score: Glasgow	13-14	10-12	6-9	< 6
Pulmonary PaO <sub>2</sub> (mmHg) / FiO <sub>2</sub>	< 400	< 300	< 200 with respiratory support	< 100 with respiratory support
Cardiological Mean Systolic Arterial Pressure (mmHg)	< 70	Dopamine $\leq$ 5 or Dobutamine (whatever dose)	Dopamine > 5 or Adrenaline $\leq$ 0.1 or Noradrenaline $\leq$ 0.1	Dopamine > 15 or Adrenaline > 0.1 or Noradrenaline > 0.1
Renal Blood creatinine $\mu$ mol/L (mg/L) or Diuresis mL/day	110-170 (1.2-1.9)	171-299 (2.0-3.4)	300-440 (3.5-4.9) or < 500	> 440 (> 5.0) or < 200
Haematological Platelets 10 <sup>9</sup> /L	< 150	< 100	< 50	< 20
Hepatic Blood bilirubin $\mu$ mol/L (mg/dL)	20-32 (1.2-1.9)	33-101 (2.0-5.9)	102-204 (6.0-11.9)	> 204 (> 12.0)

Crit Care Med 1998;26:1793-1800

fjpl.com



# SOFA Score

The European Society of Intensive Care Medicine

SOFA score	0	1	2	3	4
			<300 142-220	<200 67-141	<100 <67
<b>Mortality</b>	<b>SOFA score</b>		<b>Mortality</b>	<b>Score trend (First 48 hrs)</b>	
<10%	0-6		>50%	Increasing	
15-20%	7-9		27-35%	Unchanged	
40-50%	10-12		<27%	Decreasing	
50-60%	13-14				
>80%	15		2.0-3.4	3.5-4.9 or <5.00	>5.0 or <200
>90%	15-24				



## Clinical criteria for sepsis

- Infection plus 2 or more SOFA points (above baseline)

## Prompt outside the ICU to consider sepsis

- Infection plus 2 or more qSOFA points

Please visit [www.qsofa.org](http://www.qsofa.org)



- ❖ Outside the ICU, patients with suspected or presumed infection who are highly likely to have poor outcomes can be clinically identified using qSOFA
  - SBP < 100mm Hg
  - RR > 22 breath/min
  - Altered mental status
  
- ❖ In the ICU, patients with suspected or presumed infection who are highly likely to have poor outcomes can be clinically identified by the presence of **2 or more SOFA points**



Patients with a SOFA score of 2 or more had an overall mortality risk of approximately 10% in a general hospital population with presumed infection.

## 2016 Septic Shock Criteria

Despite adequate fluid resuscitation

- vasopressors needed to maintain MAP  $\geq 65$  mmHg

AND

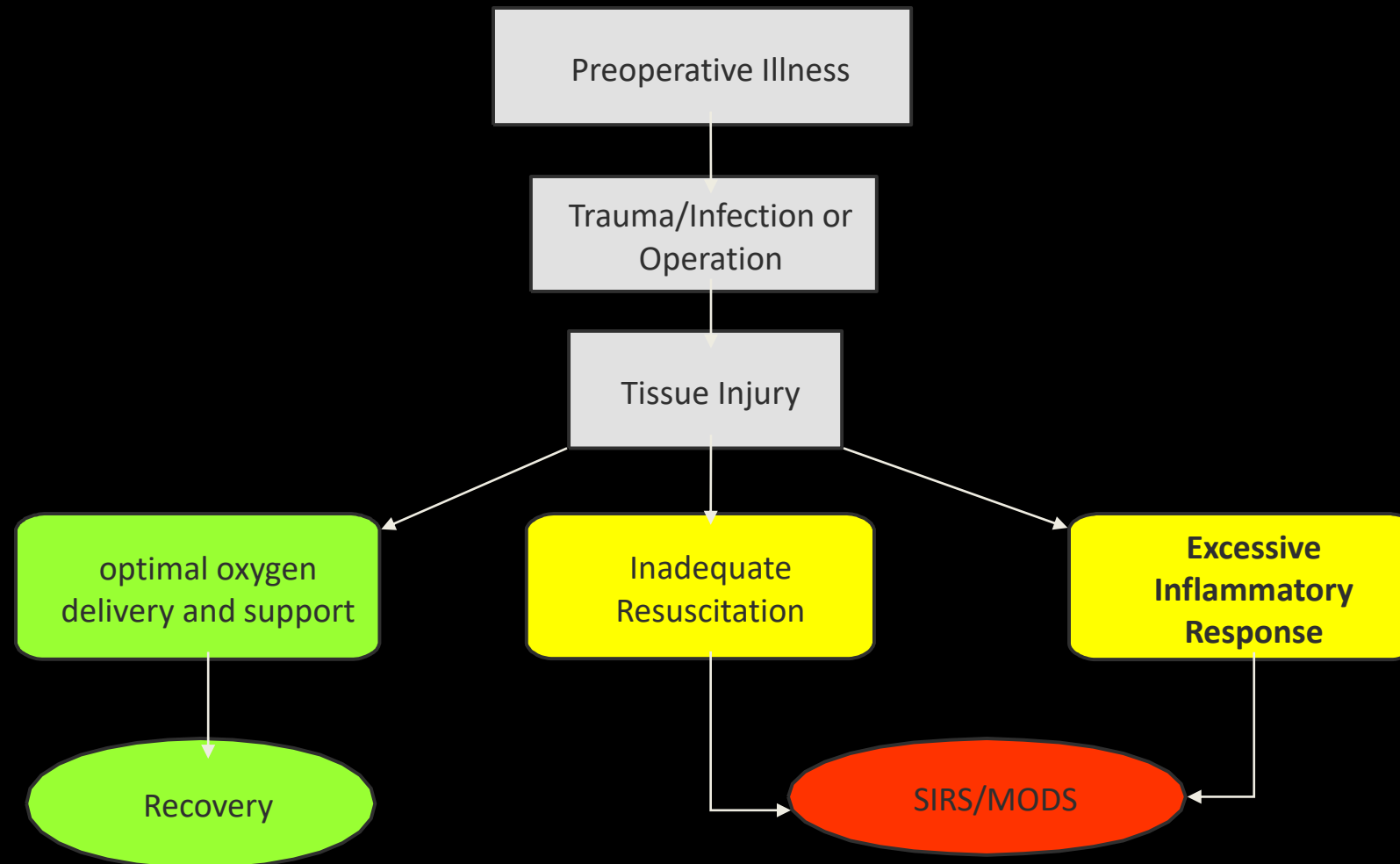
- lactate  $> 2$  mmol/l



Mortality of Septic shock exceeds 40 %

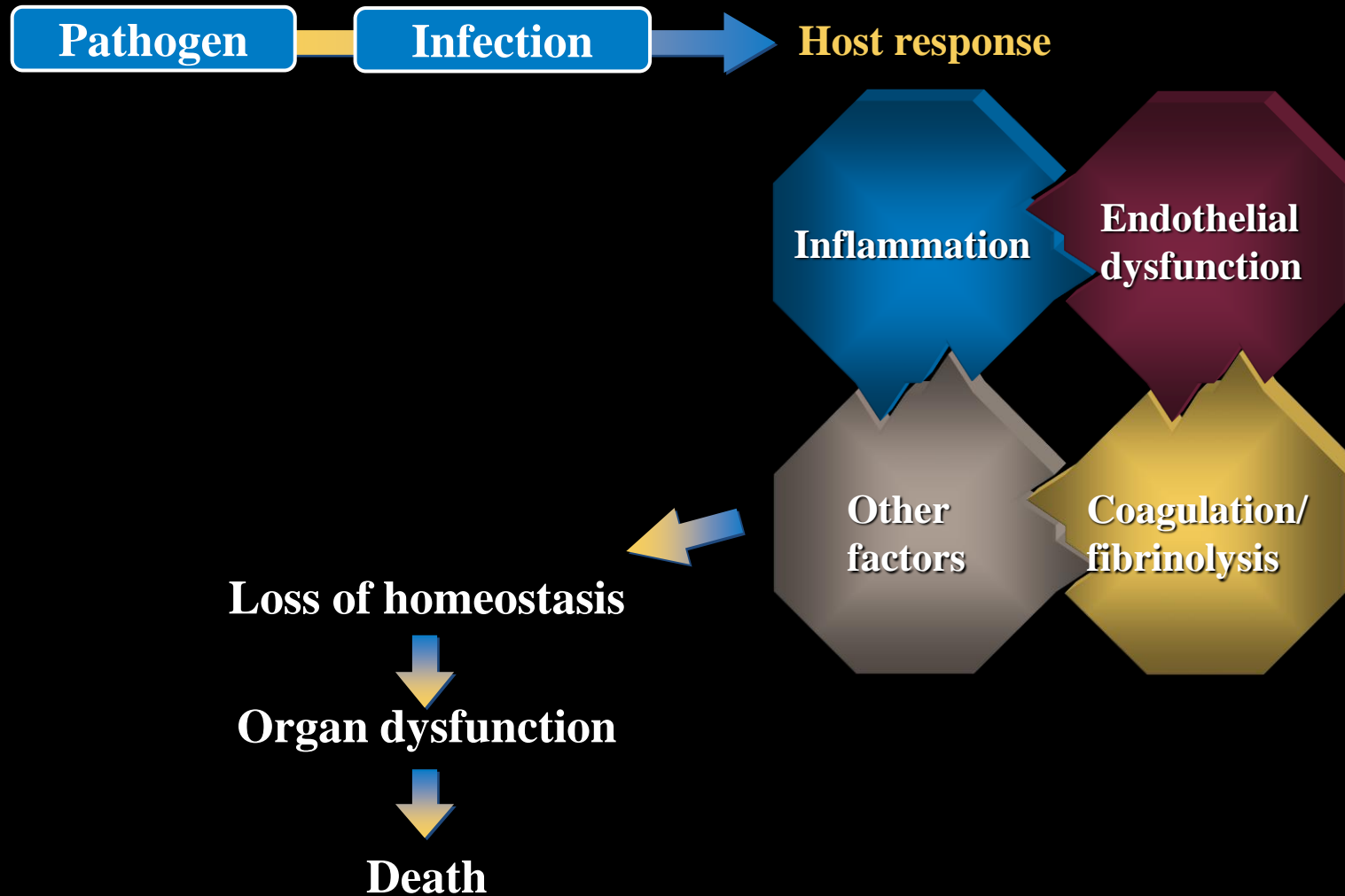


# Pathogenesis of SIRS/MODS



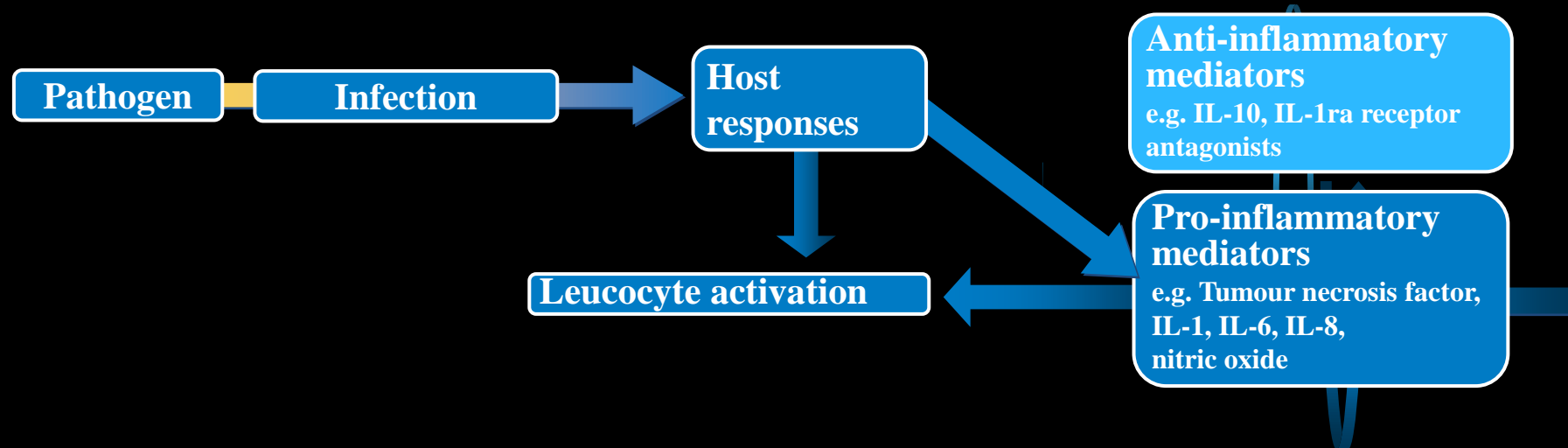
# Pathogenesis of sepsis

*An overview*



# Pathogenesis of sepsis

## *An overview*



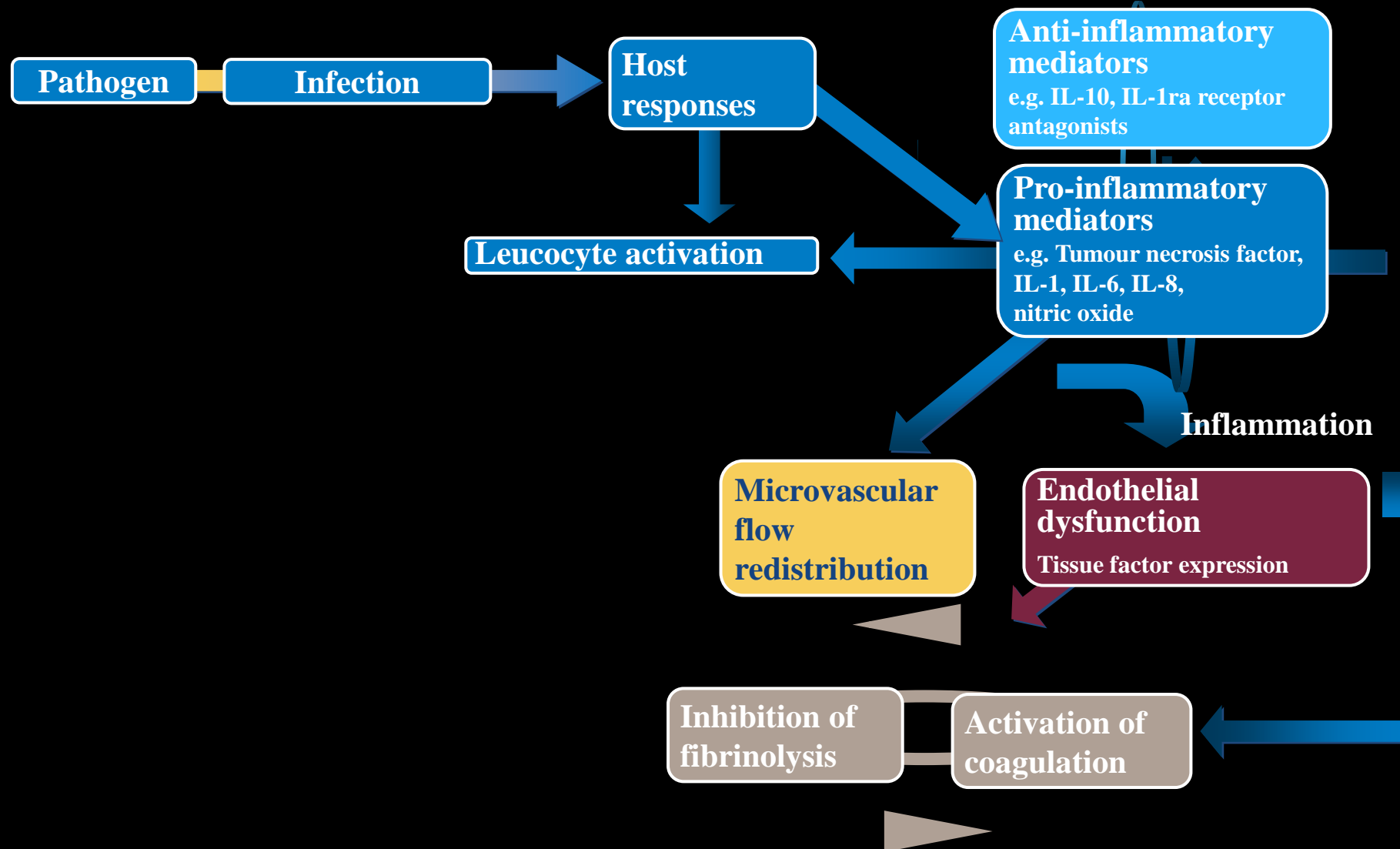
# Inflammation

- Initial response to any pathogens is the release of pro-inflammatory mediators
  - *to allow WBC to reach the infected area.*
- Subsequently, an anti-inflammatory response
  - *attempt to regain homeostasis and prevent “leaking capillary syndrome”.*
- The ability to activate and then eventually downregulate the inflammatory response to infection is a vital immune process and it is this ability that is lost in sepsis and severe sepsis.



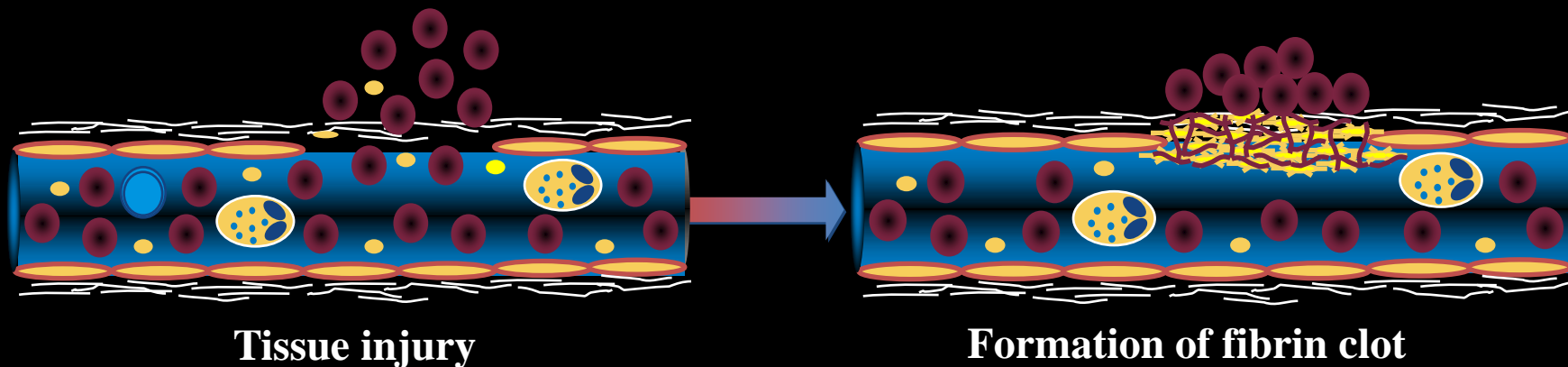
# Pathogenesis of sepsis

## *An overview*



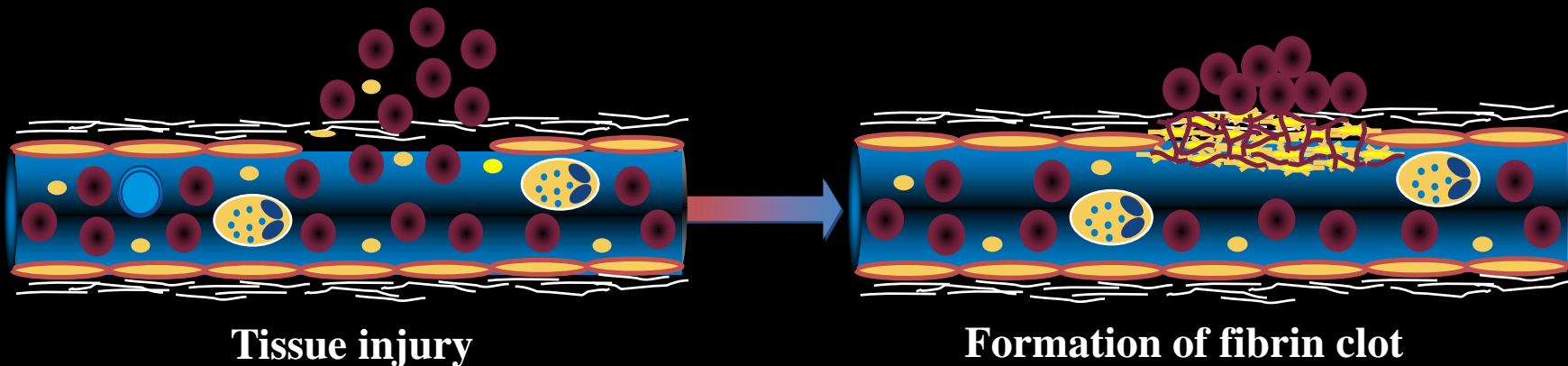
# The role of the endothelium

- Release of mediators of vasodilatation and/or vasoconstriction
- Release of cytokines and inflammatory mediators
- Allows leucocytes to access infection sites
- Plays an important role in the coagulation cascade, maintaining the physiological equilibrium between coagulation and fibrinolysis

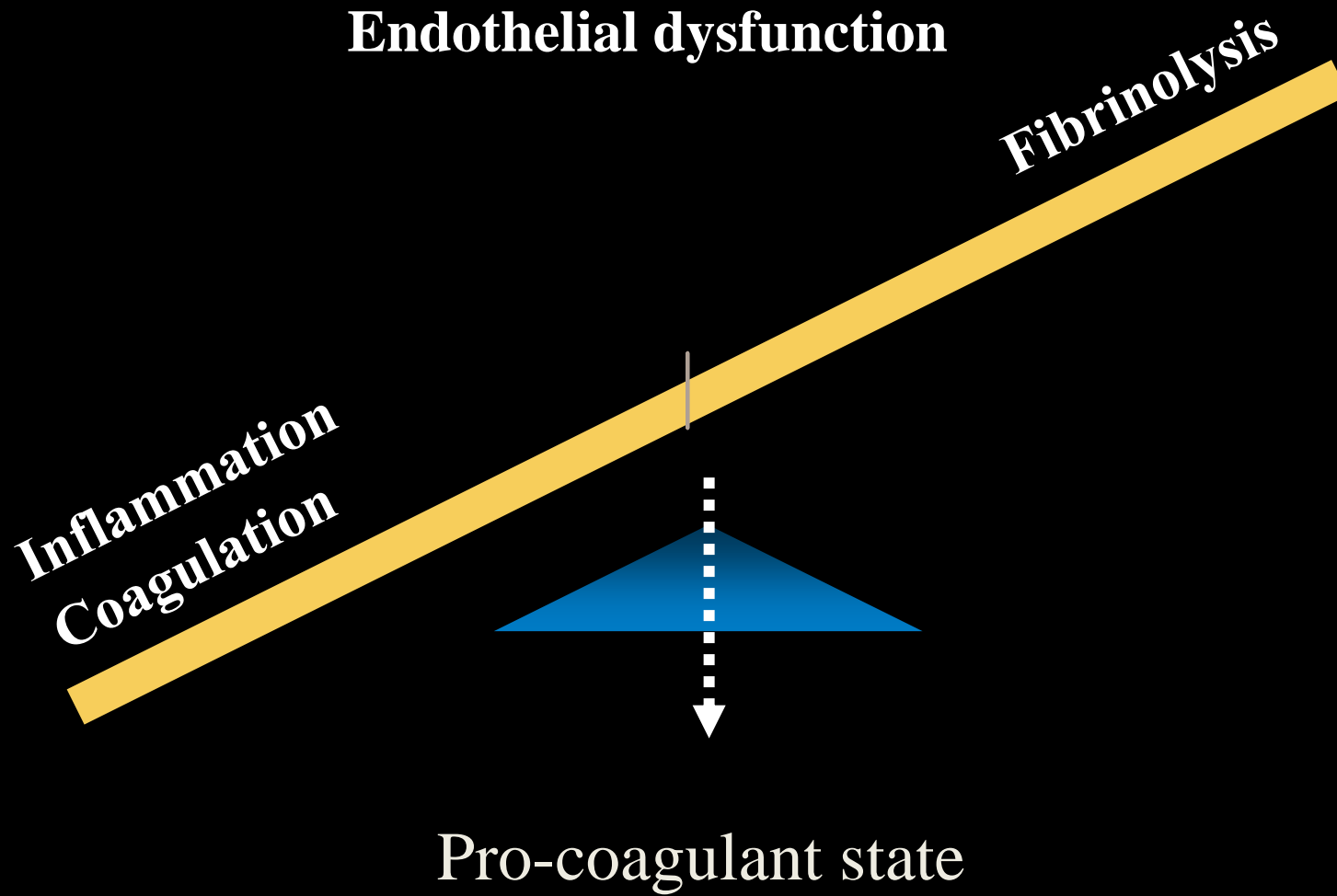


# The role of the endothelium

- In sepsis, the regulatory function of the endothelium fails, leading to:
  - Excessive vasodilation and relative hypovolaemia
  - Leaking capillaries and generalised tissue damage
  - Tissue factor (TF) release initiates **procoagulant state**
  - Micro-thrombus formation compromising blood supply and leading to tissue necrosis
  - Inactivation of Protein C and suppression of fibrinolysis



# Loss of homeostasis in sepsis





# Disseminated Intravascular Coagulation (DIC)

DIC can cause:

- bleeding
- large vessel thrombosis
- haemorrhagic tissue necrosis
- microthrombi leading to organ failure

Widespread clotting causes consumption of:

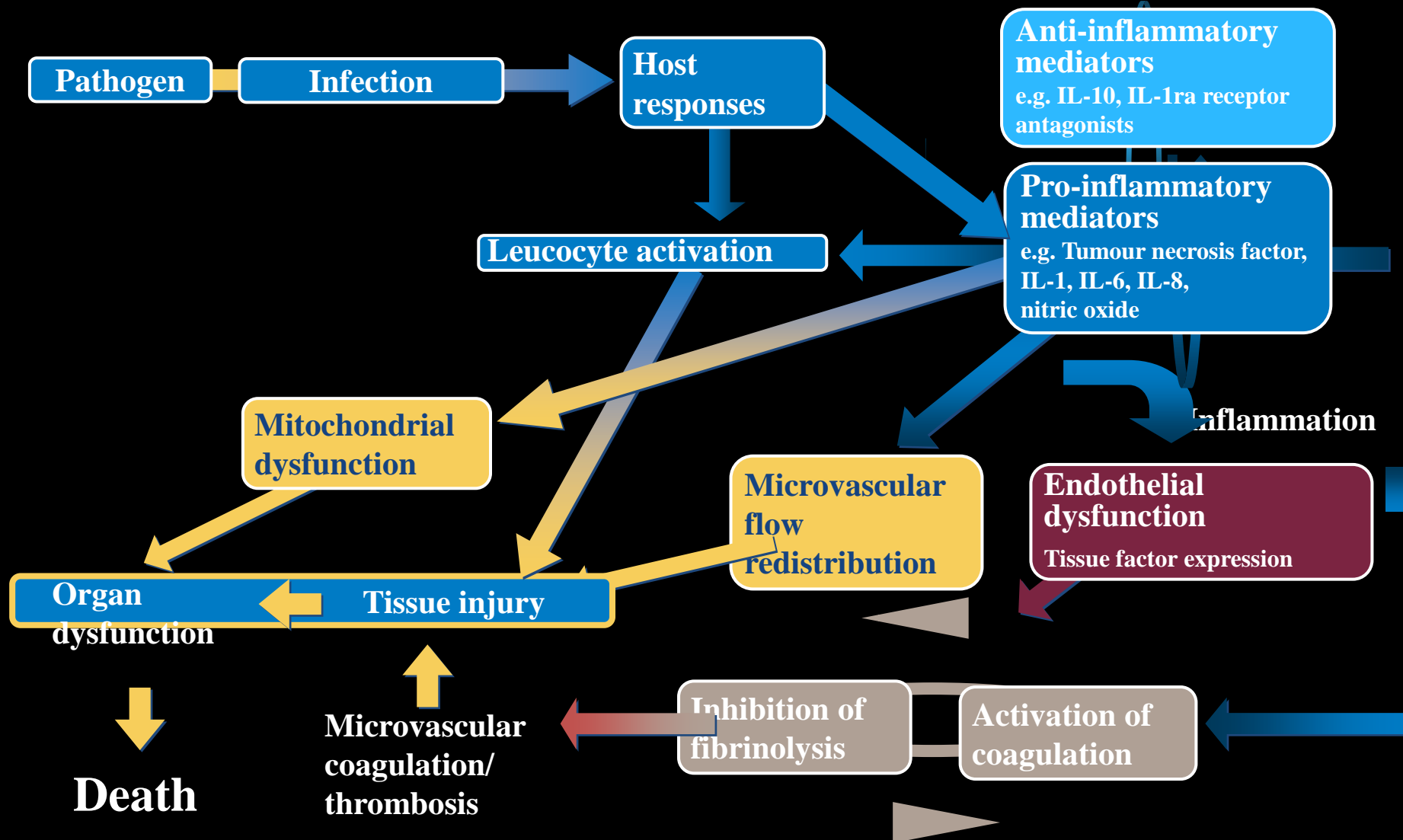
- Low platelets
- clotting factors long clotting time
- fibrinogen

*As a result, bleeding risk increases*



# Pathogenesis of sepsis

## *An overview*



# Mediators of Septic Response



# Pro-inflammatory Mediators

- Bacterial Endotoxin
- TNF- $\alpha$
- Interleukin-1
- Interleukin-6
- Interleukin-8
- Platelet Activating Factor (PAF)
- Interferon-Gamma
- Prostaglandins
- Leukotrienes
- Nitric Oxide



# Anti-inflammatory Mediators

- Interleukin-10
- PGE2
- Protein C
- Interleukin-4
- Interleukin-12
- Lipoxins
- GM-CSF
- TGF
- IL-1RA



Published in final edited form as:

*Clin Chest Med.* 2008 December ; 29(4): 617–viii. doi:10.1016/j.ccm.2008.06.010.

## **The Compensatory Anti-inflammatory Response syndrome (CARS) in Critically ill patients**

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<sup>b</sup>Division of Surgical Research, Department of Surgery, The Warren Alpert Medical School of Brown University, Providence, RI 02912, USA

# Molecular Mediators in Pathophys

- Parallel to SIRS is CARS
  - Compensatory Anti-inflammatory Response System
    - Attempts to down regulate the SIRS response
    - IL-4, IL-10, transforming growth factor beta, CSF, soluble receptors to TNF, antagonists to TNF-alpha and IL-1
    - If CARS reaction is severe it will manifest as anergy and infection susceptibility

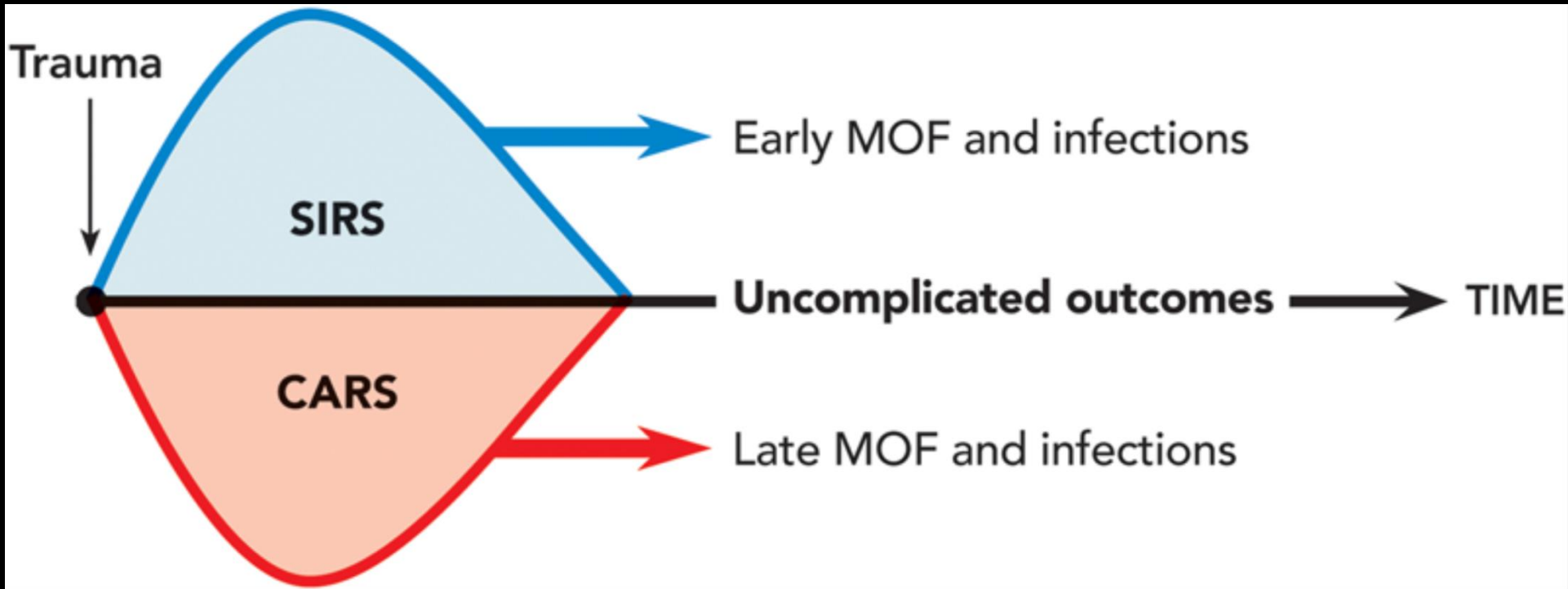


Figure Legend:

Fig. 2. Trauma-induced injury activates innate immune responses to produce pro- and antiinflammatory cytokines. Imbalance between the systemic inflammatory response syndrome and the compensatory antiinflammatory response (immunosuppression) increases morbidity of trauma patients. In the first hours, the magnitude of the systemic inflammatory response syndrome is correlated with early multiple organ failure and infections. In the following days, immunosuppression contributes to the increased incidence of nosocomial infections and late sepsis. CARS = compensatory anti-inflammatory response; MOF = multiple organ failure; SIRS = systemic inflammatory response syndrome.





# Making Matters Worse

## The Role of Endothelium in Sepsis

Normal endothelium has anticoagulant abilities and plays a role in the body's homeostasis abilities including:

- Vasomotor tone
- Movement of cells and nutrients
- Maintaining blood fluidity

When activated, endothelium also plays a role in the inflammatory, coagulation, and fibrinolytic components of sepsis.

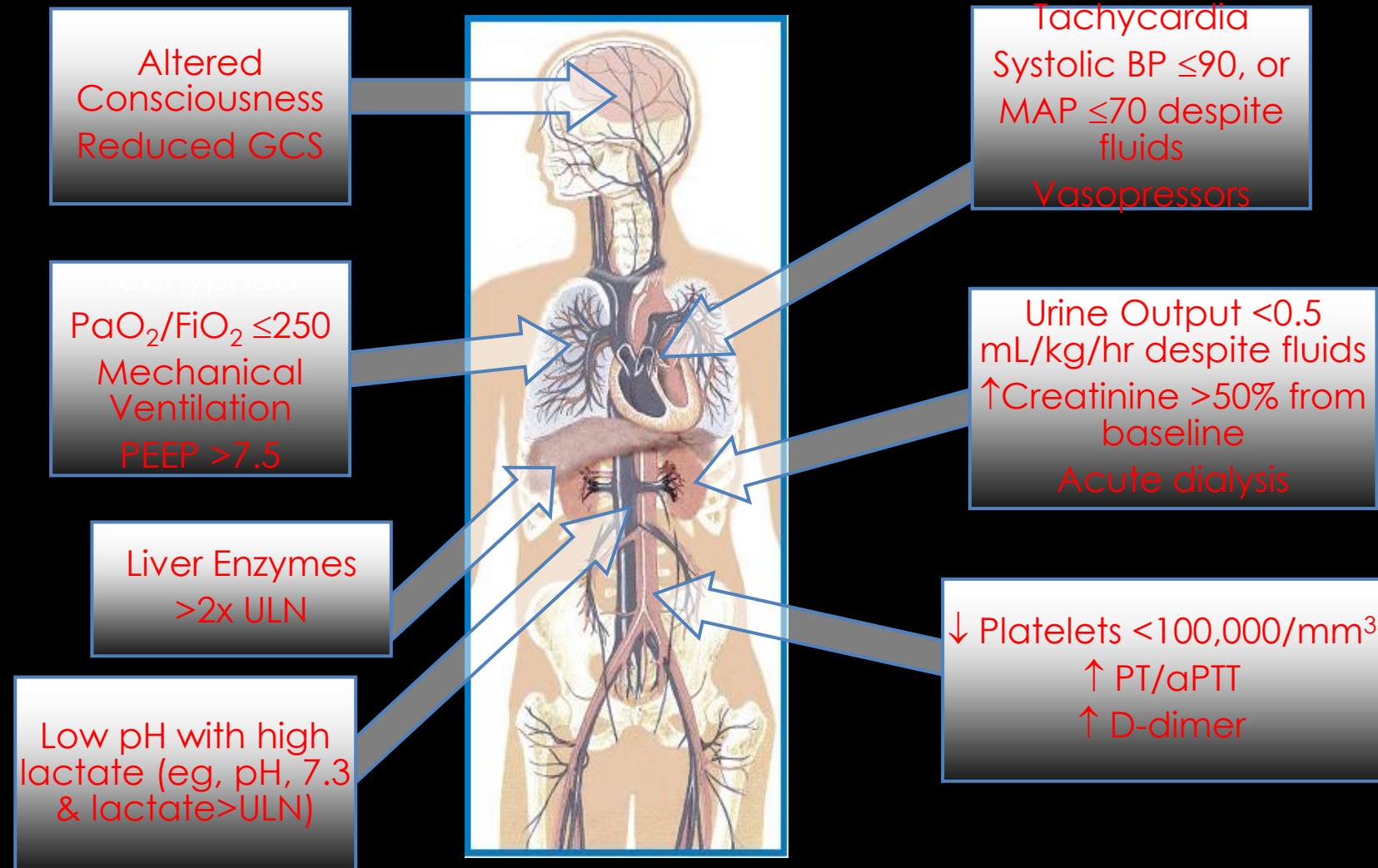


# Response

- Physiology
  - Heart rate
  - Respiration
  - Fever
  - Blood pressure
  - Cardiac output
  - WBC
  - Hyperglycemia
- Markers of Inflammation
  - TNF
  - IL-1
  - IL-6
  - Procalcitonin
  - PAF



# IDENTIFYING ACUTE ORGAN DYSFUNCTION AS A MARKER OF SEVERE SEPSIS



# Organ Dysfunction

- Lungs ➤ **Adult Respiratory Distress Syndrome**
- Kidneys ➤ Acute Tubular Necrosis
- CVS ➤ **Shock**
- CNS ➤ Metabolic encephalopathy
- PNS ➤ Critical Illness Polyneuropathy
- Coagulation ➤ **Disseminated Intravascular Coagulopathy**
- GI ➤ Gastroparesis and ileus
- Liver ➤ Cholestasis
- Endocrine ➤ **Adrenal insufficiency**
- Skeletal Muscle ➤ Rhabdomyolysis

✓ **Specific therapy exists**

# Why do Septic Patients Die?

## Organ Failure



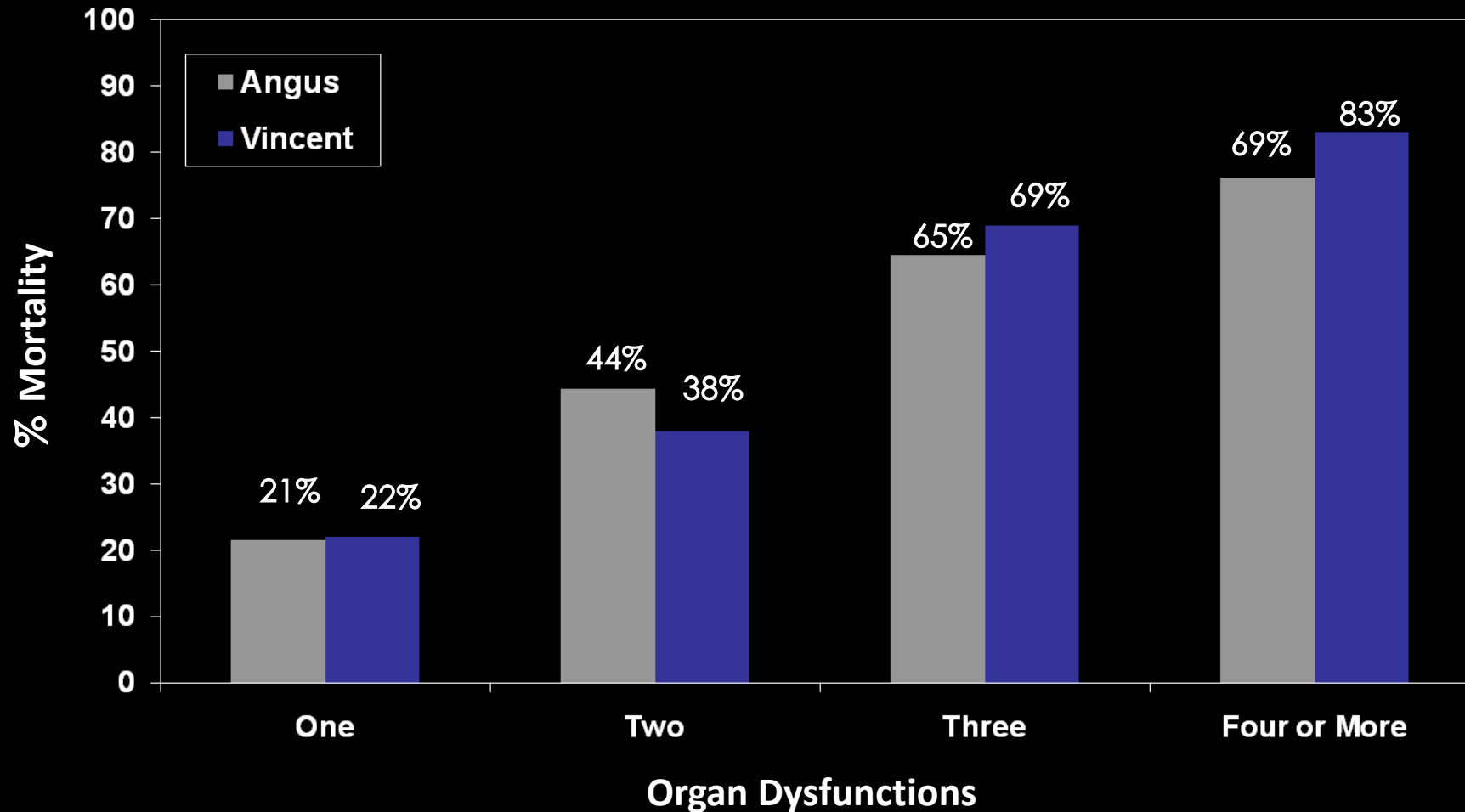
# Organ Failure and Mortality

- Knaus, et al. (1986):
  - Direct correlation between number of organ systems failed and mortality.
  - Mortality Data:

#OSF	D1	D2	D3	D4	D5	D6	D7
<b>1</b>	22%	31%	34%	35%	40%	42%	41%
<b>2</b>	52%	67%	66%	62%	56%	64%	68%
<b>3</b>	80%	95%	93%	96%	100%	100%	100%



# SEVERE SEPSIS-ASSOCIATED MORTALITY INCREASES WITH THE NUMBER OF ORGAN DYSFUNCTIONS



Angus DC, et al. *Crit Care Med.* 2001;29:1303-1310.

Vincent JL, et al. *Crit Care Med.* 1998;21:1793-1800.

Fourth Year Lectures 2017



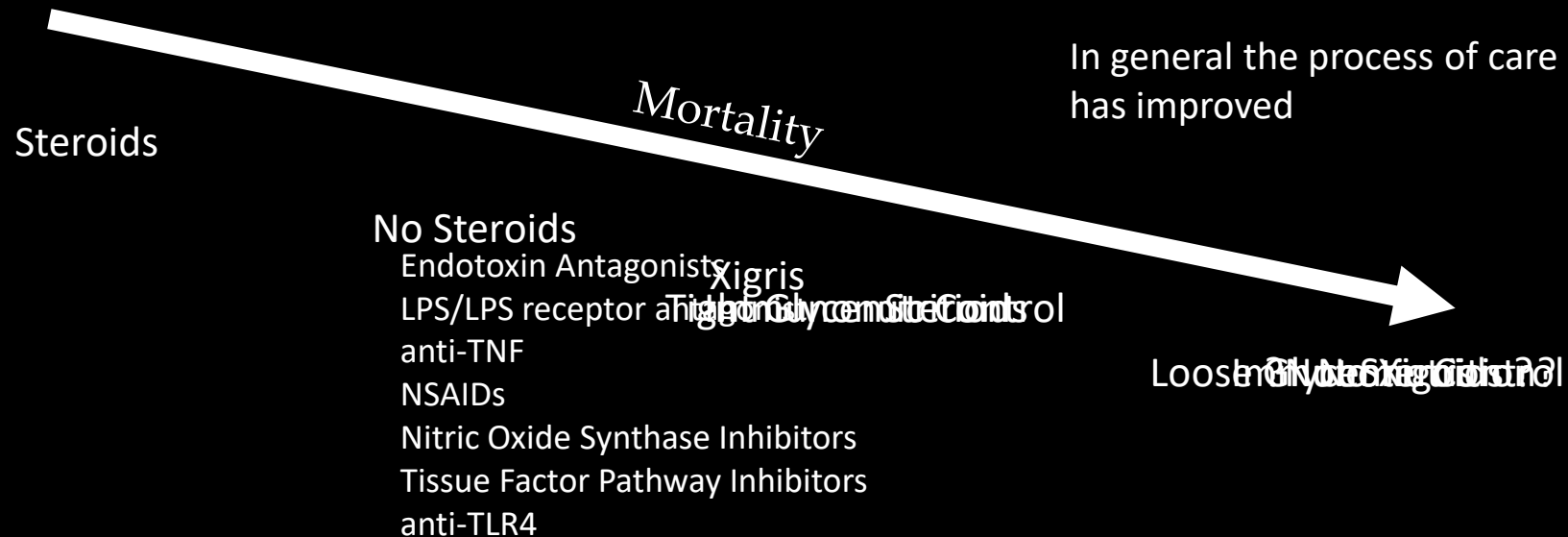
# Evolution of Sepsis care

## Established Core Rx:

Source Control  
Antibiotics  
Resuscitation  
Supportive Care

## Established Core Rx:

Source Control  
More Antibiotics  
Faster Resuscitation  
Better Supportive Care





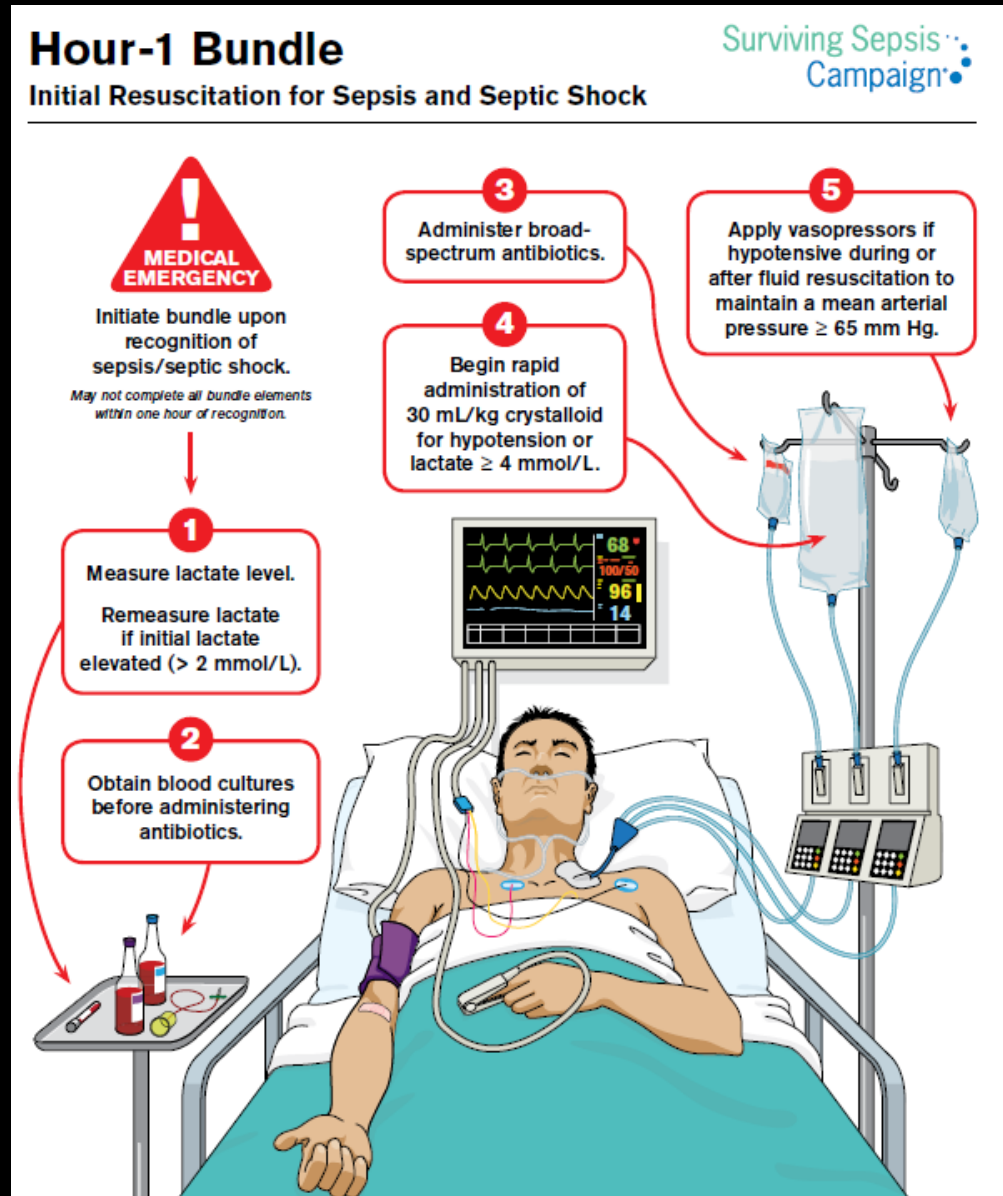
# Surviving Sepsis Campaign: International Guidelines for Management of Severe Sepsis and Septic Shock: 2012

R. Phillip Dellinger, MD<sup>1</sup>; Mitchell M. Levy, MD<sup>2</sup>; Andrew Rhodes, MB BS<sup>3</sup>; Djillali Annane, MD<sup>4</sup>; Herwig Gerlach, MD, PhD<sup>5</sup>; Steven M. Opal, MD<sup>6</sup>; Jonathan E. Sevransky, MD<sup>7</sup>; Charles L. Sprung, MD<sup>8</sup>; Ivor S. Douglas, MD<sup>9</sup>; Roman Jaeschke, MD<sup>10</sup>; Tiffany M. Osborn, MD, MPH<sup>11</sup>; Mark E. Nunnally, MD<sup>12</sup>; Sean R. Townsend, MD<sup>13</sup>; Konrad Reinhart, MD<sup>14</sup>; Ruth M. Kleinpell, PhD, RN-CS<sup>15</sup>; Derek C. Angus, MD, MPH<sup>16</sup>; Clifford S. Deutschman, MD, MS<sup>17</sup>; Flavia R. Machado, MD, PhD<sup>18</sup>; Gordon D. Rubenfeld, MD<sup>19</sup>; Steven A. Webb, MB BS, PhD<sup>20</sup>; Richard J. Beale, MB BS<sup>21</sup>; Jean-Louis Vincent, MD, PhD<sup>22</sup>; Rui Moreno, MD, PhD<sup>23</sup>; and the Surviving Sepsis Campaign Guidelines Committee including the Pediatric Subgroup\*

Dellinger RP, Levy MM, Rhodes A, et al. Surviving Sepsis Campaign: International Guidelines for Management of Severe Sepsis and Septic Shock: 2012. *Critical Care Medicine* 2013;41(2):580–637.



# 1 Hour Bundle



# Surviving Sepsis targets of fluid resuscitation

What are they?

- SBP
- MAP
- CVP
- U/o
- Lactate
- ScvO<sub>2</sub>
- Hct



# Surviving Sepsis targets of fluid resuscitation

## What are they?

- SBP > 90
- MAP > 65
- CVP 8 - 12
- U/o > 0.5 ml/kg/hr
- Lactate < 1
- ScvO<sub>2</sub> >70
- Hct > 30



- at least 30 mL/kg of IV crystalloid fluid be given within the first 3 h
- additional fluids be guided by frequent reassessment of hemodynamic status (BPS)



- Crystalloids are favored as the initial fluid
- Hydroxyethyl starches are likely harmful
- Albumin may have a role, particularly if a lot of fluid is given



# Markers of perfusion

## What are they?

- Clinical signs
  - Warm skin, conscious level, u/o
- Haemodynamic variables
  - CVP
- Bloods
  - Serum Lactate
  - ScvO<sub>2</sub>



# CVP

What does it mean?





# CVP

What does it mean?

Starling's Law

Estimate of LVEDV (i.e. preload)

Not always a good correlation with volume-responsiveness

However if low strongly suggestive of hypovolaemia



# Lactate

What does it mean?



# Lactate

## What does it mean?

- Increased production (anaerobic glycolysis)
  - Tissue hypoperfusion
  - Tissue dysoxia
- Reduced metabolism
  - Hepatic
  - Renal
- <1 is normal, 1-2 is a concern, >2 is bad, >4 is very bad



# ScvO<sub>2</sub>

What does it mean?



# ScvO<sub>2</sub>

What does it mean?

- Balance between oxygen delivery and consumption (VO<sub>2</sub>)
- $ScvO_2 = SaO_2 - \frac{VO_2}{CO}$
- Target > 70%



# ScvO<sub>2</sub>

What can I do if it's low?



# ScvO<sub>2</sub>

What can I do if it's low?

$$\text{Delivery} = [\text{Hb}] \times \text{SpO}_2 \times 1.34 \times \text{HR} \times \text{SV}$$



What can I do if it's low?

Delivery =  $[Hb] \times SpO_2 \times 1.34 \times HR \times SV$

Fluid optimise

Transfuse packet cells

Hct > 30%

Inotropes





# “Time Zero”

- Time Zero = time of presentation
  - ED, Medical Floors, ICU
- 1 Hour Bundle



microbiologic cultures (including blood) be obtained before starting antimicrobial therapy in patients with suspected sepsis or septic shock if doing so results in no substantial delay in the start of antimicrobials.

# Antibiotic therapy

- intravenous antimicrobial therapy as early as possible and within the first hour of recognition
- empiric broad-spectrum therapy with one or more antimicrobials to cover all likely pathogens (including bacterial and potentially fungal or viral coverage)
- antimicrobial therapy to be narrowed once pathogen identification and sensitivities are established and/or adequate clinical improvement is noted .

# Hospital Mortality by Time to Antibiotics

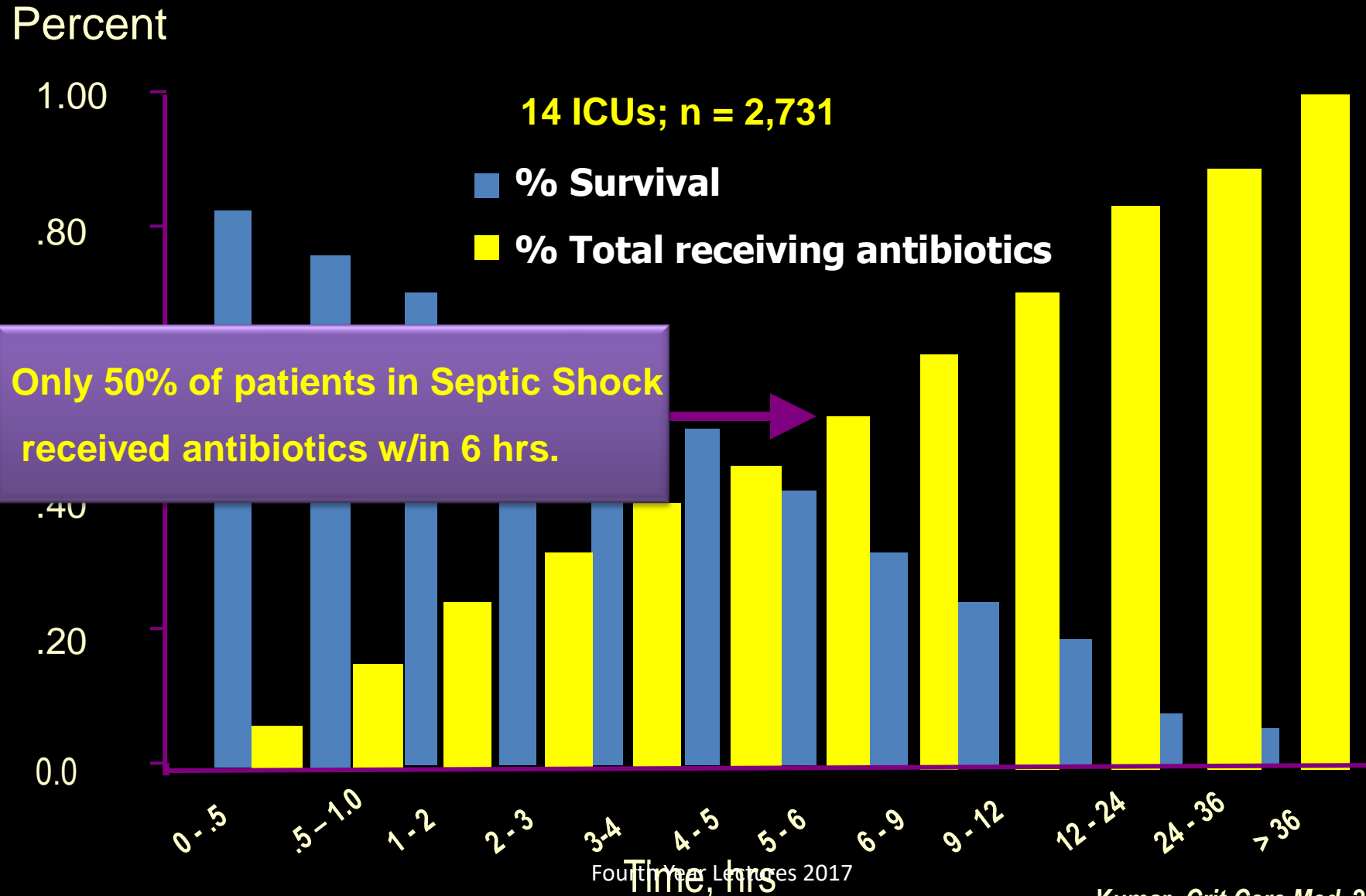
Time to ABX <sup>1</sup> , hrs	OR <sup>2</sup>	95% CI		p-value	Probability of mortality <sup>3</sup>	95% CI	
0 (ref)	1.00	---	---	---	18.7	17.5	19.9
1	1.05	1.02	1.07	< 0.001	19.3	18.3	20.4
2	1.09	1.04	1.15	< 0.001	20.0	19.1	21.0
3	1.14	1.06	1.23	< 0.001	20.8	19.7	21.8
4	1.19	1.08	1.32	< 0.001	21.5	20.3	22.8
5	1.25	1.11	1.41	< 0.001	22.3	20.7	23.9
6	1.31	1.13	1.51	< 0.001	23.1	21.2	25.1

<sup>1</sup>Time to ABX is based on 15,948 observations that are greater than or equal to zero

<sup>2</sup>Hospital mortality odds ratio referent group is 0 hours for the time to ABX and is adjusted by the number of baseline organ failures, infection type (community vs. nosocomial), and geographic region (Europe, North America, and South America)



# Septic Shock: Timing of Antibiotics



# Source Control

**a specific anatomic diagnosis of infection requiring emergent source control to be identified or excluded as rapidly as possible and that any required source control intervention be implemented as soon as medically and logistically practical after the diagnosis is made.**



# Vasoactive agents

- **Norepinephrine is the first choice vasopressor**



# CORTICOSTEROIDS

**intravenous hydrocortisone to treat septic shock patients if adequate fluid resuscitation and vasopressor therapy are UNABLE to restore hemodynamic stability.**





# GLUCOSE CONTROL

**We recommend a protocolized approach to blood glucose management in ICU patients This approach should target an upper blood glucose level  $\leq 180$  mg/dL**



- Hit fast and hit Hard
- IV fluids
- Antibiotics
- Source control



Thank You