CRITCARE BITES

SHOCK

Wang Zhemin

SICM
Society of Intensive Care Medicine
SINGAPORE

MAD FOR MEDICINE

CONTENT

- What is shock
- Causes of shock
- Haemodynamic targets – Pressure, flow and oxygen delivery
- Fluids
- Vasopressors and Inotropes
- Specific shock states: Septic shock, cardiogenic shock, mixed shock

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WHAT IS SHOCK?

- Shock is a state of **circulatory insufficiency** resulting in **inadequate oxygen delivery to meet cellular metabolic needs**, causing tissue hypoxia and organ dysfunction
- It is often, but not always, associated with hypotension (SBP < 90 or MAP < 65mmHg)
- Useful clinical markers of shock include
  - **Mental status**
  - **Capillary refill time** (>3 seconds)
  - **Urine output** (urinary catheter should be inserted for monitoring)
  - **Lactate** (>2mmol/L)

LACTATE

- Causes
  - Type A: Shock, cytopathic states (cyanide poisoning), local ischemia (ischemic bowel)
  - Type B: Disease states (haematological malignancy, liver failure), medication (metformin, salbutamol, adrenaline), inborn errors of metabolism
- Clinical utility:
  - **Diagnosis**
  - **Prognosis**
  - **Monitoring**: Lactate clearance

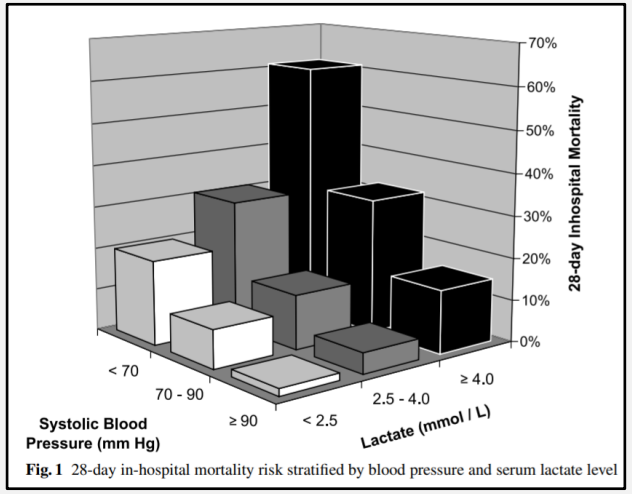

Fig. 1 28-day in-hospital mortality risk stratified by blood pressure and serum lactate level

Howell, M.D., Donnino, M., Clardy, P. *et al.* Occult hypoperfusion and mortality in patients with suspected infection. *Intensive Care Med* **33**, 1892–1899 (2007). https://doi-org.libproxy1.nus.edu.sg/10.1007/s00134-007-0680-5

Original Investigation | Caring for the Critically Ill Patient FREE

February 17, 2019

Effect of a Resuscitation Strategy Targeting Peripheral Perfusion Status vs Serum Lactate Levels on 28-Day Mortality Among Patients With Septic Shock

The ANDROMEDA-SHOCK Randomized Clinical Trial

Glenn Hernández, MD, PhD[1]; Gustavo A. Ospina-Tascón, MD, PhD[2]; Lucas Petri Damiani, MSc[3]; et al

- Comparison of perfusion-targeted vs lactate level-targeted resuscitation strategy
- No statistical significant difference in mortality

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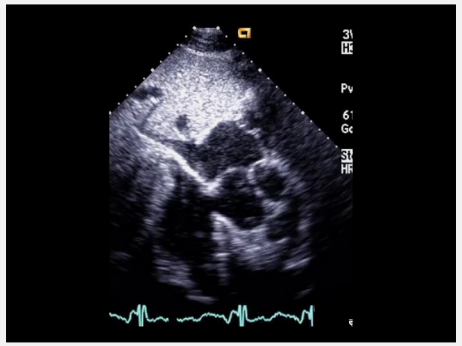
CAUSES OF SHOCK

- **Classical classification of shock based on hypovolemia, distributive** (septic, anaphylactic, distributive), **cardiogenic, obstructive** provides a basic framework, but has limitations as often multiple pathophysiological mechanisms may occur concurrently.
- An alternative proposed classification is based on the **tank (preload), pump (cardiac function) and pipes (vessel tone)** analogy.
- Shock can also be classified as **high output** (usually vasodilatory, warm peripheries) and **low output** (cardiogenic/hypovolemic/obstructive, cold peripheries)
- Importantly, **multiple contributary etiologies of shock may co-exist concurrently**

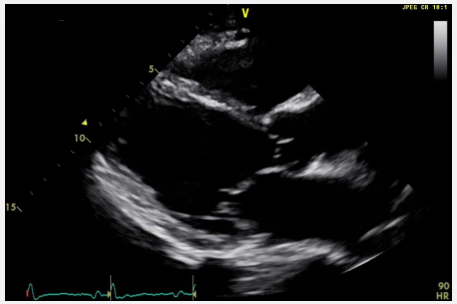
	Hypovolemic	Distributive	Cardiogenic	Obstructive
History	Fluid losses: GI (diarrhea, vomiting), urinary, (DM crisis), drains; check IO charts Hemorrhage: Sites (GI, gynae, urinary, MSK, vascular, retroperitoneal), recent procedures (renal biopsy, surgery)	Sepsis: Clinical features of infection Anaphylaxis: Triggers (drugs, insect bites, food), symptoms (rash, diarrhea, SOB) Hypocortisolism: Steroid/TCM use Neurogenic: Spinal trauma/surgery	Chest pain, palpitations, diaphoresis, syncope	Pulmonary Embolism: Risk factors (Recent surgery, immobility, COVID, pregnancy), symptoms (chest pain, hemoptysis, leg swelling Tension Pneumothorax: Pleuritic chest pain, recent procedure (e.g. lung biopsy) Cardiac tamponade: Pleuritic chest pain, risk factors (recent ACS, known pericardial effusion)
Physical Examination	Hydration status DRE, abdominal examination, AAA, examine fracture site	Sepsis: Head to toe examination (don't forget head and neck, spine and joints, perineum) Anaphylaxis: Rash, urticaria Hypocortisolism: Cushingoid appearance	New murmurs	Pulmonary Embolism: Lower limb swelling (DVT) Pneumothorax: Unequal breath sounds/hyperresonance on percussion, tracheal deviation Cardiac tamponade: Muffled heart sounds
Investigations	FBC (anemia) Renal panel: Urea/creatinine elevation	Sepsis: Blood cultures, UFEME/urine c/s, CXR, inflammatory markers *Hypocortisolism: Random cortisol*	Troponin, ECG	CXR: Pneumothorax, cardiomegaly *D-dimer, CTPA for PE*

Undifferentiated Shock

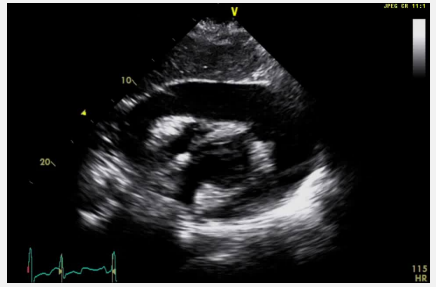
Hypovolaemic

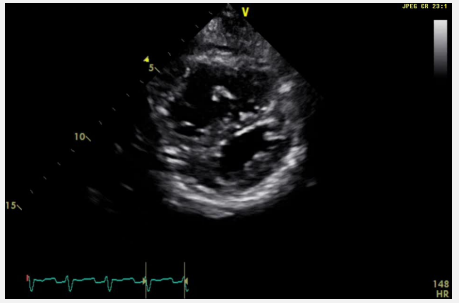


Cardiogenic

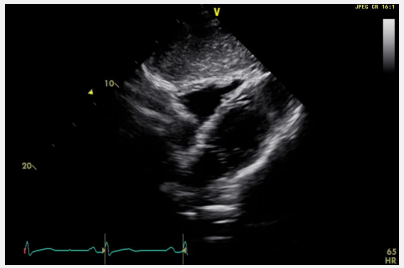


Obstructive





Distributive



Taken from Dr Chia Yew Woon's slides

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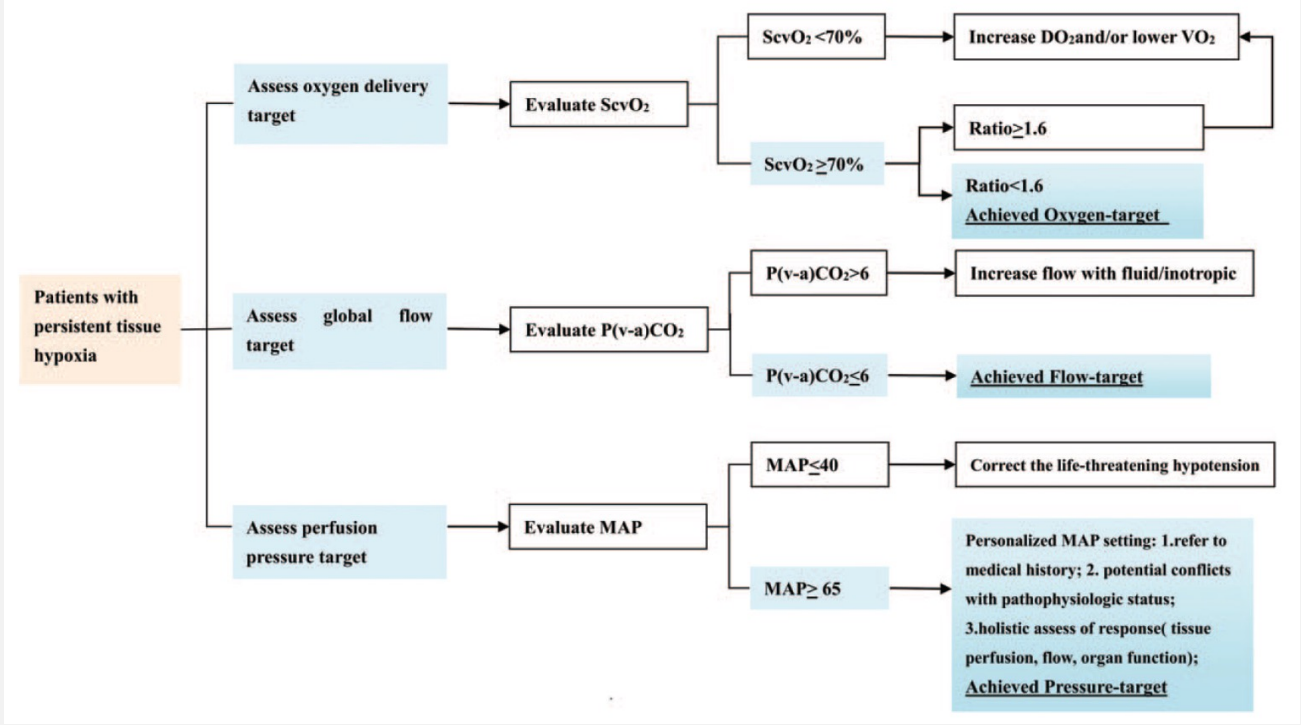
HAEMODYNAMIC TARGETS

- Ensure adequate **blood pressure** – needed for perfusion gradient
- Ensure adequate **oxygen supply to demand matching**
- Ensure adequate **flow** (cardiac output)



He H, Long Y, Zhou X, Wang X, Zhang H, Chai W, Cui N, Wang H, Liu D. Oxygen-Flow-Pressure Targets for Resuscitation in Critical Hemodynamic Therapy. Shock. 2018 Jan;49(1):15-23.

BLOOD PRESSURE

- A minimum mean arterial pressure is needed to provide a **pressure gradient to maintain tissue perfusion** at the level of organ capillaries
- Vital organs like the kidney and brain have an **autoregulatory range** where blood flow can be kept constant through arteriolar constriction and dilation – the lower limit of this range is **~ 60mmHg**, and can be altered in chronic hypertension
- The landmark SEPSISPAM (NEJM 2014) study showed no mortality difference between MAP 65-70mmHg vs 80-85mmHg. However there was **higher RRT requirement among chronic hypertensives in lower BP arm**, and higher incidence of AF in higher BP arm

BLOOD PRESSURE

- MAP of 65mmHg serves as a rough guide
- Consider **lower targets in context of bleeding** (prevent clot dislodgement) and **higher targets in chronic hypertension** (possible renal benefit)
- **Organ specific pressures**: Brain (Cerebral perfusion pressure = MAP – Intracranial pressure), abdomen (Abdominal perfusion pressure = MAP – intraabdominal pressure), heart (consider higher MAP in severe pulmonary hypertension)
- Adequacy guided by **end organ function** monitoring

OXYGEN DELIVERY

Rate of oxygen delivery (ml per minute)

Haemoglobin concentration (grams per litre)

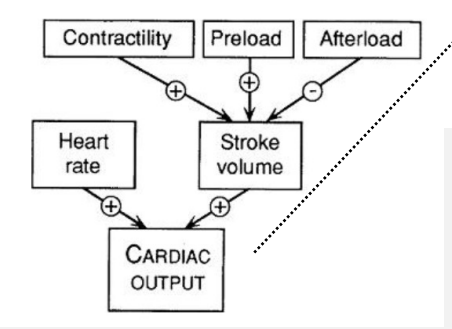
$$DO_2 = CO \times (1.39 \times [Hb] \times SaO_2 + (0.003 \times PaO_2))$$

Cardiac output (litres per minute)

Oxygen binding capacity of haemoglobin: 1.39 ml per gram

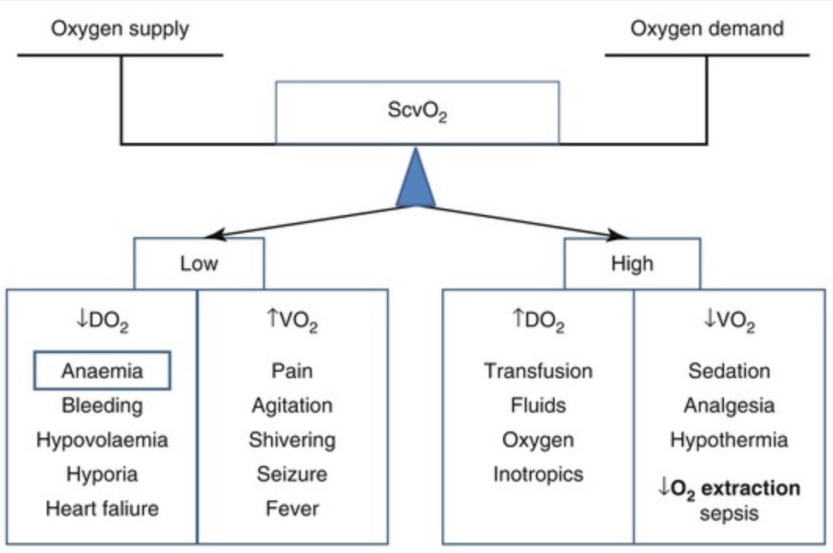
Haemoglobin oxygen saturation expressed as a fraction (i.e. 97% is expressed as 0.97)

Amount of dissolved oxygen in the blood, in ml.
For every 1 mmHg of oxygen tension, 0.003ml of oxygen gas is dissolved in 100ml of blood.



CENTRAL VENOUS OXYGEN SATURATION (SCVO2)

- ScvO2 (a surrogate of SvO2) is the **oxygen saturation in the central venous system**
- Its value is indicative of the **balance between oxygen delivery and consumption** wherein either reduced delivery or increased consumption with lead to desaturation.
- The normal extraction ratio is 1:5, hence **normal values are 70-80%**
- Low ScvO2 (<70%) can occur due to low oxygen delivery (reduced CO, Hb, SaO2) or increased consumption (seizures, hypermetabolic states)
- A high ScvO2 (>80%) may indicate failure of oxygen utilisation (cytotoxic dysoxia in cyanide poisoning, mitochondrial dysfunction) or reduced oxygen consumption when organ damage is severe.

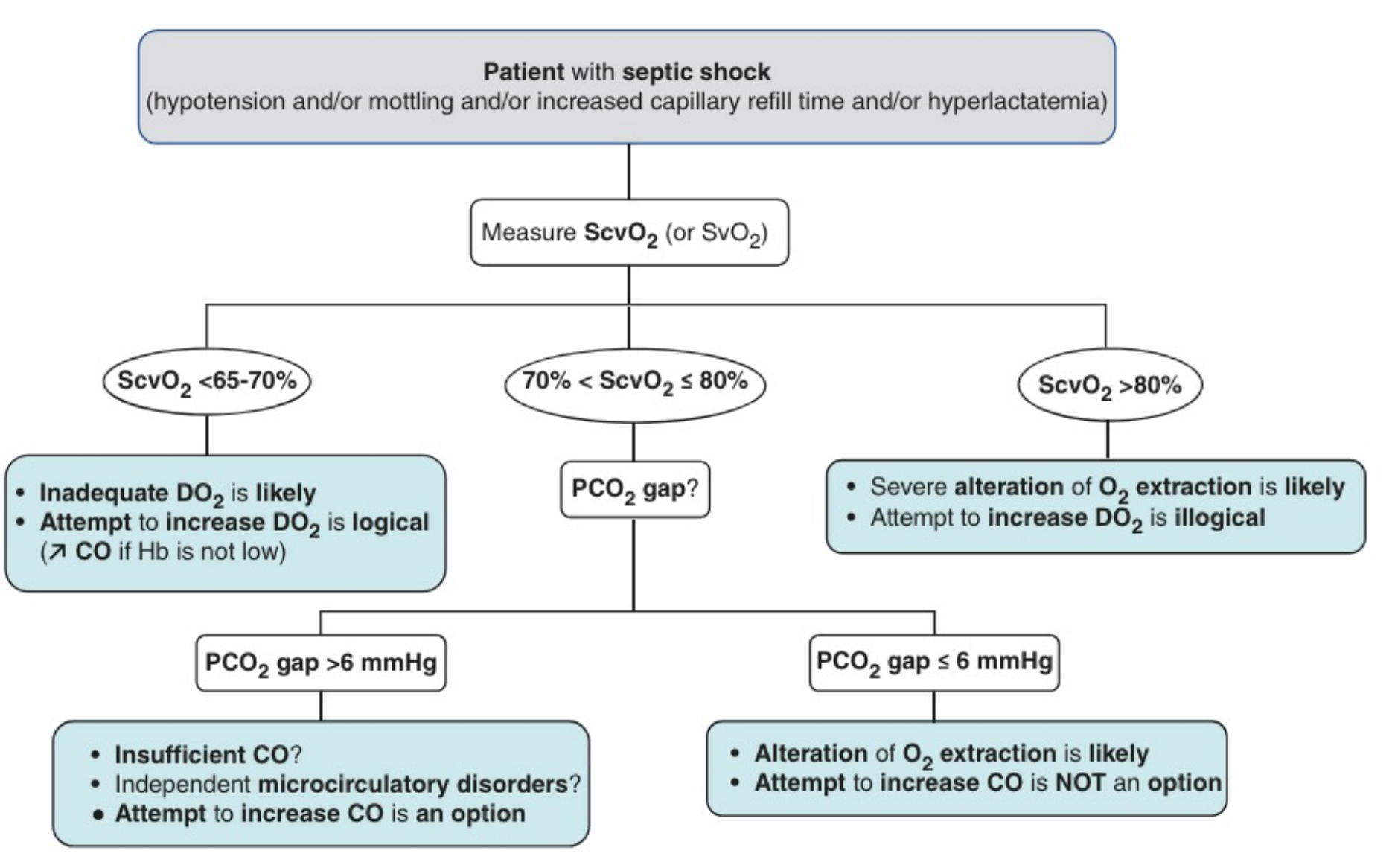


FLOW

- **Flow represents the CO** component of the oxygen delivery equation – and this is determined by heart rate x stroke volume, and stroke volume is affected by preload, contractility and afterload
- Because blood pressure is affected by both CO and SVR (effectively LV afterload), the use of high doses of vasopressors to maintain MAP may paradoxically impair flow, resulting in **loss of haemodynamic coherence**
- Flow can be assessed using the CO2 gap or various measures of cardiac output (echocardiography, pulse contour analysis, thermodilution)

CO2 GAP

- The CO2 gap (Pcv-aCO2) is the difference in PcvCO2 and PaCO2
- It is a reflection of pulmonary blood flow which is required for CO2 clearance (based on the Fick equation), providing a surrogate of cardiac output
- A value of >6mmHg suggests a low flow state
- Of note, microcirculatory dysfunction can also cause an elevation in the CO2 gap.



Teboul, JL., Monnet, X., De Backer, D. (2019). Should We Abandon Measuring SvO_2 or $ScvO_2$ in Patients with Sepsis?. In: Vincent, JL. (eds) Annual Update in Intensive Care and Emergency Medicine 2019. Annual Update in Intensive Care and Emergency Medicine. Springer, Cham. https://doi-org.libproxy1.nus.edu.sg/10.1007/978-3-030-06067-1_17

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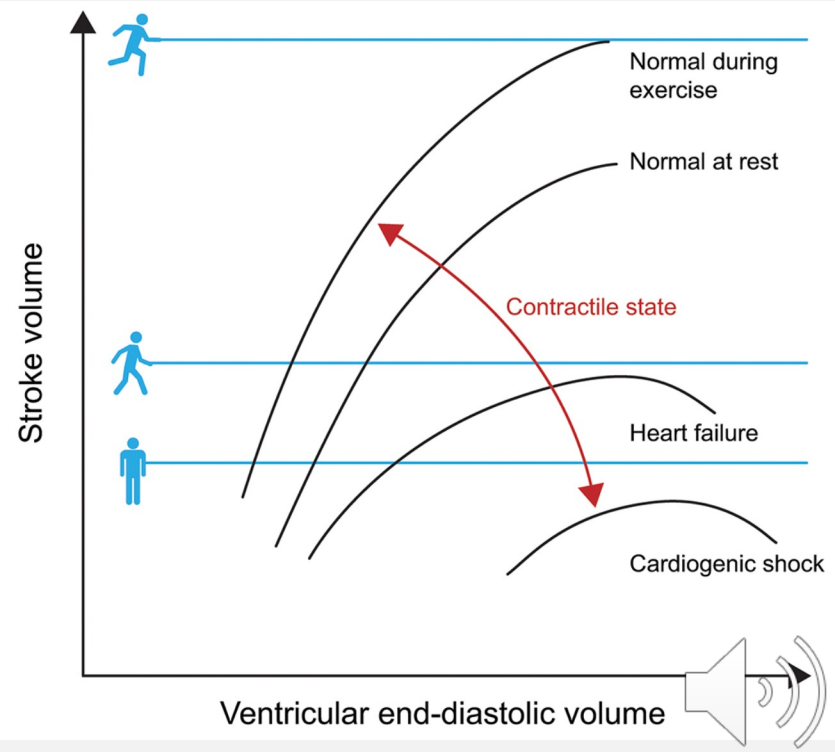
FLUIDS

- Fluid administration **increases the stressed volume** of the venous system, resulting in **increased preload** to the heart. If the heart is on the steep portion of the Starling's curve, a fluid bolus will **increase stroke volume**, and in turn cardiac output
- In most instances, initial resuscitation can be performed with 20-30ml/kg/BW of balanced crystalloids in aliquots of 250-500ml boluses over 15-30 minutes.
- Especially after initial fluid resuscitation (or in patients with cardiogenic/obstructive shock), fluid administration strategy should be individualized based on **fluid responsiveness** and **fluid tolerance**



FLUID RESPONSIVENESS

- Fluid responsiveness is defined as a **10-15% increase in stroke volume in response to 500ml of fluids** over 15-30 minutes
- Only ~ 50% of ICU patients are fluid responsive and excessive fluids can result in complications (pulmonary edema, renal impairment etc)
- Fluid responsiveness can be assessed based on
  - Increasing preload (passive leg raise, fluid bolus) and measuring stroke volume/cardiac output response
  - Measures that depend on heart-lung interactions (pulse pressure, stroke volume and IVC variation, end expiratory occlusion, tidal volume challenge)

PASSIVE LEG RAISE

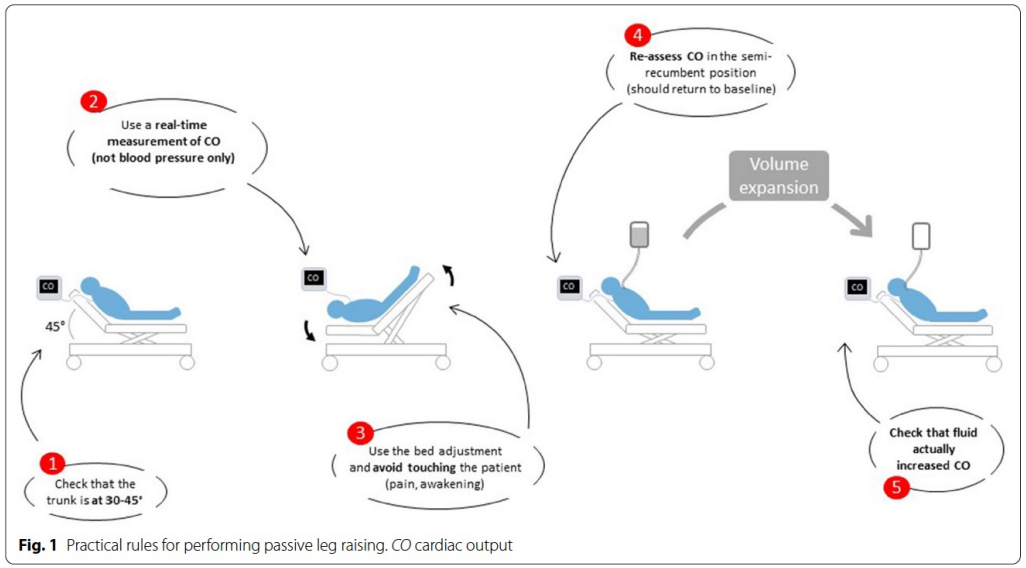
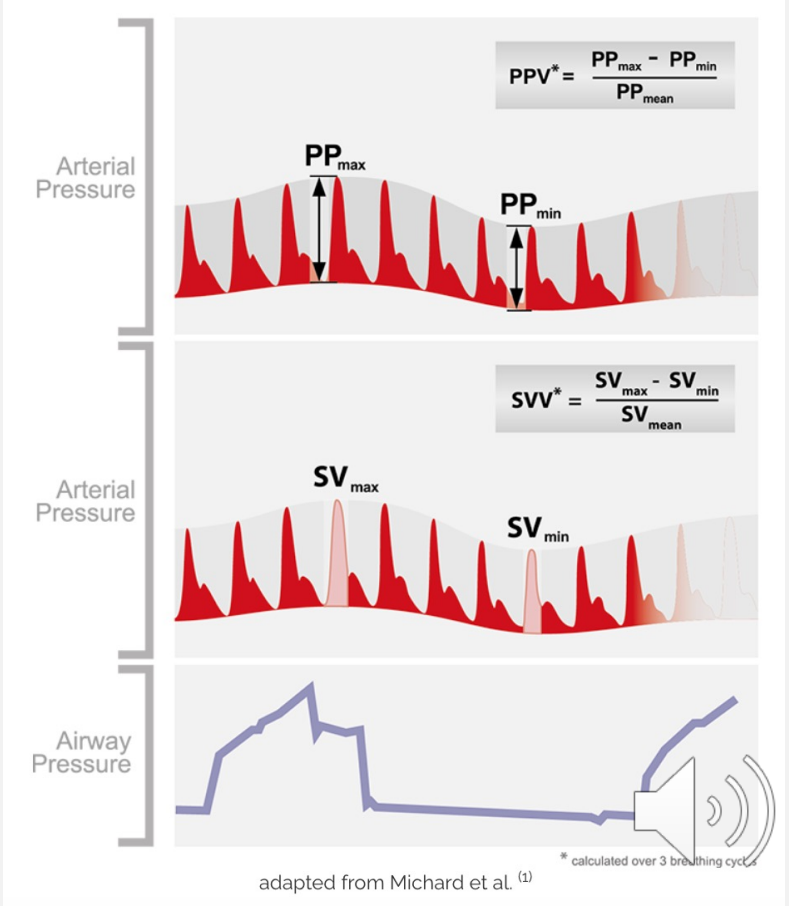


Fig. 1 Practical rules for performing passive leg raising. *CO* cardiac output

- Response measures
  - SV/CO > 10% increase: Pulse contour analysis, LVOT VTI
  - ETCO2 > 5% or 2mmHg increase
- Test does not depend on ventilation and heart rate, and **remains reliable in spontaneous ventilation and cardiac arrhythmias**

PULSE PRESSURE AND STROKE VOLUME VARIATION

- During positive pressure ventilation, insufflation decreases preload and increases afterload of the RV → Transmitted to left side and decreases LV preload
- If LV stroke volume changes in response to cyclic positive pressure ventilation, this indicates that both ventricles are preload dependent
- Typically **pulse pressure variation or stroke volume variation** (pulse contour analysis, LVOT VTI, aortic blood flow on esophageal doppler) of **>12%** is considered markers of fluid responsiveness
- **Conditions of respirophasic variation** include: Passive on the ventilator, >8ml/kg/IBW, absence of atrial fibrillation, absence of RV dysfunction

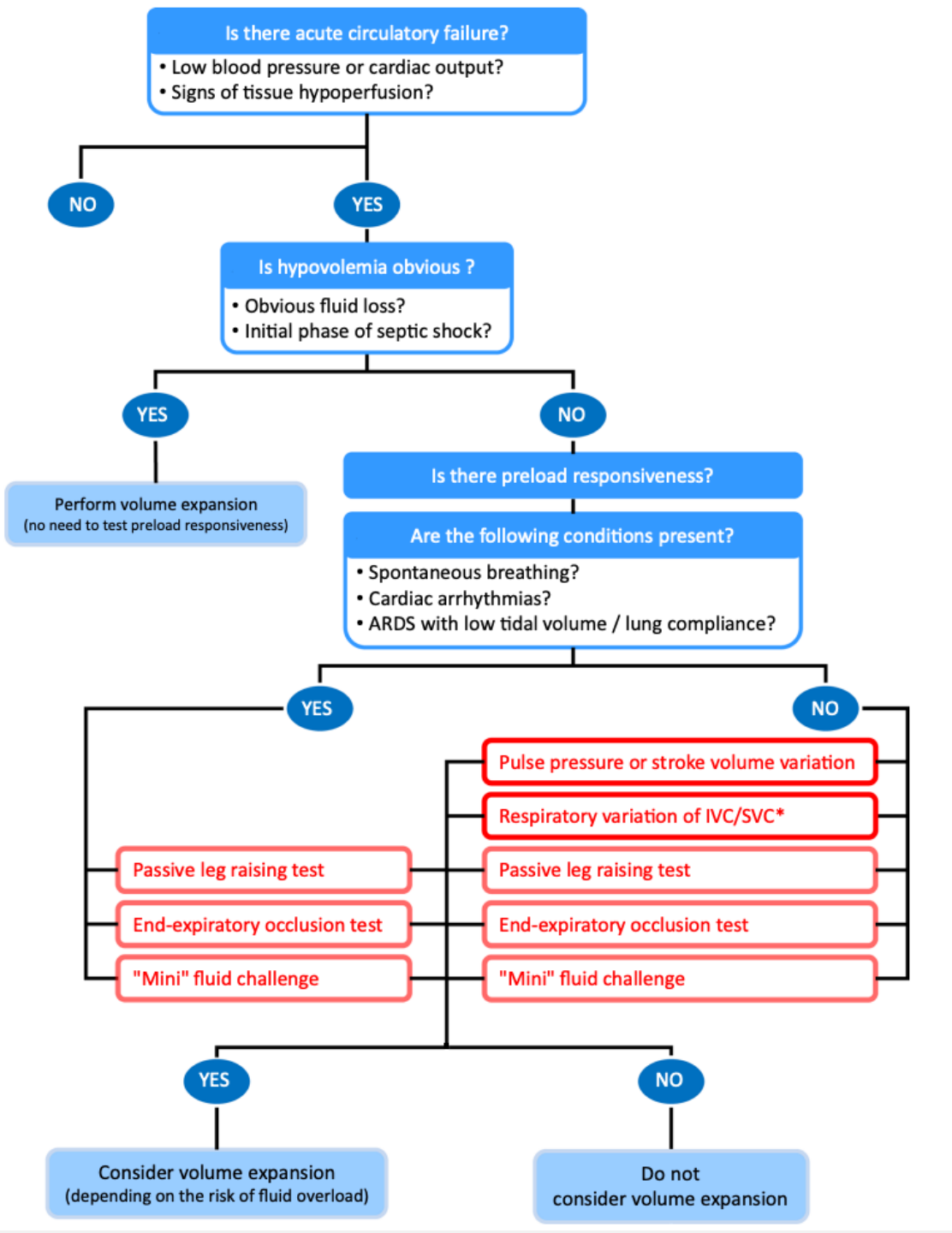


VENA CAVAL VARIATION

- Vena caval variation
  - Generally less accurate than PPV and SVV, evidence heterogeneous
  - SVC variation possibly more predictive than IVC variation, but requires TEE
  - Vena caval changes depends on whether ventilation is negative or positive pressure
    - **Negative pressure** (spontaneous vent): Vena cava **collapses** during inspiration
      - Collapsibility index ((IVCmax – IVCmin)/IVCmax) **>40-50%**
    - **Positive pressure**: Vena cava **distends** during inspiration
      - Distensibility index ((IVCmax – IVCmin)/IVCmin) **>18%** (controlled mode, >8ml/kg ibw)
  - Generally similar limitations of conditions required for respirophasic variation, except arrhythmias

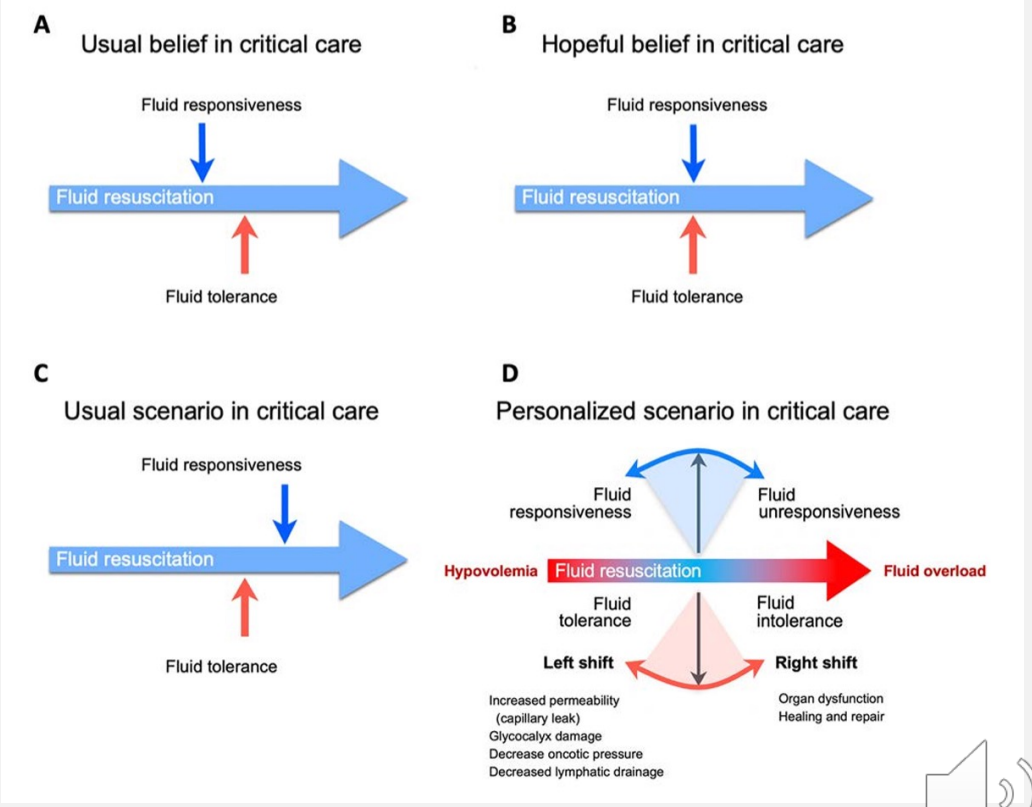
OTHERS

- Mini fluid challenge: 100-150ml of fluids given over 60-120s, CO increase > 5% on pulse contour analysis
- End-expiratory occlusion: End expiratory occlusion for 15s increases preload, CO increase > 5% on pulse contour analysis (*can be used with small tidal volumes, arrhythmias, spontaneous respiratory activity*)
- Tidal volume challenge: Increase Vt from 6 to 8ml/kg/IBW, increase in PPV by > 3.5% (*can be used in spontaneously breathing patients*)


Is there acute circulatory failure?
• Low blood pressure or cardiac output?
• Signs of tissue hypoperfusion?
NO
YES
Is hypovolemia obvious ?
• Obvious fluid loss?
• Initial phase of septic shock?
YES
NO
Perform volume expansion
(no need to test preload responsiveness)
Is there preload responsiveness?
Are the following conditions present?
• Spontaneous breathing?
• Cardiac arrhythmias?
• ARDS with low tidal volume / lung compliance?
YES
NO
Passive leg raising test
End-expiratory occlusion test
"Mini" fluid challenge
Pulse pressure or stroke volume variation
Respiratory variation of IVC/SVC*
Passive leg raising test
End-expiratory occlusion test
"Mini" fluid challenge
YES
NO
Consider volume expansion
(depending on the risk of fluid overload)
Do not
consider volume expansion

FLUID TOLERANCE

- Fluid tolerance refers to the ability to handle fluid administration without developing adverse effects (pulmonary edema, renal impairment, abdominal hypertension)
- Evaluation:
  - Clinical: SpO2, edema, pre-existing cardiac/renal impairment
  - Imaging: Chest X-ray, ultrasound (B-lines, VEXUS protocol)



FLUID CHOICE

- Crystalloids first line over colloids (CRISTAL study showed no mortality difference, colloids more costly)
- Balanced crystalloids generally preferred over normal saline (SMART study and NEJM meta-analysis suggests renal, and possible mortality benefit)
- In acute brain injury, avoid hypotonic solutions (Hartmann's) and albumin (SAFE study)
- Albumin can be considered as second line in septic shock (SAFE, ALBIOS)
- Avoid hydroxyethyl starch (6S and CHEST studies showed increased mortality and RRT requirements)

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VASOPRESSORS AND INOTROPES

- Vasopressors increase arterial vasomotor tone and increase blood pressure. Venotonic effects also increase the mean systemic filling pressure and in part increases preload.
- Inotropes act by increasing cardiac contractility. They may have concomitant vasoconstrictive (ino-constrictor) or vasodilatory (ino-dilator) properties. Inodilators may paradoxically cause a fall in blood pressure, and hence should not be titrated to a blood pressure target.
- Noradrenaline is a reasonable first line vasoactive agent in most causes of shock (septic, cardiogenic)
- Vasoactive medications can be given as push doses (acute resuscitative setting) or as infusions

VASOPRESSORS AND INOTROPES

Pure Vasopressors			
Drug	Mechanism	Dose	Notes
Vasopressin	V1 – vascular smooth muscle V2 – water retention by kidneys	Infusion 0.01 to 0.04 u/min (usually fixed dose)	Adjunct to noradrenaline in septic shock Doses >0.04u/min a/w cardiac ischemia
Phenylephrine	Pure alpha 1	Bolus: 50-200ug Infusion: 0.1-2ug/kg/min or 20-400ug/min	-May cause bradycardia (can use in vasodilatory shock with tachycardia)

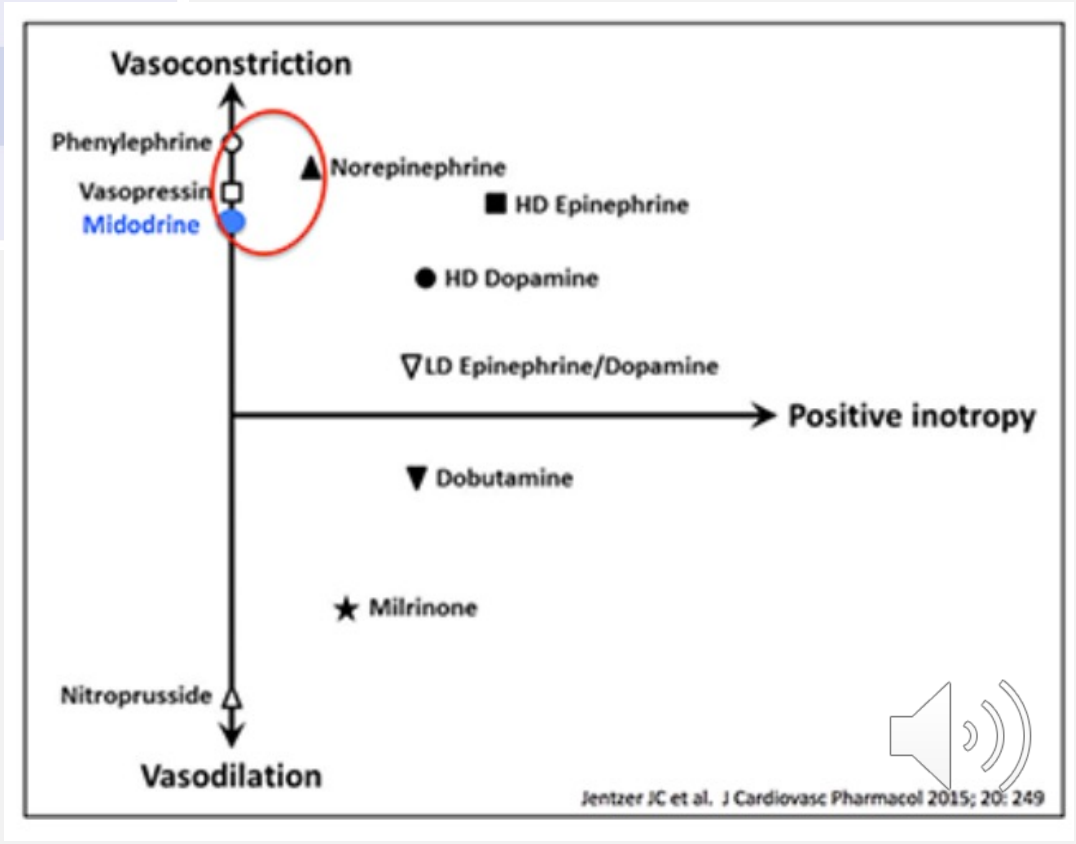
VASOPRESSORS AND INOTROPES

Vasopressors + Inotrope			
Noradrenaline	Mainly alpha 1 Some beta 1	Infusion: 0.01 to 1ug/kg/min	-Initial vasopressor of choice in septic, cardiogenic, hypovolemic shock
Adrenaline	Mainly beta 1 Some beta 2 and alpha 1	Bolus: Arrest (IV 1mg), push pressor (IV 0.1-0.5 mg), anaphylaxis (IM 0.3-0.5mg) Infusion: 0.01 to 1ug/kg/min	-First line in anaphylaxis -Can be used as adjunct in refractory septic shock -Low dose vasodilate, high dose vasoconstrict -Causes lactate elevation
Dopamine	Mixed alpha 1 and beta 1	5-20ug/kg/min	-Generally not favoured because of unpredictable effect and arrhythmogenicity

VASOPRESSORS AND INOTROPES

Inodilators			
Dobutamine	Mainly beta 1 and some beta 2	2-20ug/kg/min	-Mainly used in cardiogenic shock -Caution in significant tachycardia
Milrinone	PDE inhibitor	0.125 to 0.7ug/kg/min; can start at 0.0625 in renal impairment	-Improves cardiac output -Pulmonary vasodilation (favourable in right heart failure)

Catecholamine	Types of Receptor		
	α-1	β-1	β-2
Dobutamine	0	++	+
Dopamine (moderate dose)	0	+++	+++
Dopamine (high dose)	++	+++	+++
Adrenaline	+++	++++	+++
Noradrenaline	+++	+	
Phenylephrine	+++	0	
Ephedrine	+	+++	



VASOPRESSORS AND INOTROPES – LANDMARK TRIALS

- ***CATS Lancet 2007***: No efficacy and safety difference between epinephrine alone and norepinephrine plus dobutamine for septic shock
- ***SOAP II NEJM 2010***: No mortality difference between dopamine vs noradrenaline as first line vasopressor agent in shock, but **more arrhythmic events in dopamine group**. **Increased risk of death in cardiogenic shock.**
- ***VASST NEJM 2008*** – Population: Septic shock on min of 5ug/min of noradrenaline
  - Intervention vasopressin (0.01 to 0.03U/min), control noradrenaline (5-15ug/min)
  - No 28-day and 90-day mortality difference. **Lower mortality rate with vasopressin in less severe septic shock** subgroup, no difference in more severe septic shock
- ***VANISH JAMA 2016*** – Population: Septic shock (median noradrenaline dose 0.16ug/kg/min)
  - Study design: 2x2 factorial studying vasopressin (up to 0.06U/min) vs noradrenaline, hydrocortisone vs placebo
  - Outcome: No difference in kidney failure free days, although **lower rates of RRT in vasopressin group**
- **OptimaCC JACC 2018** – Epinephrine vs norepinephrine for cardiogenic shock, similar effect on blood pressure and cardiac index. However higher incidence of refractory shock, tachycardia and lactic acidosis in epinephrine group.
- ***DOREMI NEJM 2021***: No difference in composite outcome in milrinone and dobutamine use in cardiogenic shock

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SEPTIC SHOCK

- Sepsis is defined as life-threatening organ dysfunction resulting from dysregulated host response to an infection
- Source identification and source control is key
- Blood cultures and appropriate empirical antibiotics
- Fluid resuscitation – SSC recommends initial 30ml/kg/BW of fluids. Crystalloids recommended as first line, albumin can be used subsequently.
- Vasopressors – Early vasopressor use if hypotension is profound (can start peripheral). Noradrenaline first line, add vasopressin when noradrenaline >0.25ug/kg/min (add hydrocortisone 50mg Q6H too). Adrenaline third line.
- Other therapies: Methylene blue, ascorbic acid, beta-blockers, angiotensin 2, sorbent therapy (oxiris filter)

EARLY GOAL DIRECTED THERAPY

Emanuel Rivers seminal publication in NEJM 2001 reported the experience with early goal directed therapy (EGDT) in septic patients in an emergency department in Detroit where patients were resuscitated using fluids, vasoactive agents, red cell transfusion and inotropic agents to the following targets (CVP 8-12mmHg, MAP 65-90mmHg, ScVO2>70%) over 6 hours. Compared to non-protocolised care, the in-hospital mortality was reduced from 30.5% compared to 46.5%.

ORIGINAL ARTICLE

Early Goal-Directed Therapy in the Treatment of Severe Sepsis and Septic Shock

Emanuel Rivers, M.D., M.P.H., Bryant Nguyen, M.D., Suzanne Havstad, M.A., Julie Ressler, B.S., Alexandria Muzzin, B.S., Bernhard Knoblich, M.D., Edward Peterson, Ph.D., and Michael Tomlanovich, M.D. for the Early Goal-Directed Therapy Collaborative Group*

EARLY GOAL DIRECTED THERAPY

- Three landmark publications namely *ARISE NEJM 2014* (Australia and New Zealand), *ProMISe NEJM 2014* (UK) and *PRoCESS NEJM 2015* (USA) later failed to show mortality of EGDT compared to standard of care. This could be attributable to improvement in 'standard care' by the time these studies were performed, sicker patients in River' study and possibly inflation of results in Rivers' initial single centre study.

ORIGINAL ARTICLE

Goal-Directed Resuscitation for Patients with Early Septic Shock

The ARISE Investigators and the ANZICS Clinical Trials Group*

ORIGINAL ARTICLE

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

The ProCESS Investigators*

ORIGINAL ARTICLE

Trial of Early, Goal-Directed Resuscitation for Septic Shock

Paul R. Mouncey, M.Sc., Tiffany M. Osborn, M.D., G. Sarah Power, M.Sc., David A. Harrison, Ph.D., M. Zia Sadique, Ph.D., Richard D. Grieve, Ph.D., Rahi Jahan, B.A., Sheila E. Harvey, Ph.D., Derek Bell, M.D., Julian F. Bion, M.D., Timothy J. Coats, M.D., Mervyn Singer, M.D., et al., for the ProMISe Trial Investigators*

CARDIOGENIC SHOCK

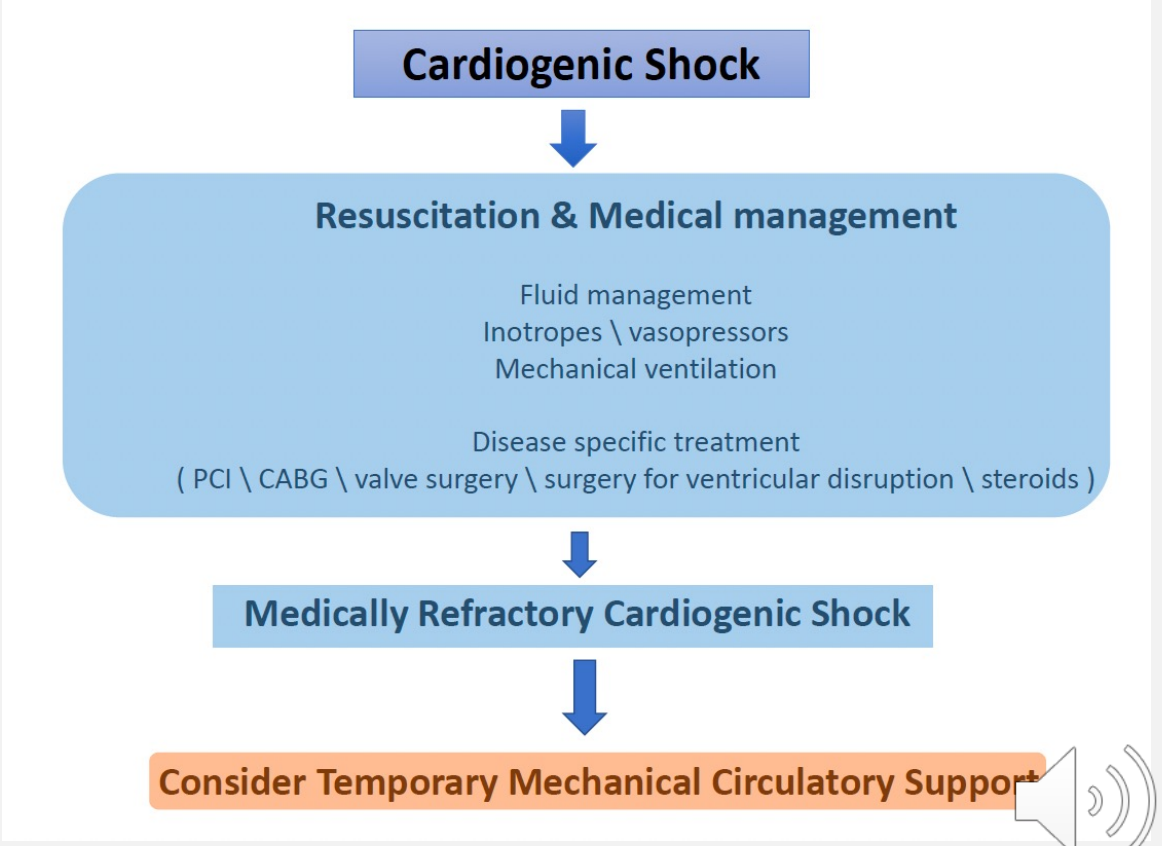
- Cardiogenic shock is defined as persistent hypotension (SBP<90) or requirement of mechanical/pharmacological support to maintain SBP>90, with hyperlactemia (>2) or oliguria (urine output < 30ml/h) in the setting of a reduced cardiac index (<2.2) and elevated filling pressures (PCWP > 15mmHg)
- The SCAI (society for cardiovascular angiography & interventions) classification grades cardiogenic shock from A to E
  - A (at risk): Risk factors for cardiogenic shock (e.g. AMI, acute heart failure)
  - B (beginning): Relative hypotension or tachycardia without hypoperfusion
  - C (classic): Evidence of hypoperfusion requiring intervention beyond volume resuscitation, typically present with relative hypotension
  - D (deteriorating): Failure to respond to initial interventions
  - E (extremis): Patient being supported by multiple interventions who may be experiencing cardiac arrest with ongoing CPR and/or ECMO

CARDIOGENIC SHOCK

- Advanced cardiac output monitoring should be used to quantify, phenotype and monitor response to treatment (PA catheter considered gold standard, but transpulmonary thermodilution and pulse contour analysis sometimes used).
- Treat underlying cause: AMI (revascularization), valvular disease (surgery, replacement)
- Judicious fluid therapy guided by measures of fluid responsiveness and tolerance
- Noradrenaline still usually the first line agent of choice in order to ensure adequate blood pressure. However, excessive afterload increase may be detrimental to a failing heart.
- While inotropes may augment cardiac output, they also increase myocardial demand. Commonly used inotropes like dobutamine and milrinone have vasodilatory effect and may hence cause hypotension, worsening coronary perfusion

CARDIOGENIC SHOCK

- No strong evidence to support a particular inotrope – dobutamine more titratable but possibly more arrhythmogenic, milrinone favoured in right heart dysfunction but less titratable and requires renal adjustment
- Inotropes should not be titrated to a blood pressure target. Instead a combination of flow indices (cardiac output monitoring, CO2 gap) and oxygen supply-demand matching (ScvO2, lactate) should be used
- Consideration of mechanical circulatory support (IABP, impella, VA-ECMO) in patients with severe cardiogenic shock refractory to medical therapy



MIXED SHOCK

- Patients in the ICU often have multiple contributary etiologies of shock – e.g. sepsis in patient with pre-existing heart failure
- The challenge is to phenotype the relative magnitude of each etiology in order to tailor therapy (fluids, vasopressors, inotropes) appropriately
- Ultrasonography and advanced cardiac output monitoring devices (pulse contour analysis, transpulmonary thermodilution, pulmonary artery catheterization) are used to assess and monitor such patients
- Treatment interventions must be guided by clear targets
  - Fluids – fluid responsiveness and fluid tolerance
  - Vasopressors – Mean arterial pressure
  - Inotropes – CO measure, CO2 gap/ScvO2

What is shock?	State of circulatory insufficiency resulting in oxygen supply-demand mismatch, causing tissue hypoxia. End organ dysfunction (AMS, reduced urine output) and lactate elevation (>2mmol/L)
Causes of shock?	Hypovolemic, vasodilatory, obstructive, cardiogenic. Multiple causes may co-exist. Ultrasound evaluation is useful.
What are important haemodynamic targets?	Blood pressure – MAP > 65 usually. Oxygen delivery determined by CO, Hb and SaO2, ScvO2 surrogate of supply-demand matching (>70%). Flow adequacy based on direct CO measurement or CO2 gap (<6mmHg)
Fluid administration	Fluid bolus increases stroke volume if fluid responsive (different methods to assess – e.g. PLR, PPV, SVV). Important to also assess for fluid tolerance. Balanced crystalloids usually favoured.
Vasopressors and Inotropes	Noradrenaline reasonable first line agent in most types of shock. Vasopressors increase vascular tone while inotropes increase cardiac contractility.
Septic Shock	Source identification, source control, antibiotics are key. Fluid therapy. Noradrenaline initial, once >0.25ug/kg/min add vasopressin (1.8U/h) and hydrocortisone (50mg Q6H).
Cardiogenic Shock	Treat cause (revascularization in AMI). Advanced CO monitoring. Noradrenaline first line. Dobutamine and milrinone commonly used inotropes. Consider MCS (IABP, impella, VA-ECMO) in severe disease.