

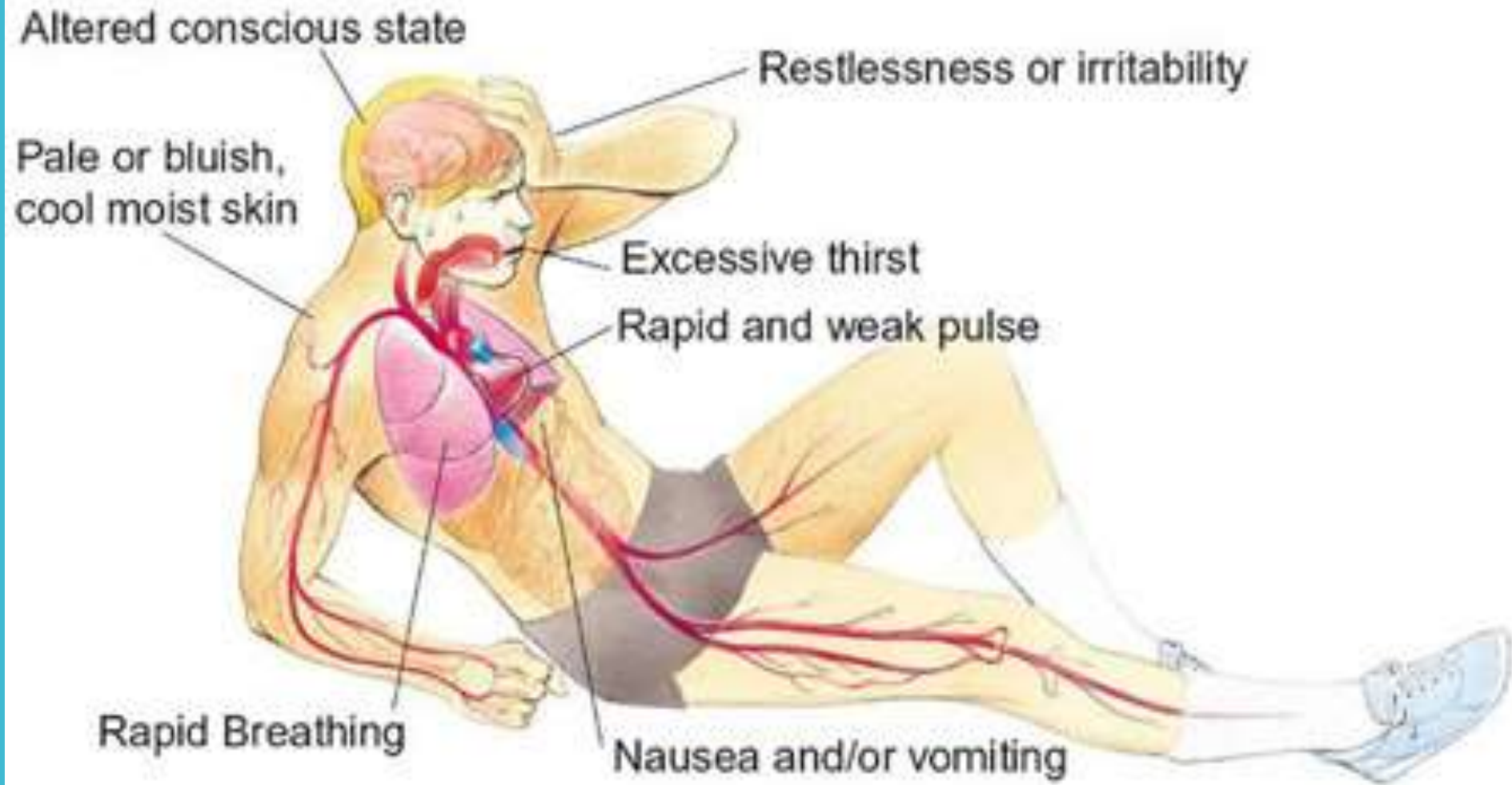
# Shock

SM Copotoiu

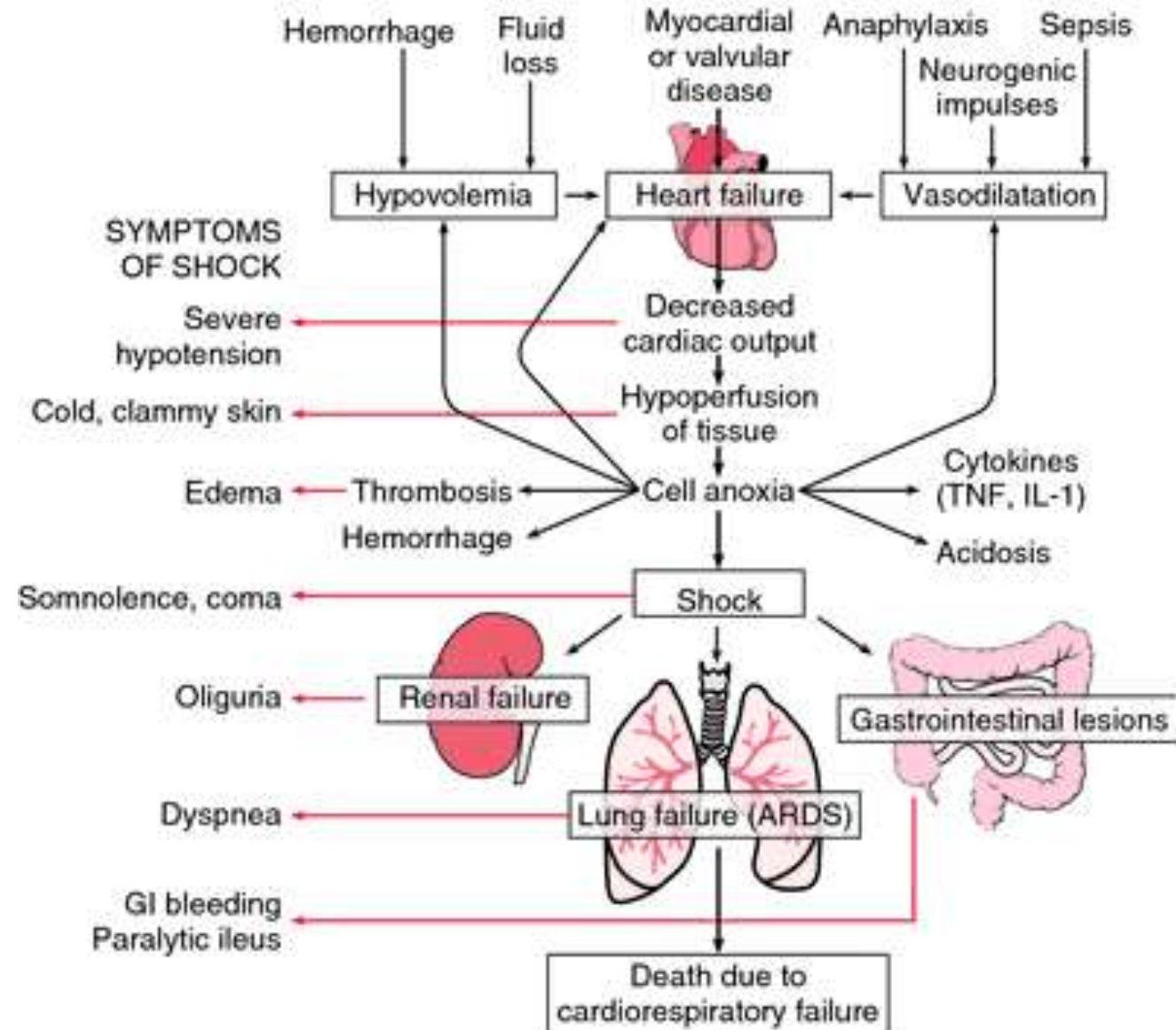
# Shock

- How could I recognize shock?
- Is there a need to classify shock?
- How should I treat shock?

# Clinical signs



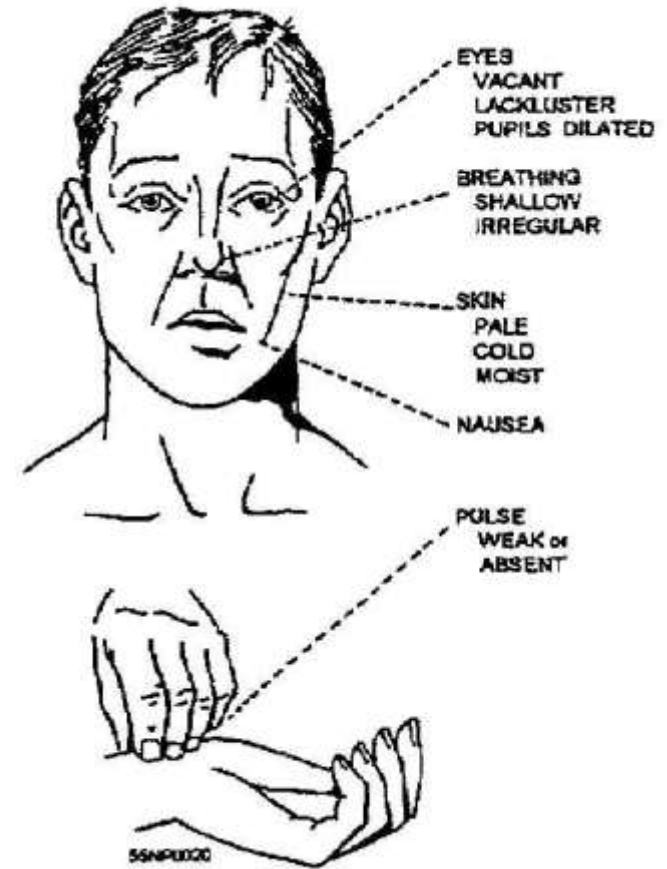
# Common pathways



# Herbal medicine

## TREATING SHOCK

Face is RED  
Lift the HEAD  
Face is PALE  
Lift the TAIL



# Shock Classification

- Hypovolemic
- Cardiogenic
- Distributive
- Obstructive shock

# Shock classification

- Hypodynamic
  - Low cardiac output state: ↓CI, ↑SVR, ↑O<sub>2</sub> extraction, lactic acidosis
  - Hypovolemic
  - Cardiogenic
  - Obstructive
- Hyperdynamic
  - High output state: ↑CI, ↓SVR, O<sub>2</sub> utilization impaired, ↑lactate
  - Distributive: septic, anaphylactic, neurogenic
- Endocrine

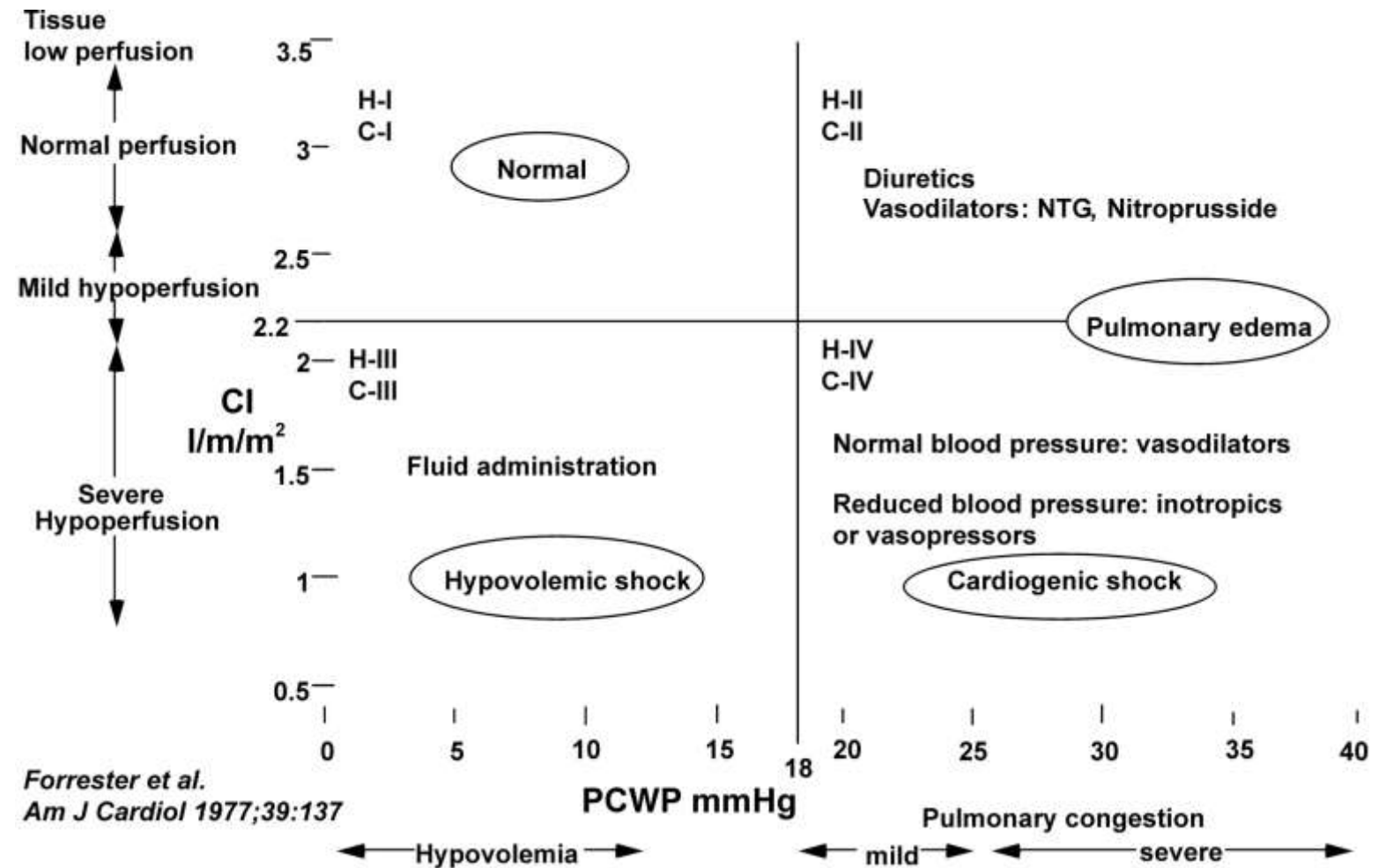
# Shock classification

- Hypodynamic
  - Low cardiac output state
  - Hypovolemic
  - Cardiogenic
  - Obstructive
- Hyperdynamic
  - High output state
  - Distributive: septic, anaphylactic
- Endocrine



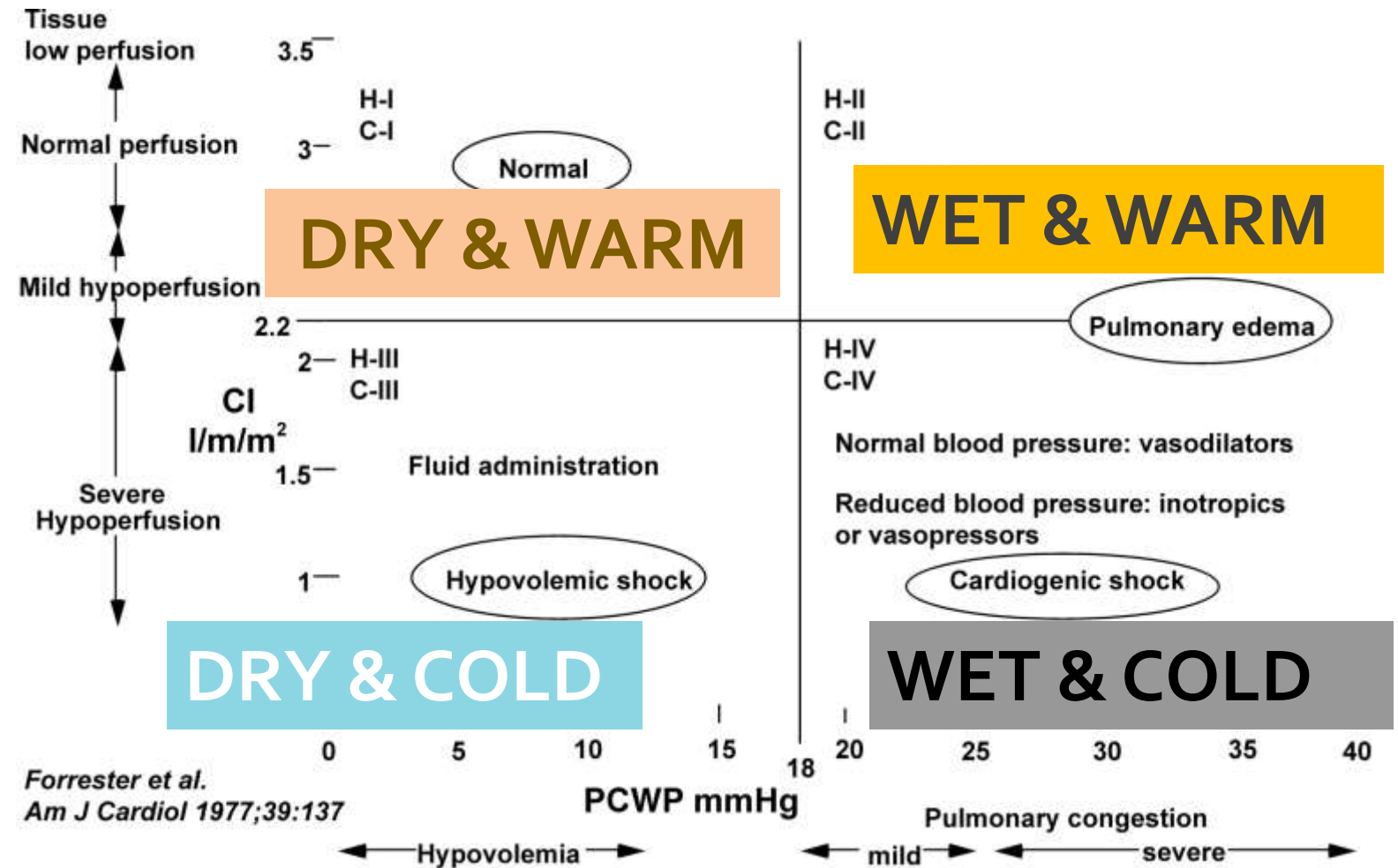
# Cardiogenic shock

Loss of contractility  
Failing systolic & diastolic functions  
hypotension  
systemic hypoperfusion  
coronary circulation impaired  
myocardial ischemia  
compensatory vasoconstriction  
+ SIRS



# Cardiogenic shock

Loss of contractility  
Failing systolic & diastolic functions  
hypotension  
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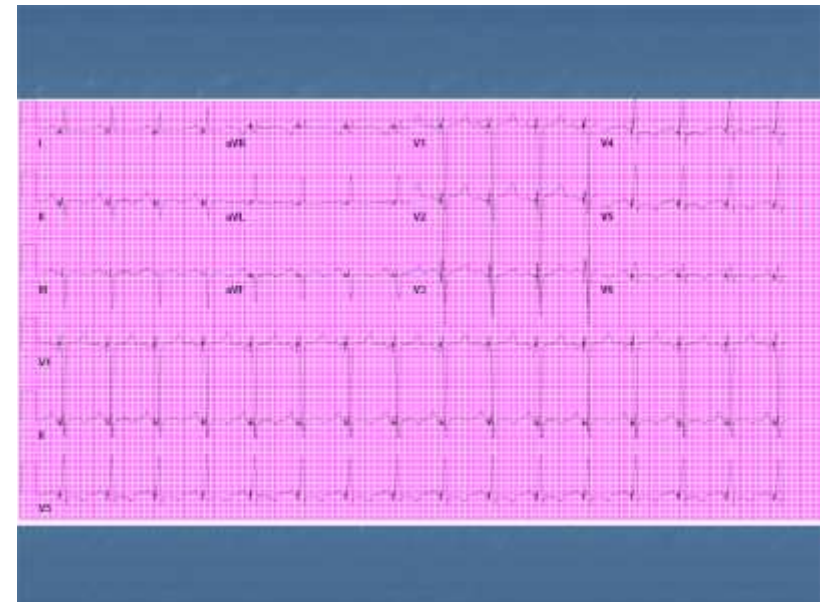
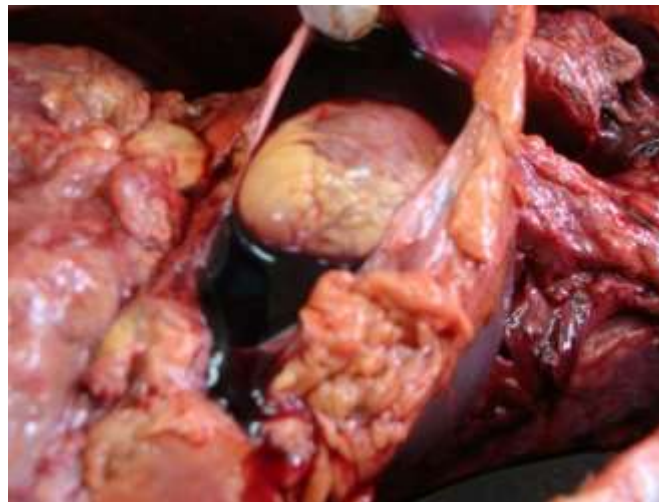
## Differential diagnosis

- All other shock forms – hypovolemic, anaphylactic
- Dissection of the Ao
- Pulmonary embolism
- Takotsubo syndrome

# Treatment

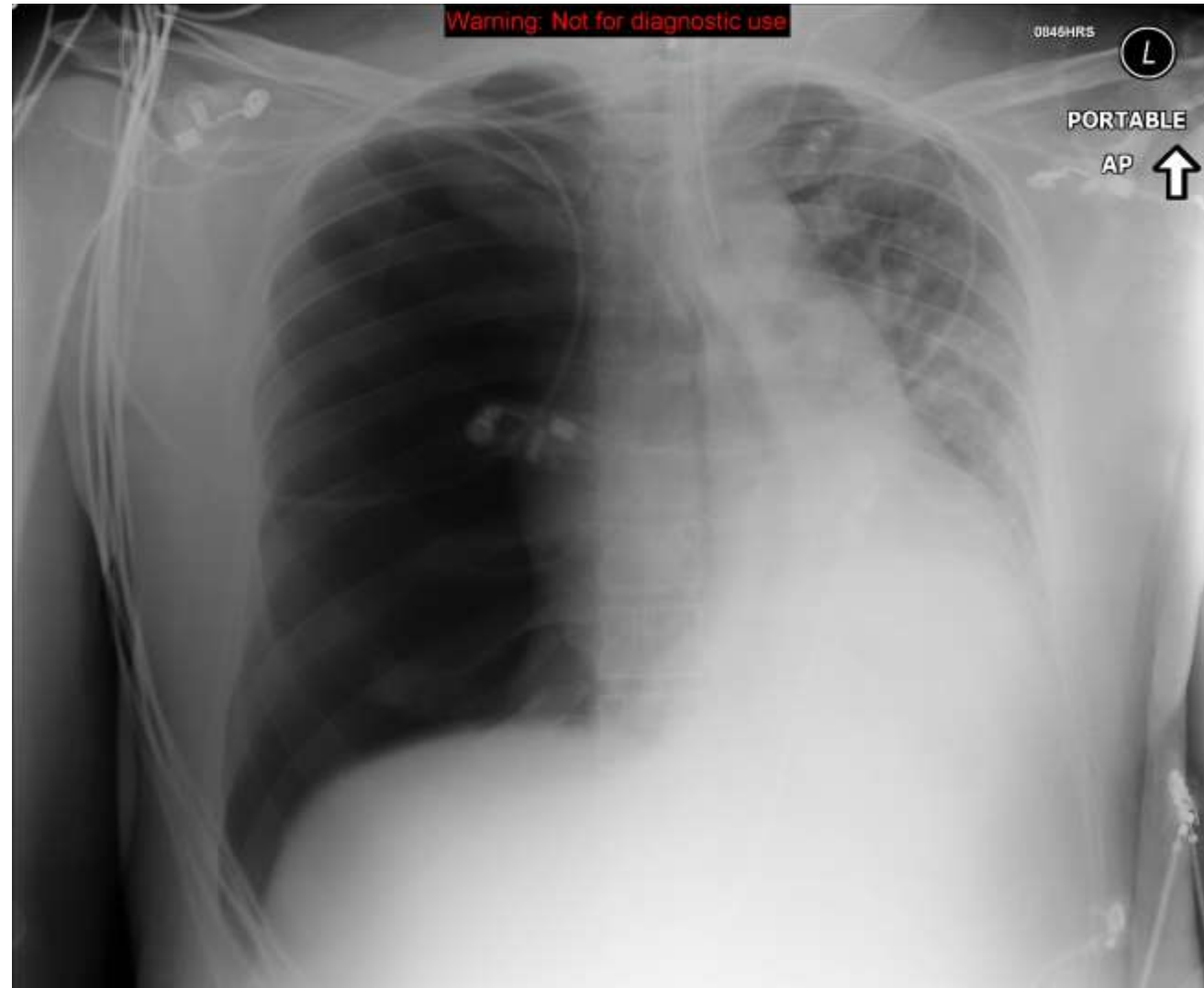
- Remove the cause: coronary intervention, surgery
- Fluid challenge
- Vasopressors : Noradrenaline + dobutamine , levosimendan
- Intraaortic balloon counterpulsation CI: Ao regurgitation
- Anticoagulation
- Treat the imbalances cautiously - they are mainly consequences

# Obstructive shock cardiac tamponade



# Obstructive shock

Tension  
pneumothorax  
Pulmonary embolus  
Haemothorax



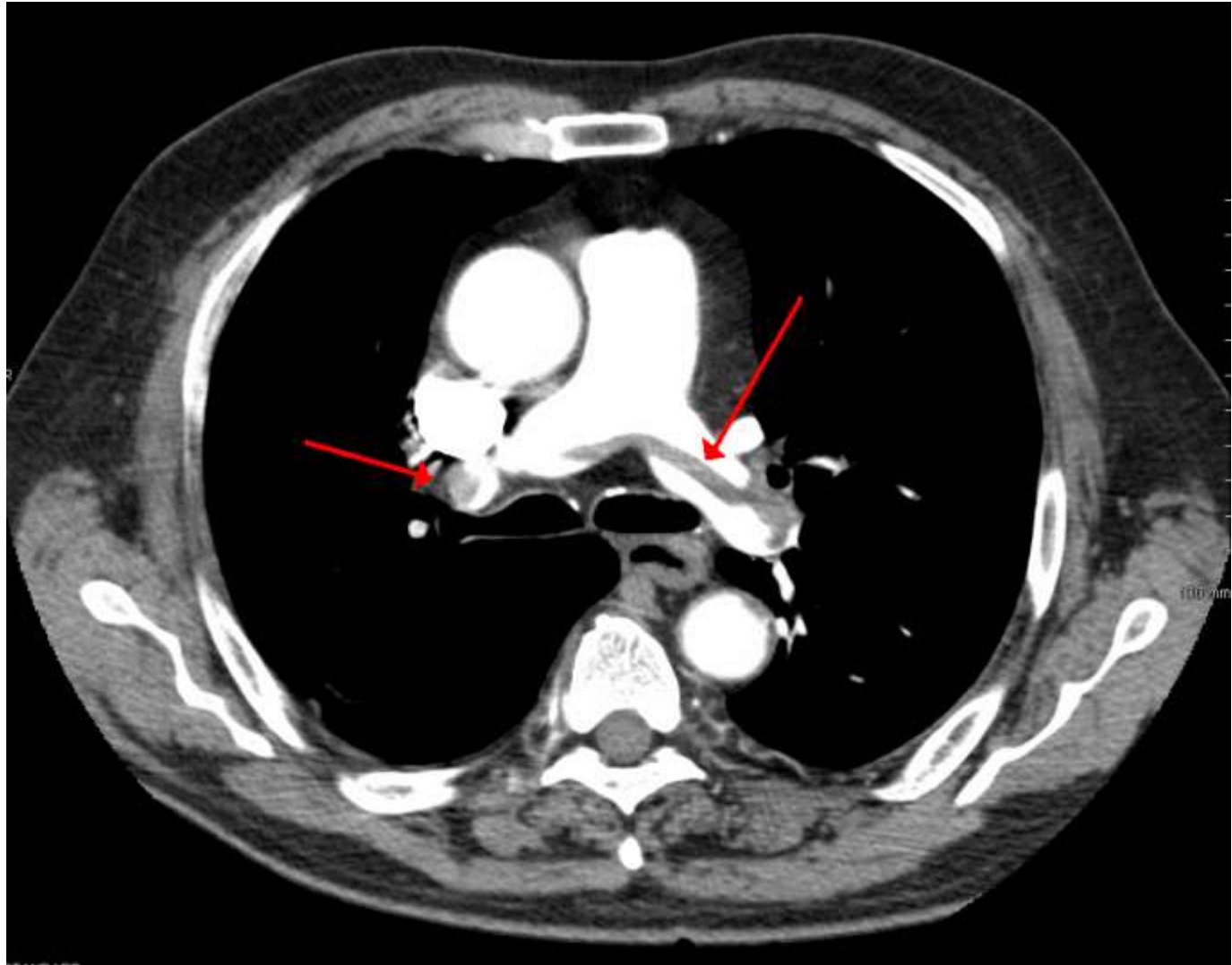
# Obstructive shock

Tension

pneumothorax

Pulmonary embolus

Haemothorax





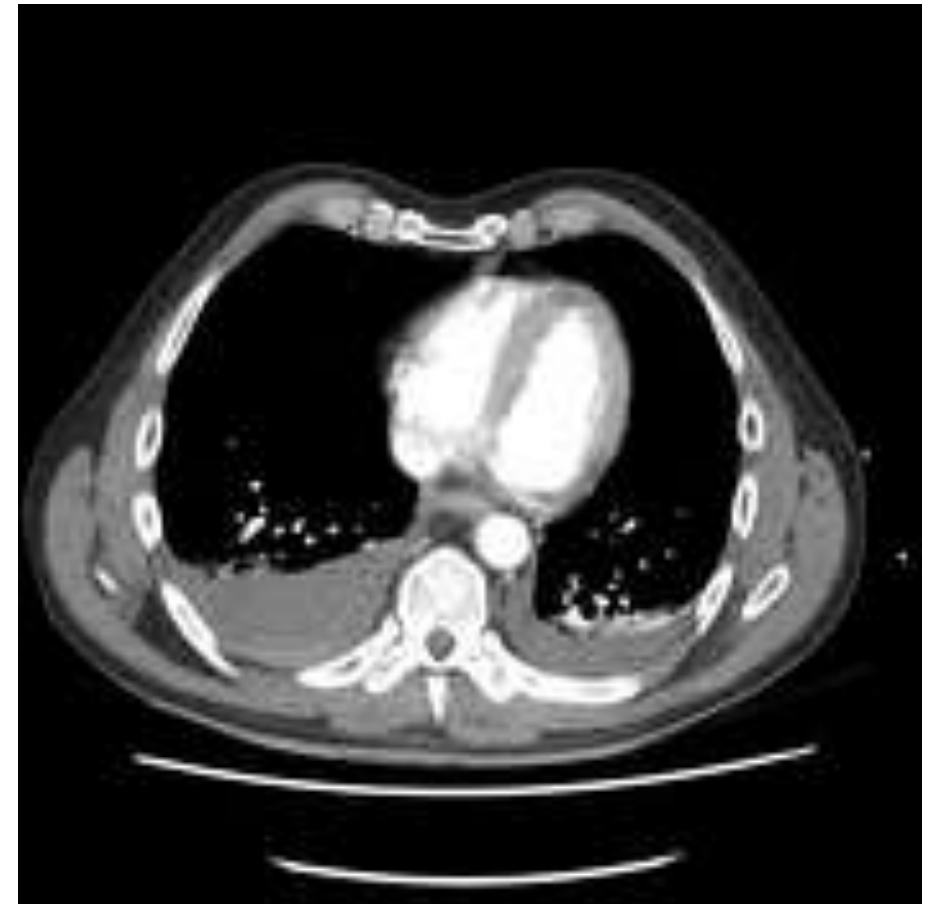
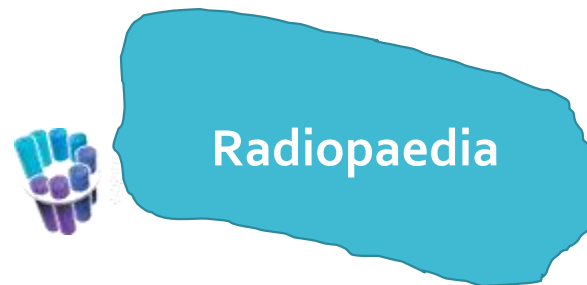
Large embolus in  
the left PA,  
scattered emboli  
in the lungs – right  
mainly





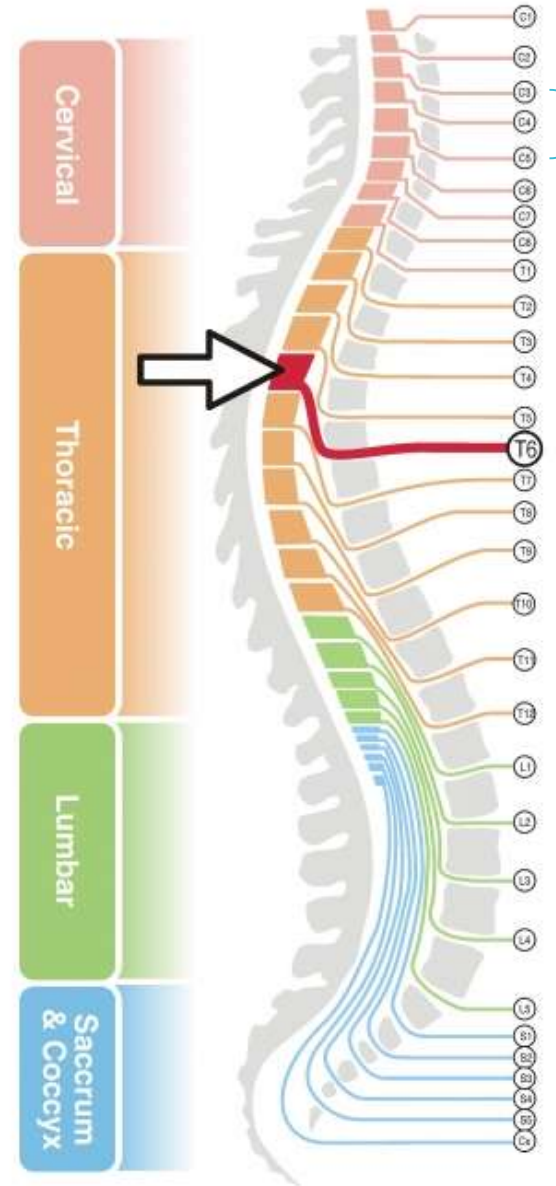
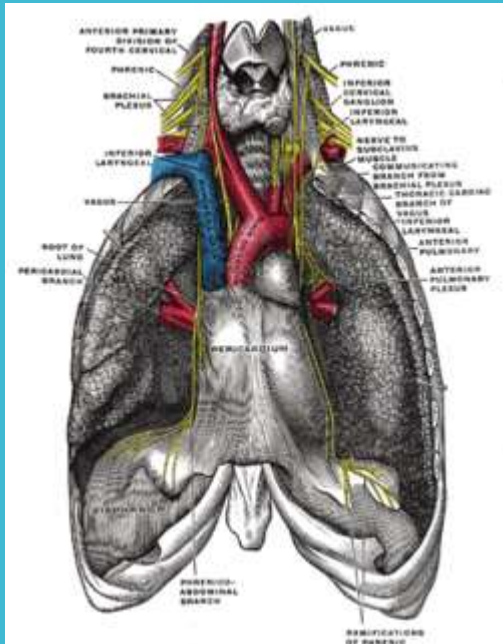
# Obstructive shock

Tension  
pneumothorax  
Pulmonary embolus  
Haemothorax



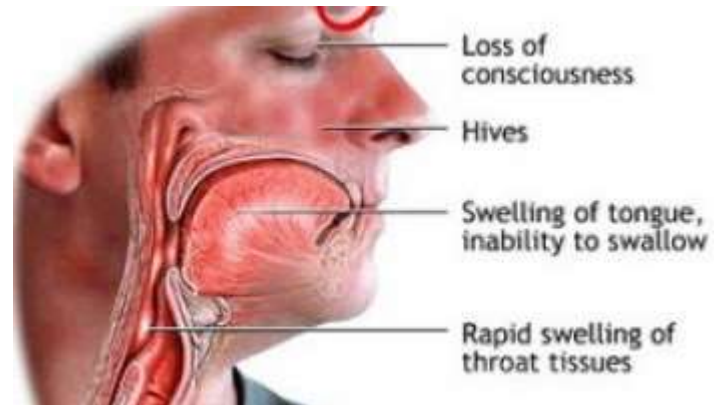
# Neurogenic shock

Autonomic dysfunction



Phrenic nerve

# Anaphylactic shock Adrenaline



# Shock parameters

**TABLE 253-4** *Physiologic Characteristics of the Various Forms of Shock*

<i>Type of Shock</i>	<i>CVP and PCWP</i>	<i>Cardiac Output</i>	<i>Systemic Vascular Resistance</i>	<i>Venous O<sub>2</sub> Saturation</i>
Hypovolemic	↓	↓	↑	↓
Cardiogenic	↑	↓	↑	↓
Septic				
Hyperdynamic	↓↑	↑	↓	↑
Hypodynamic	↓↑	↓	↑	↑↓
Traumatic	↓	↓↑	↑↓	↓
Neurogenic	↓	↓	↓	↓
Hypoadrenal	↓↑	↓	=↓	↓

**Note:** CVP, central venous pressure; PCWP, pulmonary capillary wedge pressure.

## Old but gold definition

### Inflammatory variables

Leukocytosis (WBC count  $> 12,000 \mu\text{L}^{-1}$ )

Leukopenia (WBC count  $< 4000 \mu\text{L}^{-1}$ )

Normal WBC count with greater than 10% immature forms

Plasma C-reactive protein more than two sd above the normal value

Plasma procalcitonin more than two sd above the normal value



A change in  
outcome in  
the ED → ICU

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

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**TABLE 1. Diagnostic Criteria for Sepsis**

**Infection, documented or suspected, and some of the following:**

General variables

Fever ( $> 38.3^{\circ}\text{C}$ )

Hypothermia (core temperature  $< 36^{\circ}\text{C}$ )

Heart rate  $> 90/\text{min}^{-1}$  or more than two sd above the normal value for age

Tachypnea

Altered mental status

Significant edema or positive fluid balance ( $> 20\text{ mL/kg}$  over 24 hr)

Hyperglycemia (plasma glucose  $> 140\text{ mg/dL}$  or  $7.7\text{ mmol/L}$ ) in the absence of diabetes

## Hemodynamic variables

Arterial hypotension (SBP < 90 mm Hg, MAP < 70 mm Hg, or an SBP decrease > 40 mm Hg in adults or less than two SD below normal for age)



### Organ dysfunction variables

Arterial hypoxemia ( $P_{aO_2}/F_{iO_2} < 300$ )

Acute oliguria (urine output  $< 0.5 \text{ mL/kg/hr}$  for at least 2 hrs despite adequate fluid resuscitation)

Creatinine increase  $> 0.5 \text{ mg/dL}$  or  $44.2 \text{ } \mu\text{mol/L}$

Coagulation abnormalities ( $\text{INR} > 1.5$  or  $\text{aPTT} > 60 \text{ s}$ )

Ileus (absent bowel sounds)

Thrombocytopenia (platelet count  $< 100,000 \text{ } \mu\text{L}^{-1}$ )

Hyperbilirubinemia (plasma total bilirubin  $> 4 \text{ mg/dL}$  or  $70 \text{ } \mu\text{mol/L}$ )

Tissue perfusion variables

Hyperlactatemia ( $> 1$  mmol/L)

Decreased capillary refill or mottling

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**TABLE 2. Severe Sepsis**

**Severe sepsis definition = sepsis-induced tissue hypoperfusion or organ dysfunction (any of the following thought to be due to the infection)**

Sepsis-induced hypotension

Lactate above upper limits laboratory normal

Urine output  $< 0.5 \text{ mL/kg/hr}$  for more than 2 hrs despite adequate fluid resuscitation

Acute lung injury with  $\text{Pao}_2/\text{Fio}_2 < 250$  in the absence of pneumonia as infection source

Acute lung injury with  $\text{Pao}_2/\text{Fio}_2 < 200$  in the presence of pneumonia as infection source

Creatinine  $> 2.0 \text{ mg/dL}$  ( $176.8 \text{ }\mu\text{mol/L}$ )

Bilirubin  $> 2 \text{ mg/dL}$  ( $34.2 \text{ }\mu\text{mol/L}$ )

Platelet count  $< 100,000 \text{ }\mu\text{L}$

Coagulopathy (international normalized ratio  $> 1.5$ )

**TABLE 5. Recommendations: Initial Resuscitation and Infection Issues**

**A. Initial Resuscitation**

1. Protocolized, quantitative resuscitation of patients with sepsis- induced tissue hypoperfusion (defined in this document as hypotension persisting after initial fluid challenge or blood lactate concentration  $\geq 4$  mmol/L). Goals during the first 6 hrs of resuscitation:
  - a) Central venous pressure 8–12 mm Hg
  - b) Mean arterial pressure (MAP)  $\geq 65$  mm Hg
  - c) Urine output  $\geq 0.5$  mL/kg/hr
  - d) Central venous (superior vena cava) or mixed venous oxygen saturation 70% or 65%, respectively (grade 1C).
2. In patients with elevated lactate levels targeting resuscitation to normalize lactate (grade 2C).

## **B. Screening for Sepsis and Performance Improvement**

1. Routine screening of potentially infected seriously ill patients for severe sepsis to allow earlier implementation of therapy
2. Hospital-based performance improvement efforts in severe sepsis (UG).

### C. Diagnosis

1. Cultures as clinically appropriate before antimicrobial therapy if no significant delay ( $> 45$  mins) in the start of antimicrobial(s) (grade 1C). At least 2 sets of blood cultures (both aerobic and anaerobic bottles) be obtained before antimicrobial therapy with at least 1 drawn percutaneously and 1 drawn through each vascular access device, unless the device was recently ( $<48$  hrs) inserted (grade 1C).
2. Use of the 1,3 beta-D-glucan assay (grade 2B), mannan and anti-mannan antibody assays (2C), if available and invasive candidiasis is in differential diagnosis of cause of infection.
3. Imaging studies performed promptly to confirm a potential source of infection (UG).



# Antimicrobials

## D. Antimicrobial Therapy

1. Administration of effective intravenous antimicrobials within the first hour of recognition of septic shock (grade 1B) and severe sepsis without septic shock (grade 1C) as the goal of therapy.
- 2a. Initial empiric anti-infective therapy of one or more drugs that have activity against all likely pathogens (bacterial and/or fungal or viral) and that penetrate in adequate concentrations into tissues presumed to be the source of sepsis (grade 1B).
- 2b. Antimicrobial regimen should be reassessed daily for potential deescalation (grade 1B).
3. Use of low procalcitonin levels or similar biomarkers to assist the clinician in the discontinuation of empiric antibiotics in patients who initially appeared septic, but have no subsequent evidence of infection (grade 2C).

4a. Combination empirical therapy for neutropenic patients with severe sepsis (grade 2B) and for patients with difficult-to-treat, multidrug-resistant bacterial pathogens such as *Acinetobacter* and *Pseudomonas* spp. (grade 2B). For patients with severe infections associated with respiratory failure and septic shock, combination therapy with an extended spectrum beta-lactam and either an aminoglycoside or a fluoroquinolone is for *P. aeruginosa* bacteremia (grade 2B). A combination of beta-lactam and macrolide for patients with septic shock from bacteremic *Streptococcus pneumoniae* infections (grade 2B).

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## Empirical therapy

4b. Empiric combination therapy should not be administered for more than 3–5 days. De-escalation to the most appropriate single therapy should be performed as soon as the susceptibility profile is known (grade 2B).



# Duration of ATB therapy

5. Duration of therapy typically 7–10 days; longer courses may be appropriate in patients who have a slow clinical response, undrainable foci of infection, bacteremia with *S. aureus*; some fungal and viral infections or immunologic deficiencies, including neutropenia (grade 2C).
6. Antiviral therapy initiated as early as possible in patients with severe sepsis or septic shock of viral origin (grade 2C).
7. Antimicrobial agents should not be used in patients with severe inflammatory states determined to be of noninfectious cause

# Source control

## **E. Source Control**

1. A specific anatomical diagnosis of infection requiring consideration for emergent source control be sought and diagnosed or excluded as rapidly as possible, and intervention be undertaken for source control within the first 12 hr after the diagnosis is made, if feasible (grade 1C).
2. When infected peripancreatic necrosis is identified as a potential source of infection, definitive intervention is best delayed until adequate demarcation of viable and nonviable tissues has occurred (grade 2B).

# Source control

3. When source control in a severely septic patient is required, the effective intervention associated with the least physiologic insult should be used (eg, percutaneous rather than surgical drainage of an abscess) (UG).
4. If intravascular access devices are a possible source of severe sepsis or septic shock, they should be removed promptly after other vascular access has been established (UG).

# Infection prevention

## **F. Infection Prevention**

- 1a. Selective oral decontamination and selective digestive decontamination should be introduced and investigated as a method to reduce the incidence of ventilator-associated pneumonia; This infection control measure can then be instituted in health care settings and regions where this methodology is found to be effective (grade 2B).
- 1b. Oral chlorhexidine gluconate be used as a form of oropharyngeal decontamination to reduce the risk of ventilator-associated pneumonia in ICU patients with severe sepsis (grade 2B).

# SSC bundles

## **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  $\geq 4$ mmol/L



# SSC Bundles

## 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)  $\geq 65$  mm Hg
- 6) In the event of persistent arterial hypotension despite volume resuscitation (septic shock) or initial lactate  $\geq 4$  mmol/L (36 mg/dL):
  - Measure central venous pressure (CVP)\*
  - Measure central venous oxygen saturation (Scvo<sub>2</sub>)\*
- 7) Remeasure lactate if initial lactate was elevated\*

\*Targets for quantitative resuscitation included in the guidelines are CVP of  $\geq 8$  mm Hg, Scvo<sub>2</sub> of  $\geq 70\%$ , and normalization of lactate.

# Hemodynamic support

## **G. Fluid Therapy of Severe Sepsis**

1. Crystalloids as the initial fluid of choice in the resuscitation of severe sepsis and septic shock (grade 1B).
2. Against the use of hydroxyethyl starches for fluid resuscitation of severe sepsis and septic shock (grade 1B).
3. Albumin in the fluid resuscitation of severe sepsis and septic shock when patients require substantial amounts of crystalloids

# Hemodynamic support

4. Initial fluid challenge in patients with sepsis-induced tissue hypoperfusion with suspicion of hypovolemia to achieve a minimum of 30 mL/kg of crystalloids (a portion of this may be albumin equivalent). More rapid administration and greater amounts of fluid may be needed in some patients (grade 1C).
5. Fluid challenge technique be applied wherein fluid administration is continued as long as there is hemodynamic improvement either based on dynamic (eg, change in pulse pressure, stroke volume variation) or static (eg, arterial pressure, heart rate) variables (UG).



# Hemodynamic support

## **H. Vasopressors**

1. Vasopressor therapy initially to target a mean arterial pressure (MAP) of 65 mm Hg (grade 1C).
2. Norepinephrine as the first choice vasopressor (grade 1B).
3. Epinephrine (added to and potentially substituted for norepinephrine) when an additional agent is needed to maintain adequate blood pressure (grade 2B).

# Hemodynamic support

4. Vasopressin 0.03 units/minute can be added to norepinephrine (NE) with intent of either raising MAP or decreasing NE dosage (UG).
5. Low dose vasopressin is not recommended as the single initial vasopressor for treatment of sepsis-induced hypotension and vasopressin doses higher than 0.03-0.04 units/minute should be reserved for salvage therapy (failure to achieve adequate MAP with other vasopressor agents) (UG).

# Hemodynamic support

6. Dopamine as an alternative vasopressor agent to norepinephrine only in highly selected patients (eg, patients with low risk of tachyarrhythmias and absolute or relative bradycardia) (grade 2C).
7. Phenylephrine is not recommended in the treatment of septic shock except in circumstances where (a) norepinephrine is associated with serious arrhythmias, (b) cardiac output is known to be high and blood pressure persistently low or (c) as salvage therapy when combined inotrope/vasopressor drugs and low dose vasopressin have failed to achieve MAP target (grade 1C).
8. Low-dose dopamine should not be used for renal protection (grade 1A).
9. All patients requiring vasopressors have an arterial catheter placed as soon as practical if resources are available (UG).

# Hemodynamic support

## I. Inotropic Therapy

1. A trial of dobutamine infusion up to 20 micrograms/kg/min be administered or added to vasopressor (if in use) in the presence of (a) myocardial dysfunction as suggested by elevated cardiac filling pressures and low cardiac output, or (b) ongoing signs of hypoperfusion, despite achieving adequate intravascular volume and adequate MAP (grade 1C).
2. Not using a strategy to increase cardiac index to predetermined supranormal levels (grade 1B).

# SSC recommendations

## **J. Corticosteroids**

1. Not using intravenous hydrocortisone to treat adult septic shock patients if adequate fluid resuscitation and vasopressor therapy are able to restore hemodynamic stability (see goals for Initial Resuscitation). In case this is not achievable, we suggest intravenous hydrocortisone alone at a dose of 200 mg per day (grade 2C).
2. Not using the ACTH stimulation test to identify adults with septic shock who should receive hydrocortisone (grade 2B).
3. In treated patients hydrocortisone tapered when vasopressors are no longer required (grade 2D).
4. Corticosteroids not be administered for the treatment of sepsis in the absence of shock (grade 1D).
5. When hydrocortisone is given, use continuous flow (grade 2D).



# Supportive therapy

## K. Blood Product Administration

1. Once tissue hypoperfusion has resolved and in the absence of extenuating circumstances, such as myocardial ischemia, severe hypoxemia, acute hemorrhage, or ischemic heart disease, we recommend that red blood cell transfusion occur only when hemoglobin concentration decreases to  $<7.0$  g/dL to target a hemoglobin concentration of 7.0 –9.0 g/dL in adults (grade 1B).
2. Not using erythropoietin as a specific treatment of anemia associated with severe sepsis (grade 1B).



# Supportive therapy

3. Fresh frozen plasma not be used to correct laboratory clotting abnormalities in the absence of bleeding or planned invasive procedures (grade 2D).
4. Not using antithrombin for the treatment of severe sepsis and septic shock (grade 1B).
5. In patients with severe sepsis, administer platelets prophylactically when counts are  $<10,000/\text{mm}^3$  ( $10 \times 10^9/\text{L}$ ) in the absence of apparent bleeding. We suggest prophylactic platelet transfusion when counts are  $<20,000/\text{mm}^3$  ( $20 \times 10^9/\text{L}$ ) if the patient has a significant risk of bleeding. Higher platelet counts ( $\geq 50,000/\text{mm}^3$  [ $50 \times 10^9/\text{L}$ ]) are advised for active bleeding, surgery, or invasive procedures (grade 2D).

# Supportive therapy

## **L. Immunoglobulins**

1. Not using intravenous immunoglobulins in adult patients with severe sepsis or septic shock (grade 2B).

## **M. Selenium**

1. Not using intravenous selenium for the treatment of severe sepsis (grade 2C).

# Supportive therapy

Mechanical ventilation +++

## **P. Sedation, Analgesia, and Neuromuscular Blockade in Sepsis**

1. Continuous or intermittent sedation be minimized in mechanically ventilated sepsis patients, targeting specific titration endpoints (grade 1B).
2. Neuromuscular blocking agents (NMBAs) be avoided if possible in the septic patient *without ARDS* due to the risk of prolonged neuromuscular blockade following discontinuation. If NMBAs must be maintained, either intermittent bolus as required or continuous infusion with train-of-four monitoring of the depth of blockade should be used (grade 1C).

## Supportive therapy

### **R. Renal Replacement Therapy**

1. Continuous renal replacement therapies and intermittent hemodialysis are equivalent in patients with severe sepsis and acute renal failure (grade 2B).
2. Use continuous therapies to facilitate management of fluid balance in hemodynamically unstable septic patients (grade 2D).

### **S. Bicarbonate Therapy**

1. Not using sodium bicarbonate therapy for the purpose of improving hemodynamics or reducing vasopressor requirements in patients with hypoperfusion-induced lactic acidemia with pH  $\geq 7.15$  (grade 2B).

### **T. Deep Vein Thrombosis Prophylaxis**

1. Patients with severe sepsis receive daily pharmacoprophylaxis against venous thromboembolism (VTE) (grade 1B). This should be accomplished with daily subcutaneous low-molecular weight heparin (LMWH) (grade 1B versus twice daily UFH, grade 2C versus three times daily UFH). If creatinine clearance is  $<30$  mL/min, use dalteparin (grade 1A) or another form of LMWH that has a low degree of renal metabolism (grade 2C) or UFH (grade 1A).
2. Patients with severe sepsis be treated with a combination of pharmacologic therapy and intermittent pneumatic compression devices whenever possible (grade 2C).
3. Septic patients who have a contraindication for heparin use (eg, thrombocytopenia, severe coagulopathy, active bleeding, recent intracerebral hemorrhage) not receive pharmacoprophylaxis (grade 1B), but receive mechanical prophylactic treatment, such as graduated compression stockings or intermittent compression devices (grade 2C), unless contraindicated. When the risk decreases start pharmacoprophylaxis (grade 2C).



# Supportive therapy



Clostridium  
difficile



PPI

## U. Stress Ulcer Prophylaxis

1. Stress ulcer prophylaxis using H2 blocker or proton pump inhibitor be given to patients with severe sepsis/septic shock who have bleeding risk factors (grade 1B).
2. When stress ulcer prophylaxis is used, proton pump inhibitors rather than H2RA (grade 2D)
3. Patients without risk factors do not receive prophylaxis (grade 2B).

# Supportive therapy

## V. Nutrition

1. Administer oral or enteral (if necessary) feedings, as tolerated, rather than either complete fasting or provision of only intravenous glucose within the first 48 hours after a diagnosis of severe sepsis/septic shock (grade 2C).
2. Avoid mandatory full caloric feeding in the first week but rather suggest low dose feeding (eg, up to 500 calories per day), advancing only as tolerated (grade 2B).
3. Use intravenous glucose and enteral nutrition rather than total parenteral nutrition (TPN) alone or parenteral nutrition in conjunction with enteral feeding in the first 7 days after a diagnosis of severe sepsis/septic shock (grade 2B).
4. Use nutrition with no specific immunomodulating supplementation rather than nutrition providing specific immunomodulating supplementation in patients with severe sepsis (grade 2C).

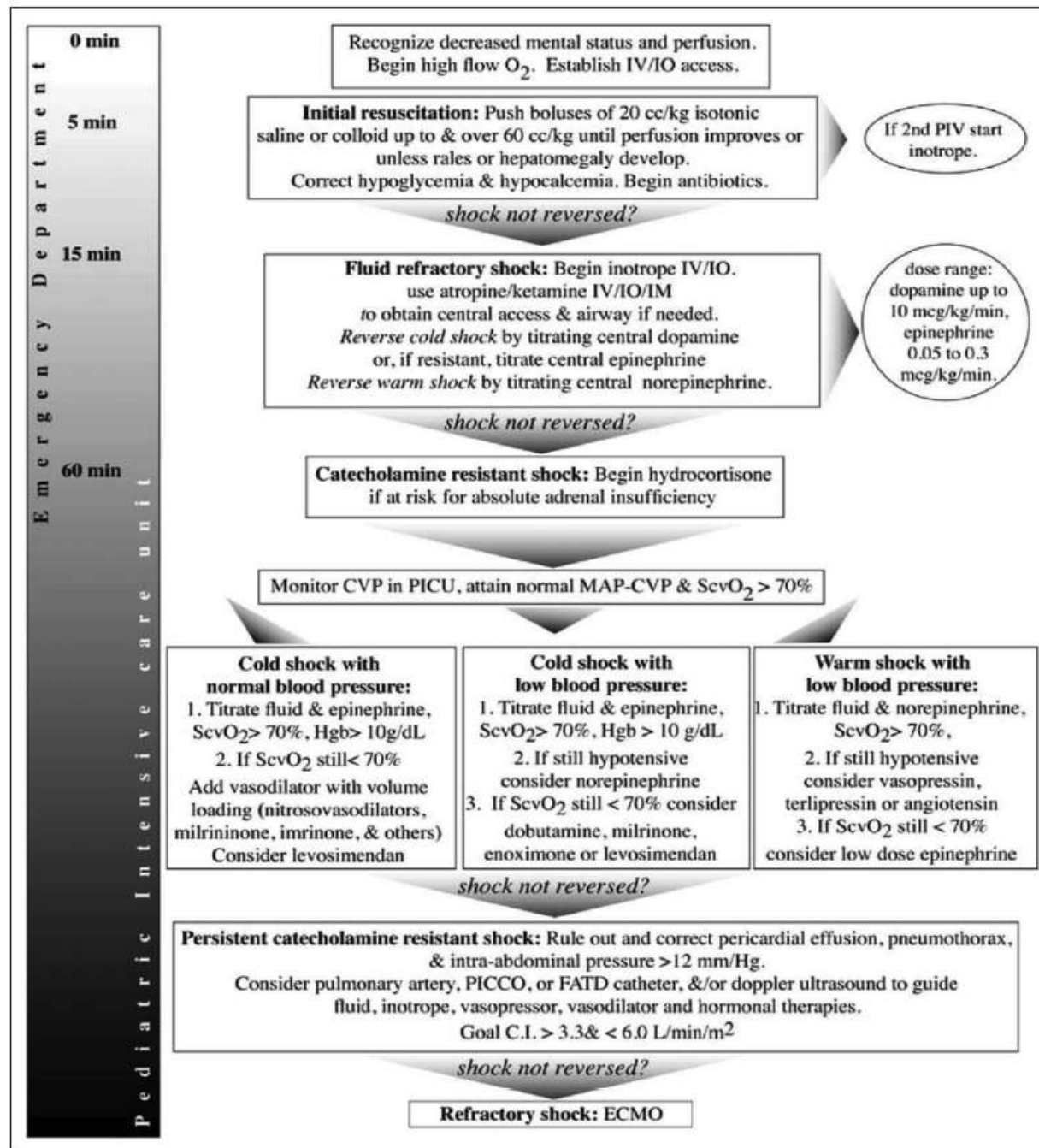


# Supportive therapy

## W. Setting Goals of Care

1. Discuss goals of care and prognosis with patients and families (grade 1B).
  2. Incorporate goals of care into treatment and end-of-life care planning, utilizing palliative care principles where appropriate (grade 1B).
  3. Address goals of care as early as feasible, but no later than within 72 hours of ICU admission (grade 2C).
-

# Children's septic shock



**Figure 2.** Algorithm for time sensitive, goal-directed stepwise management of hemodynamic support in infants and children. Reproduced from Brierley J, Carcillo J, Choong K, et al: Clinical practice parameters for hemodynamic support of pediatric and neonatal septic shock: 2007 update from the American College of Critical Care Medicine. *Crit Care Med* 2009; 37:666-688.

# DIC ISTH score

Laboratory Test	Result	Score
Platelet count (cells/uL)	>100,000	0
	50,000 – 100,000	1
	<50,000	2
Increase in fibrinogen and fibrin-related markers (eg, FDP's)	None	0
	Moderately Increased	2
	Strongly increased	3
Prolonged prothrombin time	<3	0
	3-5.9	1
	>6	2
Fibrinogen	>1 g/dL	0
	< 1 g/dL	1

fastbleep))

# DIC meningitis

