Surgical Critical Care

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Objectives

Medical Expert:

1. Evidence and indications for **hemodynamic monitoring** (arterial catheter, central venous catheter, pulmonary artery catheter)
2. Definition, classification of **shock**
3. Diagnosis and management of various causes of shock (hypovolemic, cardiogenic, septic, neurologic and anaphylactic)
4. Evidence and end points of **resuscitation**
5. Definition, classification and management of **respiratory failure** (acute lung injury, ARDS, indications for tracheostomy)
6. Methods and indications for various modes of ventilation support
7. Etiology, diagnosis, grading and management of **abdominal compartment syndrome**
8. Etiology, diagnosis and management of acute renal failure (indications for dialysis)
9. Pathophysiology and management of **sepsis**
10. Goal directed therapy in ICU
11. Definition and microbiology of surgical site infections
12. **Nutrition** in the critically ill patient (TPN, enteral feeds)

Collaborator:

1. Evidence for critical care out reach teams

Health Advocate:

1. **Prophylaxis** in critically ill patient (GI, VAP, DVT etc….)

Manager:

1. Indications for admission and discharge from ICU

Scholar:

1. Review of some of the most recent seminal papers on topic

(Staff to lead Discussion)

Agenda

1. Introduction to ICU
2. Shock, hemodynamic monitoring, and resuscitation
3. Sepsis
4. Respiratory failure, mechanical ventilation, ECMO, tracheostomy
5. Abdominal compartment syndrome
6. Nutrition for the critically ill patient

Intensive Care Unit

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ICU

- Specific unit in hospital where advanced monitoring and organ support are available
  - Mechanical ventilation
  - Renal replacement therapy
  - Invasive cardiac monitoring
  - Vasopressors
  - Equipment
  - Close monitoring: high nurse to patient ratio (1:1 or 1:2)

- Postoperative monitoring in medically ill patients or for postoperative complications

Prophylaxis in ICU

- **VTE**
  - LMWH

- **Peptic ulcer**
  - PPI

- **Ventilation associated pneumonia**
  - Elevate head of bed
  - Daily sedation ”vacations” and assessment of readiness to extube
  - Daily oral care with chlorhexidine

Shock

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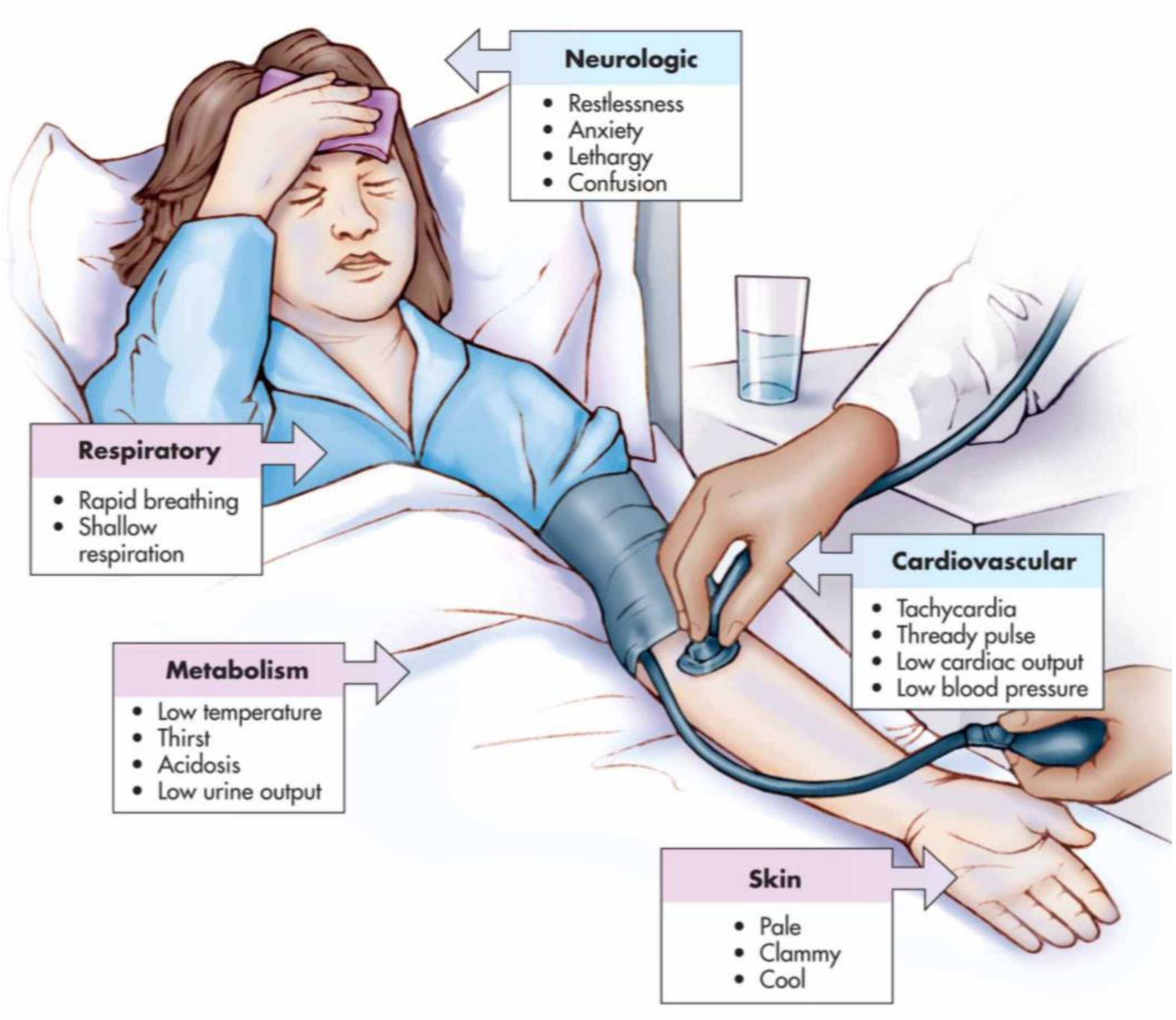
Recognizing shock



Hypovolemic shock

Causes

- Hemorrhagic
  - Trauma
  - GI bleed
- Non-hemorrhagic
  - Absolute fluid loss (renal, GI)
  - Redistributive or third spacing

Hypovolemic/hemorrhagic shock

TABLE 8.4

CLASSIFICATION OF HEMORRHAGIC SHOCK

	CLASS I	CLASS II	CLASS III	CLASS IV
Blood loss (mL)	Up to 750	750–1,500	1,500–2,000	>2,000
Blood loss (%)	Up to 15	15–30	30–40	40
Heart rate	<100	>100	>120	>140
Blood pressure	Normal	Normal	Decreased	Decreased
Pulse pressure	Normal	Decreased	Decreased	Decreased
Respiratory rate	14–20	20–30	30–40	>35
Urine output (mL/h)	>30	20–30	5–15	Minimal
Mental status	Normal	Mildly anxious	Anxious and confused	Confused and lethargic
Fluid replacement	Crystalloid	Crystalloid	Crystalloid and blood	Crystalloid and blood

Cardiogenic shock

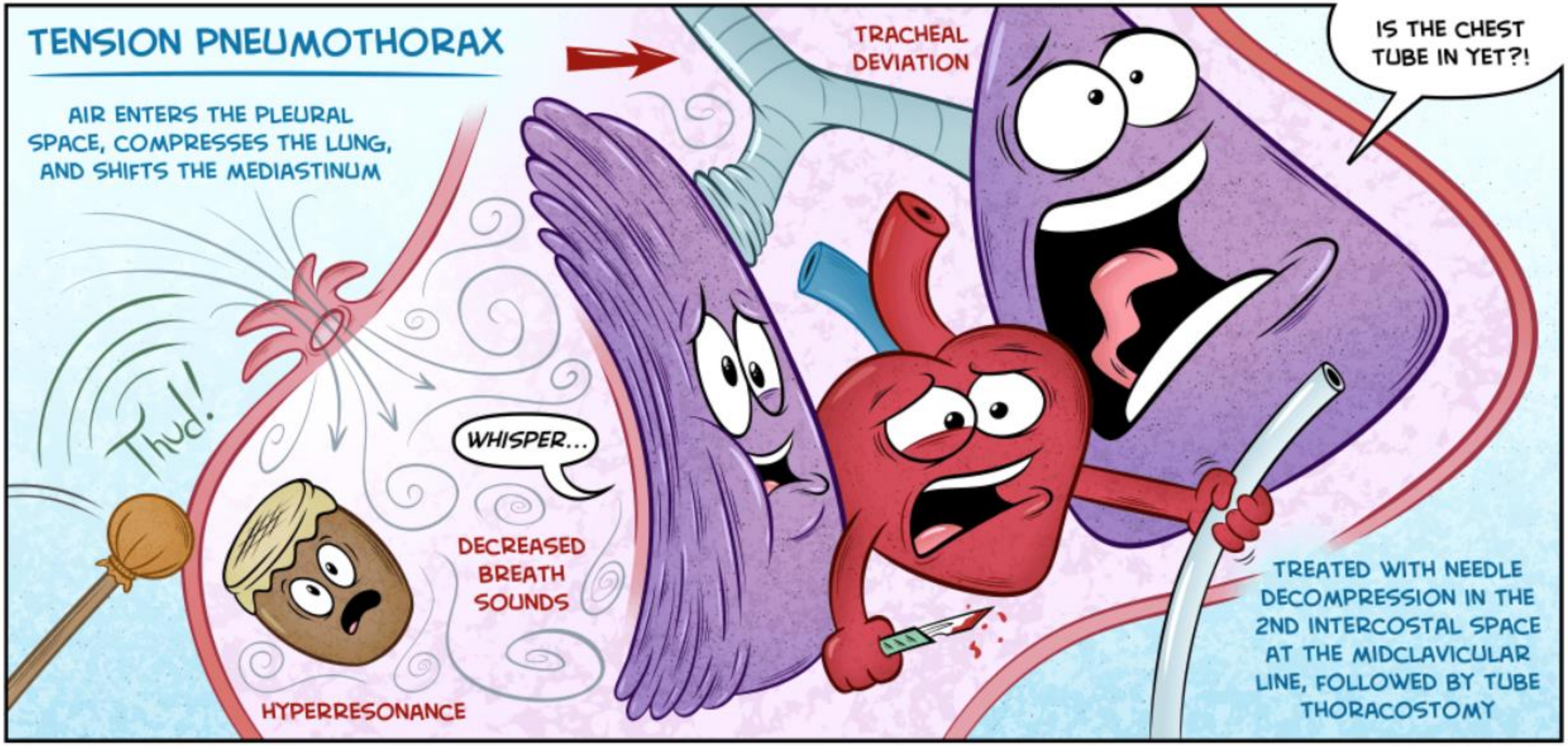
Causes

- **Myocardial**
  - Ischemia
  - Infarction
  - Contusion

- **Valvular**
  - Infection
  - Ruptured papillary muscle
  - Stenosis

- **Arrhythmia**

Obstructive shock



WWW.MEDCOMIC.COM

Causes

- Tension pneumothorax
- Cardiac tamponade
  - Beck's Triad
    - Hypotension
    - Muffled heart sounds
    - JVD
- Positive pressure ventilation
- Mediastinal tumor

Distributive shock

- **Septic**
- **Anaphylactic**
  - Drugs
  - venoms
- **Neurogenic**
  - Spinal cord injury

TABLE 1: Commonly used inotropic and vasopressor medications

Medication	Dose range	Mechanism	Indications
Norepinephrine	1-20 µg/min	α_1, α_2, β_1	Inotrope and vasoconstrictor
Epinephrine	1-20 µg/min	α_1, α_2, β_1, β_2	Inotrope and vasoconstrictor
Dopamine	1-20 µg/kg/min	α_1, α_2, β_1, β_2, dopamine	Inotrope and vasoconstrictor
Dobutamine	2-20 µg/kg/min	β_1, β_2	Inotrope and vasodilator
Phenylephrine	20-200 µg/min	α_1	Vasoconstrictor
Isoproterenol	1-20 µg/min	β_1, β_2	Inotrope and chronotrope
Milrinone	0.25-0.75 µg/kg/min	Phosphodiesterase 3 inhibitor	Inotrope and vasodilator
Vasopressin	0.01-0.04 U/min	Vasopressin V_1 and V_2 receptors	Vasoconstrictor in catecholamine-resistant shock

Monitoring the shock state

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Hemodynamic monitoring

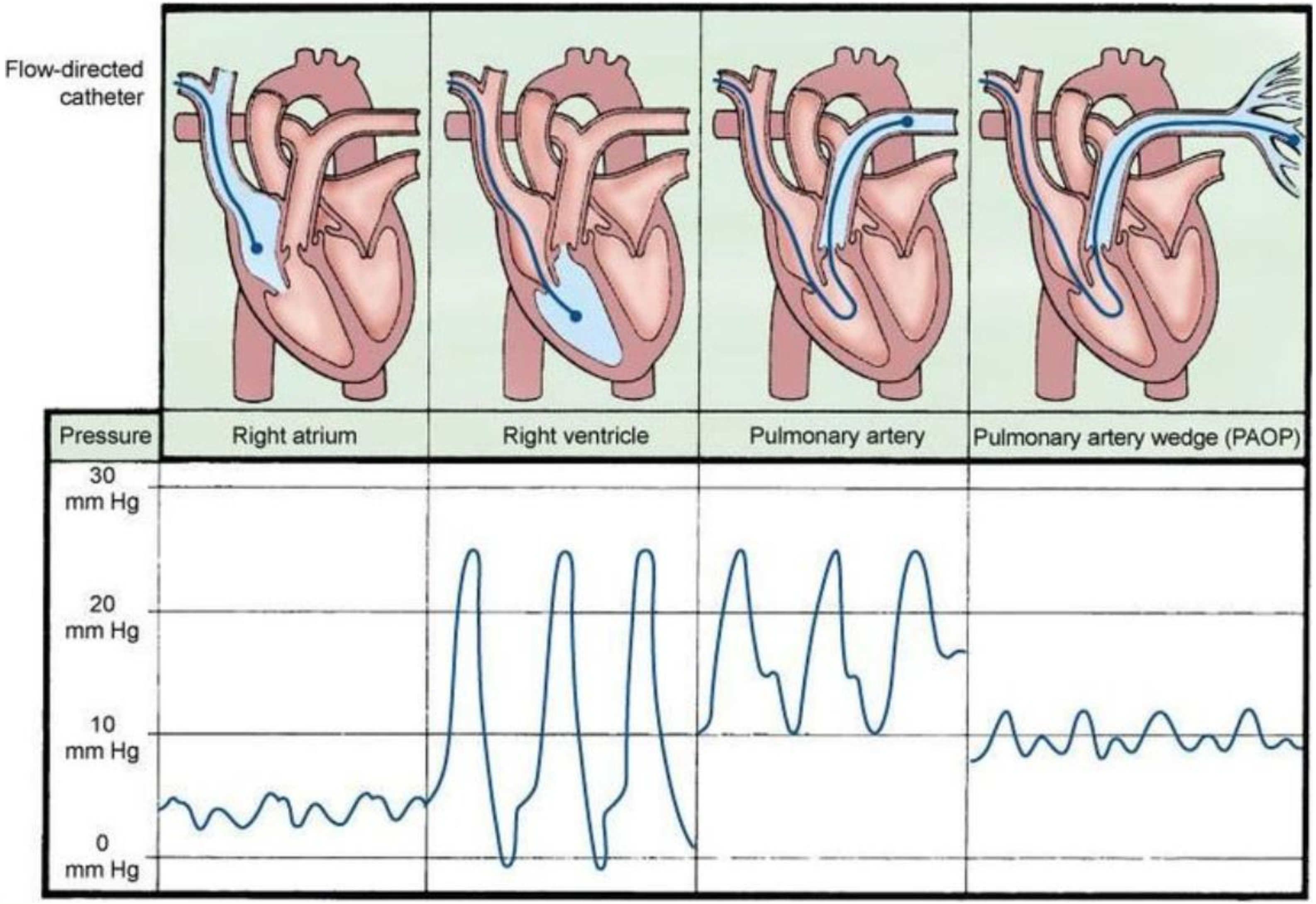
- Vitals
  - HR
  - BP

- **Arterial catheters**
  - Continuous monitoring of systemic arterial pressure
  - Frequent arterial blood gas monitoring
  - Complications: infection, thrombosis
  - Radial or dorsalis pedis preferred to brachial or femoral

Central venous catheters

- Indications
  - Long term venous access for TPN, vasoactive medications
  - Measure central venous pressure (CVP)
- Complications
  - Dysrhythmias
  - Pneumothorax
  - Arterial puncture + intimal flap
  - Pseudoaneurysm
  - Hemorrhage
  - Air embolism
- CVP monitoring
  - Assess right heart function
  - Assess volume status
  - ScvO2

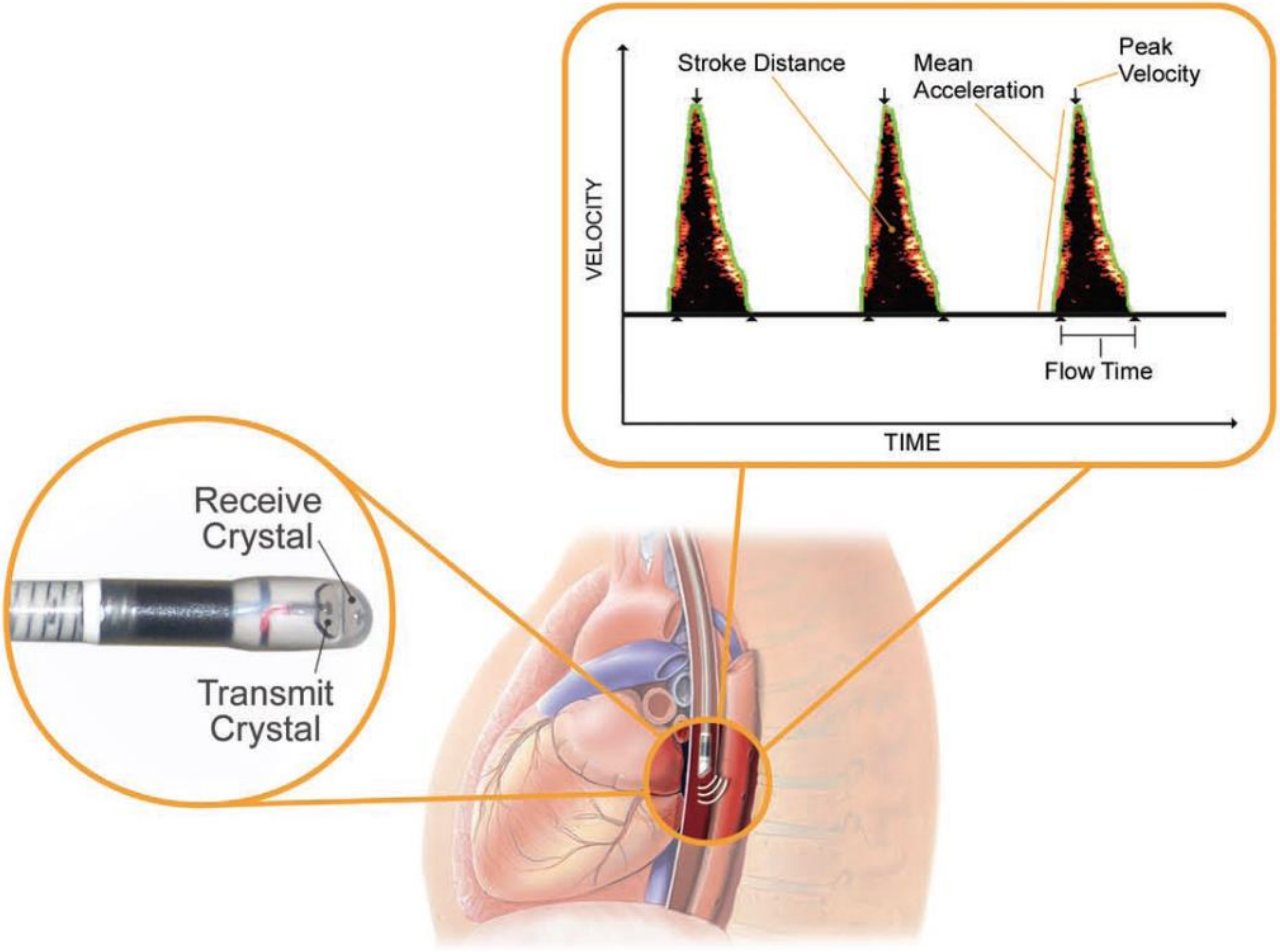
Pulmonary arterial catheters



Pulmonary arterial catheters

- Can directly measure:
  - CVP
  - Right arterial pressure
  - Pulmonary arterial pressure
  - Right ventricular end – diastolic pressure
  - Pulmonary capillary wedge pressure
    - Estimation of left ventricular end diastolic pressure
    - Low PCWP indicates low LV end diastolic volume
  - Mixed oxygen saturation
- Measurements provide information on volume status, cardiac performance
- **Current evidence does not demonstrate survival benefit and may be associated with higher morbidity**

Esophageal Doppler



Pulse contour derived cardiac output (FLO TRAC)

- Transducer that can be hooked up to any arterial line

- Uses pressure points and vascular resistance to calculate:
  - Stroke volume
  - Continuous cardiac output
  - Stroke volume variability - % of variability in stroke volume between inspiration ad expiration
    - > 13% in a patient with normal lung compliance suggest patient is dry

- Full mechanical ventilation patients with fixed volume and RR only

POCUS

- Safe and effective
- Immediate images that is in real time and dynamic
- Assists in **procedural guidance** → improve success and decrease complications
- **Diagnostic assessment**
  - FAST – intra-abdominal fluid, pericardial fluid
  - Pulmonary assessment – pneumothorax, pleural effusion, consolidation
  - Assessment of volume status
  - Basic assessment of cardiac function

Type of Shock	Cardiac Function	IVC	Treatment
Septic	Hyperdyamic/ Hypodynamic	Narrow; collapses with inspiration	IV fluids +/- vasopressors
Cardiogenic	Hypodynamic	Dilated; little or no collapse with insp.	Inotropes
Hypovolemic	Hyperdynamic	Narrow & collapses	IV fluids/blood
Cardiac Tamponade (Obstructive)	Pericardial effusion; diastolic collapse RV	Dilated; no collapse	Pericardiocentesis
Pulmonary Embolus (Obstructive)	Dilated RA & RV	Dilated; little or no colapse	Thrombolytics

Courtesy of Dr. Parry

Resuscitation

Fluid resuscitation

- Crystalloids
  - **Lactated ringers**
  - **Normal saline**
  - Isotonic
  - Rapidly replaces interstitial fluid compartment
- Colloids
  - **Albumin**
  - Increases oncotic pressure and protects lung from interstitial edema
- Blood products
  - pRBC

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

A Comparison of Albumin and Saline for Fluid Resuscitation in the Intensive Care Unit

The SAFE Study Investigators*

End points of resuscitation

- Vitals
  - BP
  - HR

- End organ function
  - Urine output
    - 0.5-1 mL/kg/hr for adults
    - 1 mL/kg/hr for kids
    - 1-2 mL/kg/hr in toddlers < 2 yrs of age

  - Mental status

End points of resuscitation

- Physiologic biomarkers
  - Lactate
    - Elevation indicates shift from aerobic to anaerobic metabolism due to underperfusion/lack of oxygen delivery
    - Time required to normalize serum lactate = prognostic factor
  - Base deficit
    - Amount of a fixed base that must be added to an aliquot of blood to restore the pH to 7.40
    - Time required to normalize has even greater prognostic significance than that of lactate

  - Lactate ≥ 4 mmol/L or base deficit ≥ 6 mEq/L should be considered in shock until proven otherwise

Sepsis

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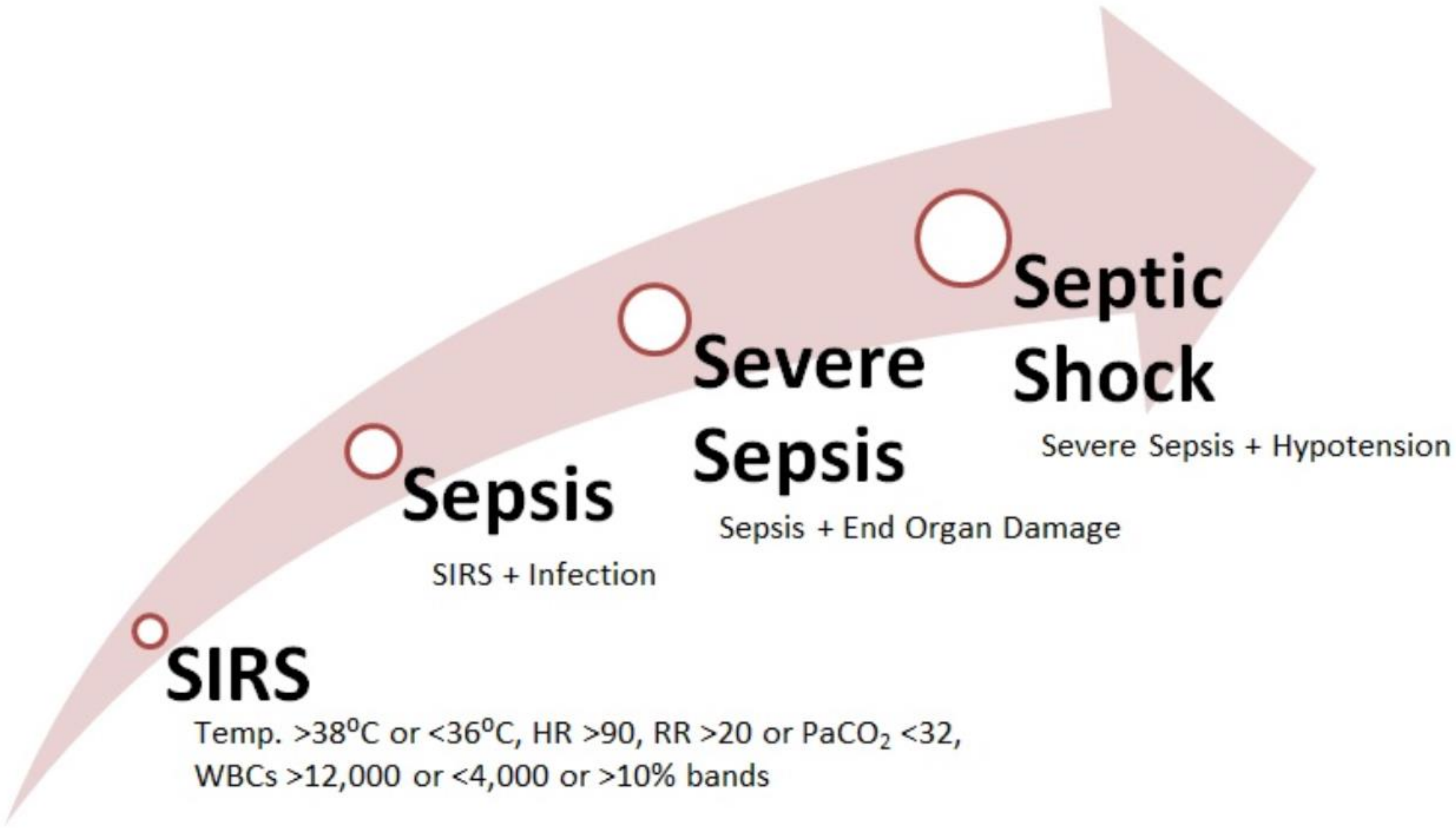
SIRS → septic shock



New definitions?

Clinical Review & Education

Special Communication | CARING FOR THE CRITICALLY ILL PATIENT

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; Rinaldo 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; Jean-Louis Vincent, MD, PhD; Derek C. Angus, MD, MPH

Def'n of sepsis: life-threatening organ dysfunction caused by a dysregulated host response to infection

Def'n of septic shock: subset of sepsis in which particularly profound circulatory, cellular, and metabolic abnormalities are associated with a greater risk of mortality than with sepsis alone

- Vasopressor requirement with maintain a MAP of 65 mmHg
- Serum lactate > 2 mmol/L in the absence of hypovolemia

Table 1. Sequential [Sepsis-Related] Organ Failure Assessment Score[a]

System	Score 0	1	2	3	4
Respiration					
Pao_2/Fio_2, mm Hg (kPa)	≥400 (53.3)	<400 (53.3)	<300 (40)	<200 (26.7) with respiratory support	<100 (13.3) with respiratory support
Coagulation					
Platelets, $\times 10^3/\mu L$	≥150	<150	<100	<50	<20
Liver					
Bilirubin, mg/dL (μmol/L)	<1.2 (20)	1.2-1.9 (20-32)	2.0-5.9 (33-101)	6.0-11.9 (102-204)	>12.0 (204)
Cardiovascular	MAP ≥70 mm Hg	MAP <70 mm Hg	Dopamine <5 or dobutamine (any dose)[b]	Dopamine 5.1-15 or epinephrine ≤0.1 or norepinephrine ≤0.1[b]	Dopamine >15 or epinephrine >0.1 or norepinephrine >0.1[b]
Central nervous system					
Glasgow Coma Scale score[c]	15	13-14	10-12	6-9	<6
Renal					
Creatinine, mg/dL (μmol/L)	<1.2 (110)	1.2-1.9 (110-170)	2.0-3.4 (171-299)	3.5-4.9 (300-440)	>5.0 (440)
Urine output, mL/d				<500	<200

Abbreviations: Fio_2, fraction of inspired oxygen; MAP, mean arterial pressure; Pao_2, partial pressure of oxygen.

[a] Adapted from Vincent et al.[27]

[b] Catecholamine doses are given as μg/kg/min for at least 1 hour.

[c] Glasgow Coma Scale scores range from 3-15; higher score indicates better neurological function.

Screening

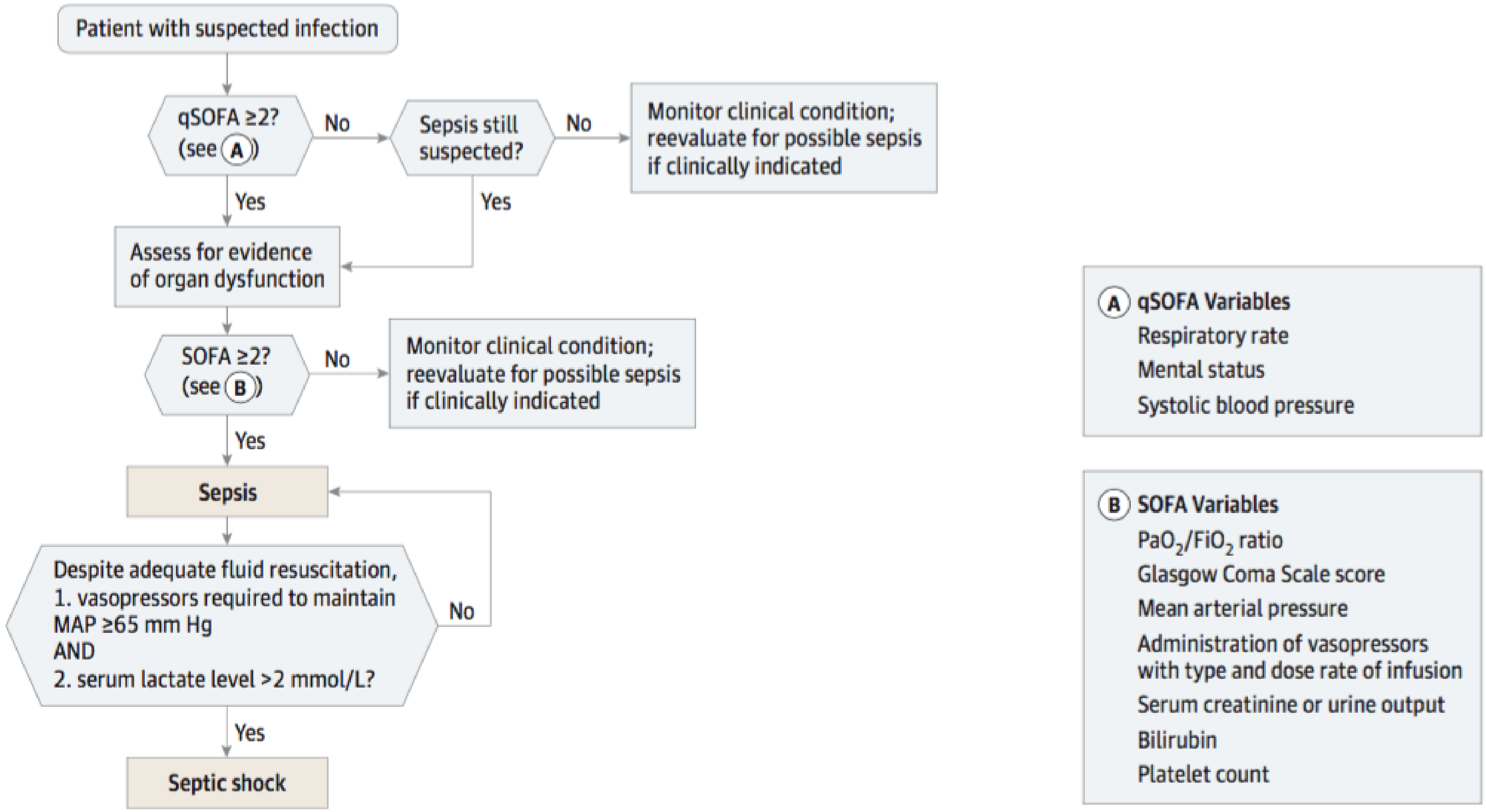
Box 4. qSOFA (Quick SOFA) Criteria

Respiratory rate ≥22/min

Altered mentation

Systolic blood pressure ≤100 mm Hg

Figure. Operationalization of Clinical Criteria Identifying Patients With Sepsis and Septic Shock



The baseline Sequential [Sepsis-related] Organ Failure Assessment (SOFA) score should be assumed to be zero unless the patient is known to have preexisting (acute or chronic) organ dysfunction before the onset of infection. qSOFA indicates quick SOFA; MAP, mean arterial pressure.

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A Randomized Trial of Protocol-Based Care for Early Septic Shock

The ProCESS Investigators*

ABSTRACT

The NEW ENGLAND JOURNAL of MEDICINE

ORIGINAL ARTICLE

Goal-Directed Resuscitation for Patients with Early Septic Shock

The ARISE Investigators and the ANZICS Clinical Trials Group*

Surviving Sepsis Campaign: Association Between Performance Metrics and Outcomes in a 7.5-Year Study

Mitchell M. Levy, MD, FCCM[1]; Andrew Rhodes, MB BS, MD (Res)[2]; Gary S. Phillips, MAS[3]; Sean R. Townsend, MD[4]; Christa A. Schorr, RN, MSN[5]; Richard Beale, MB BS[6]; Tiffany Osborn, MD, MPH[7]; Stanley Lemeshow, PhD[8]; Jean-Daniel Chiche, MD[9]; Antonio Artigas MD, PhD[10]; R. Phillip Dellinger, MD, FCCM[11]

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*

Respiratory Failure

Acute respiratory failure

Def’n: respiratory system failure or dysfunction resulting in abnormalities of gas exchange, including oxygenation and/or CO2 elimination

Common etiologies include:
- Pneumonia
- Atelectasis
- Aspiration
- Pulmonary edema
- ARDS
- PE

Classification

Hypoxemic respiratory failure (type I): $PaO_2 < 60$ mmHg on room air

- Most common form of respiratory failure
- Major immediate threat to organ function

Hypercapnic respiratory failure (type II): $PaCO_2 > 50$ mmHg on room air

Acute lung injury and ARDS

TABLE 9.3

RECOMMENDED CRITERIA FOR ACUTE LUNG INJURY AND ACUTE RESPIRATORY DISTRESS SYNDROME[a]

	TIMING	OXYGENATION	CHEST RADIOGRAPH	PULMONARY ARTERY WEDGE PRESSURE
Acute lung injury (ALI)	Acute onset	$PaO_2/FiO_2 \leq 300$ regardless of PEEP level	Bilateral infiltrates on frontal chest radiograph	≤18 when measured or no clinical evidence of left atrial hypertension
Acute respiratory distress syndrome (ARDS)	Acute onset	$PaO_2/FiO_2 \leq 200$ regardless of PEEP level	Bilateral infiltrates on frontal chest radiograph	≤18 when measured or no clinical evidence of left atrial hypertension

ARDS

FiO2 = Fraction of inspired oxygen

- Atmospheric air is 20% O2 but we often give supplemental O2

PaO2 = partial pressure of oxygen in arterial blood

PaO2/FiO2 ratio = oxygen level in the blood (arterial) to oxygen concentration that is breathed

- Helps determine problems with oxygen exchange/ventilation
- > 500 is normal

TABLE 6: New acute respiratory distress syndrome "Berlin" definition 2012

Acute respiratory distress	Syndrome (ARDS)
Timing	Within 1 week of a known clinical insult or new or worsening respiratory symptoms *(New addition, AECC stated "acute onset" with no definition)*
Chest imaging	Bilateral opacities on chest radiograph or chest computed tomographic scan *(No change from AECC definition)*
Origin of edema	Respiratory failure not fully explained by cardiac failure or fluid overload *(No change from AECC definition, but removed pulmonary artery wedge pressure criterion from definition given declining use of PA catheters)*
Oxygenation	
Mild	PaO_2/FiO_2 ratio 201-300 mm Hg with PEEP or CPAP ≥ 5 cm H_2O *(The term "acute lung injury, ALI" in AECC definition was removed, and added a minimum level of PEEP)*
Moderate	PaO_2/FiO_2 ratio 101-200 mm Hg with PEEP ≥ 5 cm H_2O
Severe	PaO_2/FiO_2 ratio ≤ 100 mm Hg with PEEP ≥ 5 cm H_2O

Prevention

Preoperative

- Smoking cessation 8 weeks prior to surgery
- Optimization of chronic pulmonary diseases

Intraoperative

- Regional anesthesia if possible

Postoperative

- Adequate pain control
- Prevention of aspiration
- Deep breathing exercises
- Chest physio/incentive spirometry

Noninvasive ventilation

- Provides positive pressure ventilation without the need for an invasive airway
- First line in ARF due to COPD exacerbation
  - Lower mortality rates
  - Decreased need for intubation
  - Less complications
  - Reduced length of hospital stay
- Safe for adult patients with ARF due to acute cardiogenic pulmonary edema

Intubation & mechanical ventilation

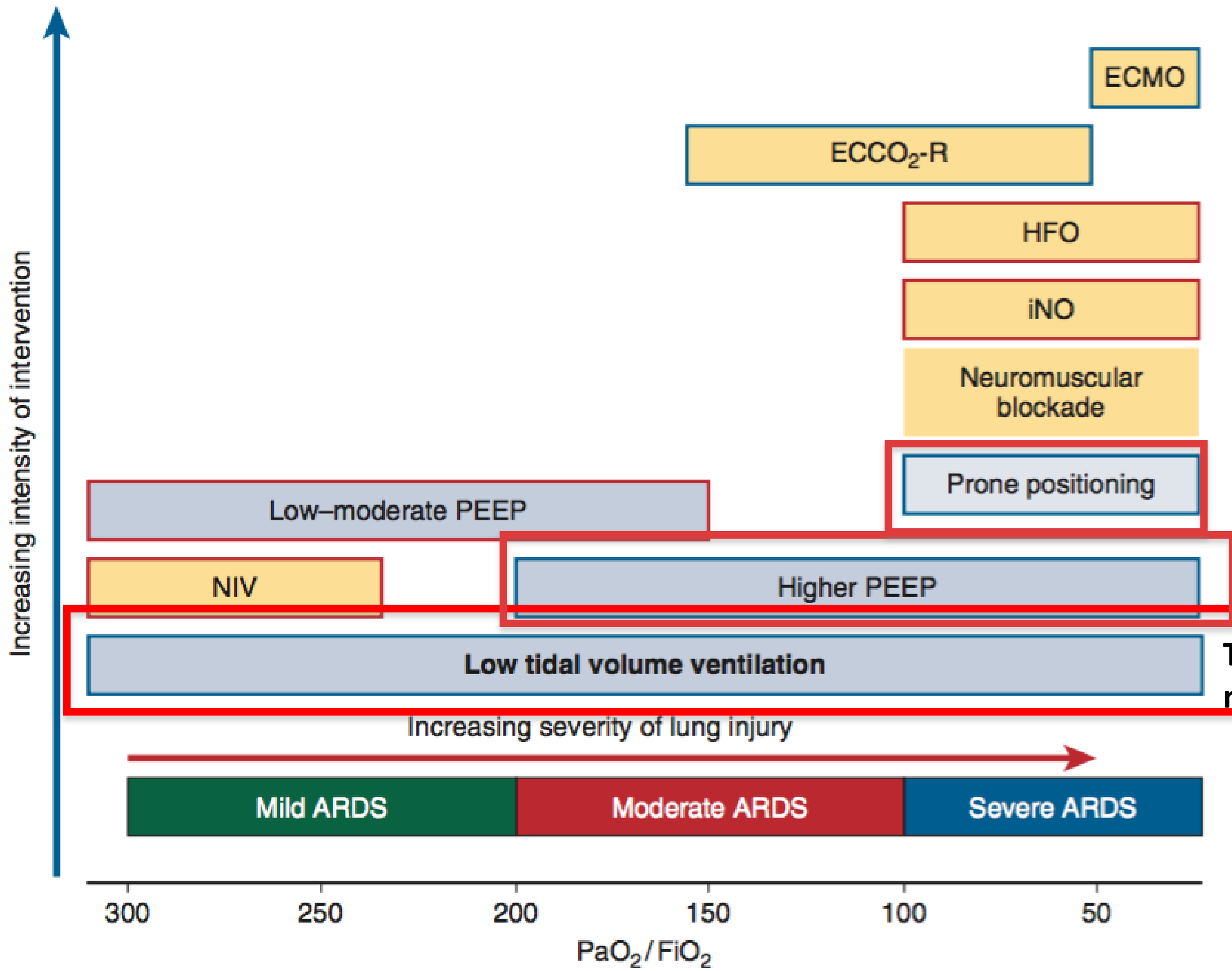
Volume modes: tidal volume is set and airway pressure is variable (depends on pulmonary compliance and airway resistance)

1. Controlled mechanical ventilation (CMV)
2. Assist-control ventilation (ACV)
3. Synchronous intermittent mandatory ventilation (SIMV)

Pressure modes: airway pressure is set and tidal volume is variable

1. Pressure control ventilation (PCV)
2. Pressure support ventilation (PSV)
3. Pressure regulated volume control (PRVC)
4. Airway pressure release ventilation (APRV)

Management

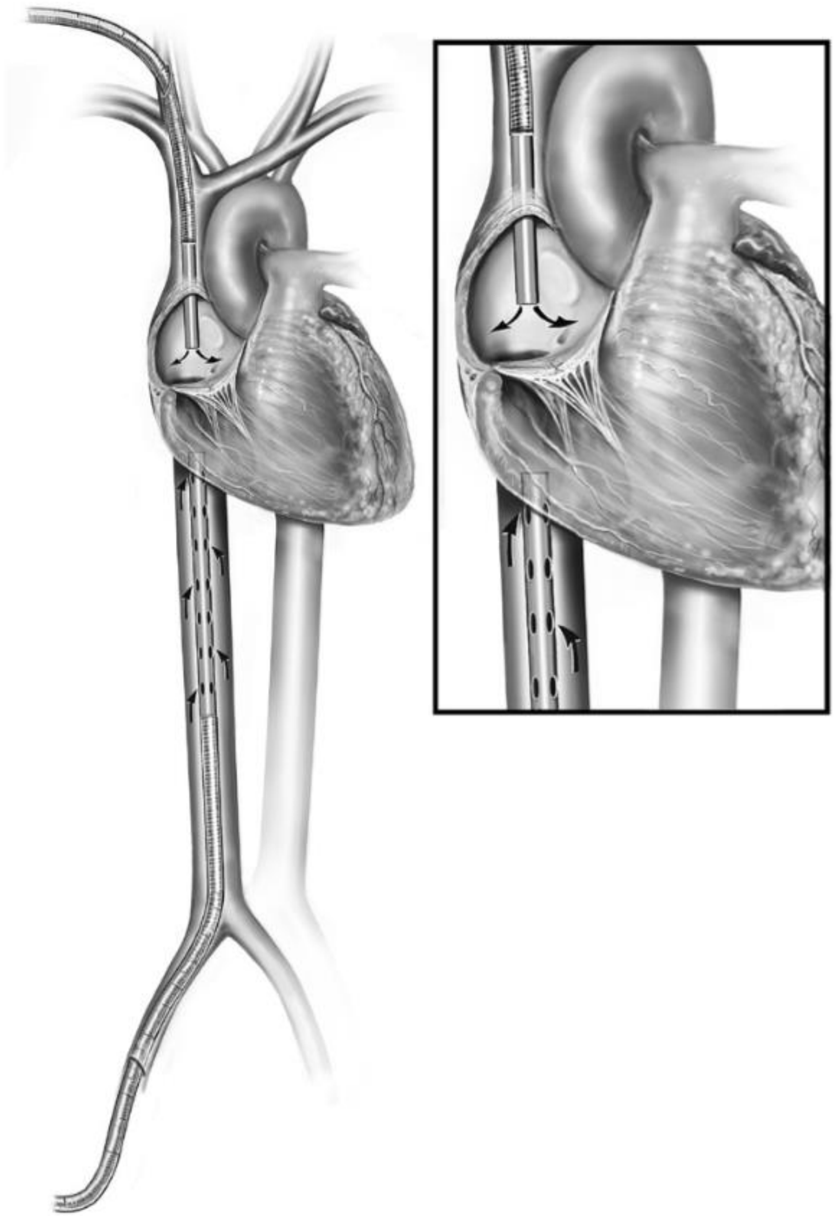


Tidal volume: 6 mL/kg

ECMO

VV ECMO: removes deoxygenated blood from the venous circulation, removes CO_2, and oxygenates the blood and returns it to the right atrium and ventricle

Indication: any adult patient suffering from acute onset and potentially reversible severe respiratory failure with significant hypoxia or hypercarbia despite maximal ventilator management



Tracheostomy

TABLE 1: Indications for tracheostomy or cricothyroidotomy

Ventilator dependence	Facilitation of ventilation support Prolonged intubation
Airway obstruction	Anatomic abnormalities Angioedema Burns Failed intubation Infection leading to obstruction Laryngeal dysfunction Neck irradiation Neoplasm Neurologic dysfunction or injury Obstructive sleep apnea Postoperative Traumatic obstruction
Pulmonary toilet	Aspiration Excessive bronchopulmonary secretions

- **Advantages**
  - Patient comfort
  - Decreased nursing care
  - Better patient communication
  - Decrease the need for ventilator dependence
  - Decreases risk of subglottic stenosis

Complications

Early (within 7 days)

- **Bleeding**
- **Pneumothorax**
- Pneumomediastinum
- Subcutaneous emphysema
- Infection
- Loss of airway (accidental decannulation)
- Airway obstruction

Late (after 7 days)

- Laryngotracheal stenosis
- Tracheoinominate fistula
- Tracheoesophageal fistula
- Tracheomalacia
- Vocal cord paralysis (rare)

Decannulation

- Off ventilator for at least 48 hours
- Little secretion/suction requirement
- Downsize – after 7-10 days until stoma track is well formed
- Trial capped period 24-48 hours

Abdominal Compartment Syndrome

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Abdominal compartment syndrome

- Normal intra-abdominal pressure is **5-7 mmHg** in a closed abdomen

- Gold standard measurement is bladder pressure
  - End expiration
  - Supine
  - Relaxed/sedated state
  - Instill 25cc NS
  - Measure 30-60 sec after instillation

Causes of increased abdominal pressure

- Intra-abdominal hemorrhage or ascites
- Circumferential torso burn
- Reduction of large ventral hernia
- Bowel distension
- Pneumoperitoneum

- **Secondary ACS** – in the absence of abdominopelvic pathology and is entirely caused by edema following shock and aggressive resuscitation

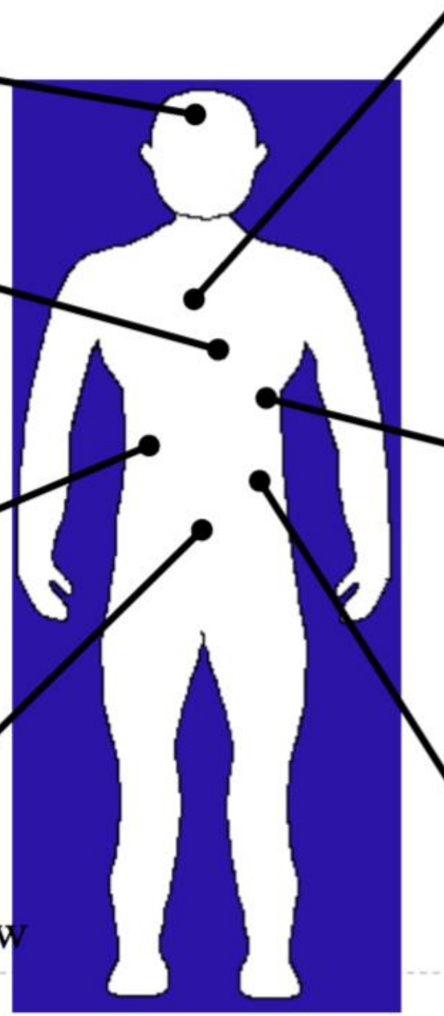
Intra-abdominal hypertension

- IAP > 12 mmHg

IAH Grading

Grade I	IAP 12-15 mmHg
Grade II	IAP 16-20 mmHg
Grade III	IAP 21-25 mmHg
Grade IV	IAP >25 mmHg

Systemic effects of IAH



CNS
- ↑ ICP
- ↓ CPP

Cardiovascular
- Hypovolemia
- ↓ venous return
- ↓ CO
- ↑ SVR
- ↑ PAOP, CVP

Hepatic
- ↓ portal blood flow
- ↓ lactate clearance

Gastrointestinal
- ↓ celiac / SMA blood flow

Pulmonary
- ↑ PIP, Paw
- ↑ Qs/Qt, Vd/Vt
- ↓ compliance/lung volume
- Atelectasis
- Hypoxia
- Hypercarbia

Thoracoabdominal
- Elevated diaphragm
- ↑ intrathoracic pressure
- IVC distortion
- ↓ wall compliance
- ↓ abd wall blood flow

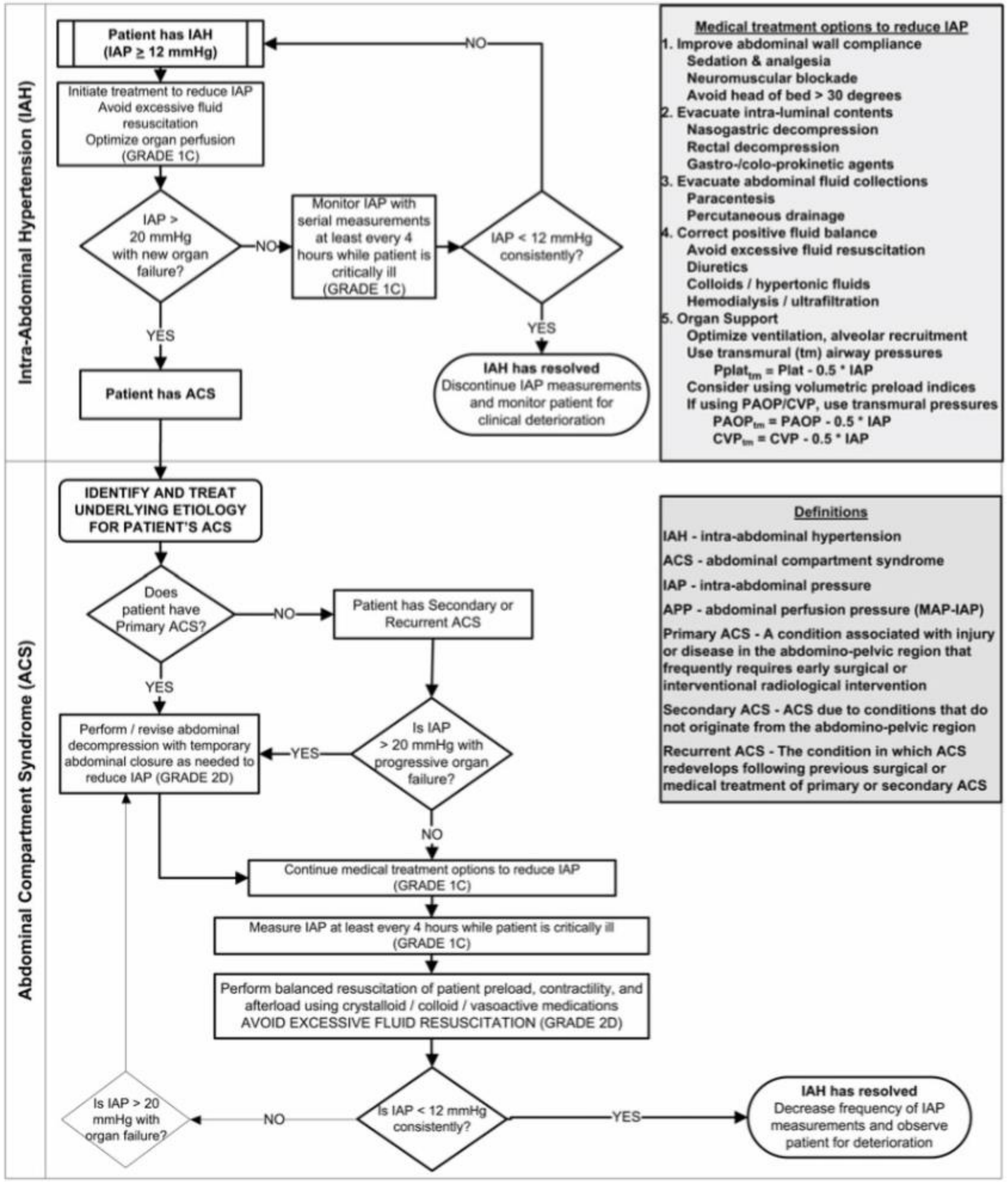
Renal
- ↓ renal blood flow
- ↓ UOP
- ↓ GFR

Courtesy of Dr. Mele/Parry

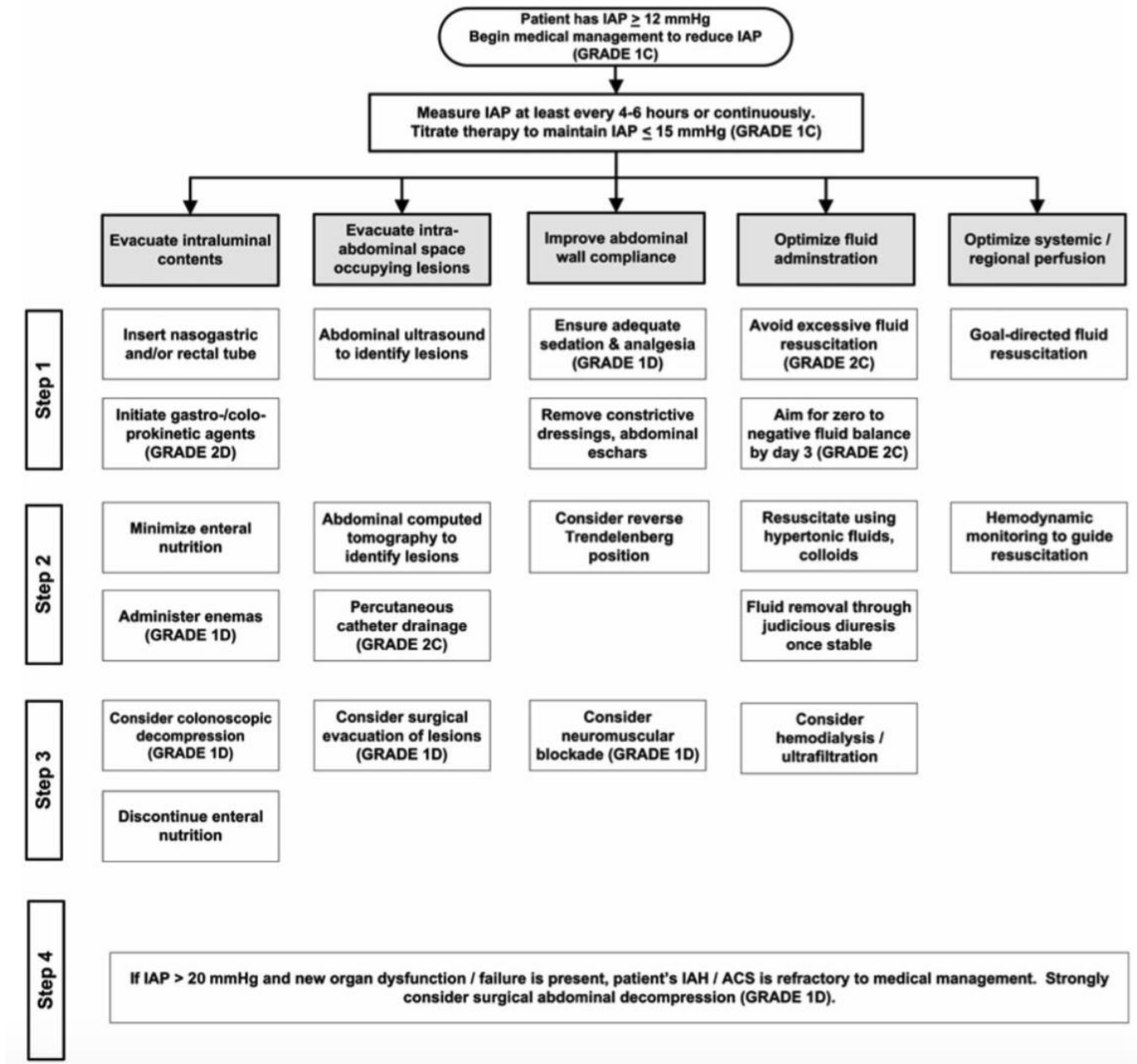
Abdominal compartment syndrome

- Sustained elevated IAP **> 20 mmHg** associated with new end organ damage/failure

- **Triad of ACS**
  - IAP > 20 mmHg
  - Adverse effect on end-organ(s)
  - Abdominal decompression has beneficial effects



Intra-Abdominal Hypertension (IAH)
Patient has IAH (IAP ≥ 12 mmHg)
Initiate treatment to reduce IAP
Avoid excessive fluid resuscitation
Optimize organ perfusion
(GRADE 1C)
IAP > 20 mmHg with new organ failure?
NO
Monitor IAP with serial measurements at least every 4 hours while patient is critically ill (GRADE 1C)
IAP < 12 mmHg consistently?
NO
YES
IAH has resolved
Discontinue IAP measurements and monitor patient for clinical deterioration
YES
Patient has ACS
Medical treatment options to reduce IAP
1. Improve abdominal wall compliance
Sedation & analgesia
Neuromuscular blockade
Avoid head of bed > 30 degrees
2. Evacuate intra-luminal contents
Nasogastric decompression
Rectal decompression
Gastro-/colo-prokinetic agents
3. Evacuate abdominal fluid collections
Paracentesis
Percutaneous drainage
4. Correct positive fluid balance
Avoid excessive fluid resuscitation
Diuretics
Colloids / hypertonic fluids
Hemodialysis / ultrafiltration
5. Organ Support
Optimize ventilation, alveolar recruitment
Use transmural (tm) airway pressures
$Pplat_{tm}$ = Plat - 0.5 * IAP
Consider using volumetric preload indices
If using PAOP/CVP, use transmural pressures
$PAOP_{tm}$ = PAOP - 0.5 * IAP
CVP_{tm} = CVP - 0.5 * IAP
Abdominal Compartment Syndrome (ACS)
IDENTIFY AND TREAT UNDERLYING ETIOLOGY FOR PATIENT'S ACS
Does patient have Primary ACS?
NO
Patient has Secondary or Recurrent ACS
YES
Perform / revise abdominal decompression with temporary abdominal closure as needed to reduce IAP (GRADE 2D)
Is IAP > 20 mmHg with progressive organ failure?
YES
NO
Continue medical treatment options to reduce IAP (GRADE 1C)
Measure IAP at least every 4 hours while patient is critically ill (GRADE 1C)
Perform balanced resuscitation of patient preload, contractility, and afterload using crystalloid / colloid / vasoactive medications
AVOID EXCESSIVE FLUID RESUSCITATION (GRADE 2D)
Is IAP < 12 mmHg consistently?
NO
Is IAP > 20 mmHg with organ failure?
YES
IAH has resolved
Decrease frequency of IAP measurements and observe patient for deterioration
Definitions
IAH - intra-abdominal hypertension
ACS - abdominal compartment syndrome
IAP - intra-abdominal pressure
APP - abdominal perfusion pressure (MAP-IAP)
Primary ACS - A condition associated with injury or disease in the abdomino-pelvic region that frequently requires early surgical or interventional radiological intervention
Secondary ACS - ACS due to conditions that do not originate from the abdomino-pelvic region
Recurrent ACS - The condition in which ACS redevelops following previous surgical or medical treatment of primary or secondary ACS


Patient has IAP ≥ 12 mmHg
Begin medical management to reduce IAP
(GRADE 1C)
Measure IAP at least every 4-6 hours or continuously.
Titrate therapy to maintain IAP ≤ 15 mmHg (GRADE 1C)
Evacuate intraluminal contents
Evacuate intra-abdominal space occupying lesions
Improve abdominal wall compliance
Optimize fluid adminstration
Optimize systemic / regional perfusion
Step 1
Insert nasogastric and/or rectal tube
Initiate gastro-/colo-prokinetic agents (GRADE 2D)
Abdominal ultrasound to identify lesions
Ensure adequate sedation & analgesia (GRADE 1D)
Remove constrictive dressings, abdominal eschars
Avoid excessive fluid resuscitation (GRADE 2C)
Aim for zero to negative fluid balance by day 3 (GRADE 2C)
Goal-directed fluid resuscitation
Step 2
Minimize enteral nutrition
Administer enemas (GRADE 1D)
Abdominal computed tomography to identify lesions
Percutaneous catheter drainage (GRADE 2C)
Consider reverse Trendelenberg position
Resuscitate using hypertonic fluids, colloids
Fluid removal through judicious diuresis once stable
Hemodynamic monitoring to guide resuscitation
Step 3
Consider colonoscopic decompression (GRADE 1D)
Discontinue enteral nutrition
Consider surgical evacuation of lesions (GRADE 1D)
Consider neuromuscular blockade (GRADE 1D)
Consider hemodialysis / ultrafiltration
Step 4
If IAP > 20 mmHg and new organ dysfunction / failure is present, patient's IAH / ACS is refractory to medical management. Strongly consider surgical abdominal decompression (GRADE 1D).

CCTC

- Sept 9, 2015 - Dec 31, 2015
- 45±6% prevalence of IAH
- 55% had Grade I IAH
- 8/128 (6.25%) developed ACS
- IAH was an independent predictor of ICU mortality

Courtesy of Pat Murphy

Nutrition

Nutrition in the critically ill

- Sources of energy
  - Carbohydrates
    - Brain cells and red blood cells are obligate users of glucose
  - Fat
  - Protein
- **Starvation adaptation**
  - Brain cells and RBCs develop the capacity to use ketones as an energy source
  - Proteins are a significant energy source in critically ill patients

Basal metabolic rate

Harris-Benedict equation

Women:

$$\text{BEE} = 655 + (9.6 \times \text{weight in kilos}) + (1.8 \times \text{height in cm}) - (4.7 \times \text{age in years})$$

Men:

$$\text{BEE} = 66\ (13.7 \times \text{weight in kilos}) + (5 \times \text{height in cm}) - (6.8 \times \text{age in years})$$

- Basal requirements in healthy adults are typically in the range of **25 kcal/kg/day**
- The critically ill patient requires **~ 35 kcal/kg/day**

TABLE 9.4

PREDICTED INCREASE IN CALORIC REQUIREMENTS AS A FUNCTION OF STRESSOR

PHYSIOLOGIC STRESS	STRESS FACTOR
Operation	1.1
Peritonitis, major infection, or long bone fracture	1.25
Severe injury/infection or multiple organ failure	1.5
Thermal injury	
10% BSA	1.25
20%–30% BSA	1.5
40% BSA	1.75
>50% BSA	2.0

BSA, body surface area.

Indirect calorimetry

- More accurate measurement of energy expenditure
- Uses O2 uptake
- Burning 1 kcal requires ~ 200mL of oxygen

Protein metabolism

- In normal metabolism, protein catabolism occurs but the amino acids get recycled into making new protein
- In starvation/critical illness → protein catabolism occurs without corresponding protein intake → **negative protein balance**
- In starvation, carbohydrates get utilized first and the body turns to protein for energy
- Acute inflammation and surgical wounds divert protein from other body tissues
  - Proteins that would otherwise strengthen the diaphragm or myocardium or participate in host defense are less available

Measuring protein reserve

- We can measure body substances that are maintained by rapid protein synthesis

  - **Prealbumin** (1/2 life = 2 days)
    - Negative acute phase reactant

  - Retinal binding protein (1/2 life = 10 days)

  - Transferrin (1/2 life = 8 days)

  - Albumin (1/2 life = 21 days)

  - IGF1
    - Relative independence of the inflammatory state of the patient

Nutritional support

- **Goal:** provide sources of energy so that endogenous proteins are not required for energy
- **Early enteral nutrition** (within 36 hrs of admission) has been shown to be associated with significantly lowered risk of infection and a shorter hospital length of stay
- If risk of aspiration → post-pyloric feeds
  - Prokinetics may help but there's no evidence for routine use
- Feeds should be given by continuous infusion rather than large boluses

TPN

- Indications

  - non-stressed patient with severe protein calorie malnutrition, scheduled to undergo surgery
    - TPN given 7 days before surgery is associated with decrease in infection rates
  - Patient with short gut syndrome → bridge to intestinal transplantation or nutritional supplementation
  - Failure of oral or enteral nutrition

Immunonutrition

- There are immune-modulating enteral formulas that contain pharmacologic properties which **enhance immune function** and **decrease inflammation**

- More expensive, so should be reserved for patient population at need
  - Patients who have undergo major gastrointestinal surgery
  - Trauma patients
  - Burn patients (TSA > 30%)
  - Head and neck cancer patients
  - Patients requiring mechanical ventilation

- Major components that contribute to immune enhancement include:
  - Arginine
  - Omega 3 fatty acids
  - Glutamine

References

- Greenfields ch. 8 shock
- Greenfields ch. 9 surgical critical care
- Cameron chapter on surgical critical care
- Sabiston ch. 23 surgical critical care
- World Society of Abdominal Compartment Syndrome
- Moore CL and Copel JA. Point-of-Care Ultrasonography. N Engl J Med 2011; 364:749-57.
- SAFE study investigators. A comparison of albumin and saline for fluid resuscitation in the intensive care unit. N Engl J Med 2004; 350:2247-56.
- The acute respiratory distress syndrome network. Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome. N Engl J Med 2000; 342:1301-8.
- Clark BJ, Moss M. The acute respiratory distress syndrome dialing in the evidence? JAMA 2016; 315: 759-61.
- Singer MS et al. The third international consensus definitions for sepsis and septic shock (sepsis 3). JAMA 2016; 315: 801-10.