Shock - from Diagnostic to Therapeutic Implications

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LEARNING OBJECTIVES

• Review the markers of tissue hypo perfusion and their applicability as in the definition of shock.
• Recognise the importance of a detailed clinical examination. This examinations should include de patient an the context of the disease.
• Which are the therapeutic and prognostic implications of diagnosing shock.
IDENTIFYING ACUTE ORGAN DYSFUNCTION AS A MARKER OF CRITICAL DISEASE

- Tachycardia
- Hypotension
- ↑ CVP
- ↑ PAOP
- Jaundice
- ↑ Enzymes
- ↓ Albumin
- ↑ PT
- Altered Consciousness
- Confusion
- Psychosis
- Tachypnea
- PaO₂ < 70 mm Hg
- SaO₂ < 90%
- PaO₂/FiO₂ ≤ 300
- Oliguria
- Anuria
- ↑ Creatinine
- ↓ Platelets
- ↑ PT/APTT
- ↓ Protein C
- ↑ D-dimer
OUTCOME IN PATIENTS WITH INFECTION

ICU mortality
Hospital mortality

(data from the SAPS 3 study)
“SHOCK IS THE RUDE UNHINGING OF THE MACHINERY OF LIFE”

Samuel Gross (1862)
Definition of shock

• Shock is defined as circulatory and cellular dysfunction, manifested by markers of hypoperfusion such as elevated blood lactate, decreased ScvO2 or SvO2, with or without hypotension.

• The definition of shock does not require the presence of hypotension. Instead, the definition of shock as “failure to deliver and/or utilize adequate amounts of oxygen” may include, but is not limited to, the presence of hypotension.
Diagnosing shock

The main limitation of clinical features is that they may not be sensitive or specific to organ dysfunction.

Though hypotension and tachycardia are clear features of shock, the absence of such clinical parameters does not exclude organ hypoperfusion.
Diagnosis of shock

- Reduced pulse pressure; Tachycardia and rarely bradycardia and severe arrhythmia may occur.
- Increased respiratory rate and dyspnea.
- Reduced alertness, decreased urinary output, mottled and cold skin as well as prolonged capillary refill time may be the result of decreased tissue perfusion.
Oxygen delivery & oxygen consumption

- Oxygen delivery: Quantity of oxygen made available to the tissues in one minute:

\[ DO_2 I = CI \times [1.39 \times Hb \times SaO_2 + (0.003 \times PaO_2)] \]
Cardiac Output and Venous Return

- Cardiac output is the quantity of blood pumped into the aorta each minute.

- Venous return is the quantity of blood flowing from the veins to the right atrium.

- Except for temporary moments, the cardiac output should equal the venous return.
Cardiac output = Stroke Volume \times Heart Rate
At rest, the cardiac output for a normal 70 Kg person is 5 L/min:

Cardiac output = Stroke Volume x Heart Rate

5L/min = 70 ml x 70 / min

During exercise, cardiac output may increase to > 20 liters/minutes

Cardiac Output is controlled to meet the bodies needs
Relationship Between Cardiac Output and Blood Pressure

✓ Blood pressure is required to ensure appropriate blood flow for adequate tissue perfusion, and its determinants are related as:

\[
\text{Arterial Pressure} = \text{Cardiac Output} \times \text{Systemic resistance}
\]

MAP = CO x SVR
SVR and arterial vasomotor tone are controlled by several factors:

- Sympathetic outflow
- Circulating catecholamines and hormones
- Local metabolic factors (NO, O2, CO2, prostaglandins, etc.)
**Control of Cardiac Output**

<table>
<thead>
<tr>
<th>CLINICAL IMPLICATION</th>
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<td>There is no normal value of cardiac output for any individual, the level is determined by the body requirements.</td>
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Increasing oxygen delivery

- Oxygen delivery: Quantity of oxygen made available to the tissues in one minute:

\[ \text{DO}_2 \text{I} = \text{CI} \times [1.39 \times \text{Hb} \times \text{SaO}_2 + (0.003 \times \text{PaO}_2)] \]
Central and mixed venous oxygen saturation

- Mixed venous oxygen saturation (SvO2) is a functional assessment of the balance between global tissue oxygen delivery and oxygen consumption;
- Measurement of the mixed venous oxygen saturation requires placement of a pulmonary artery catheter;
- Central venous oxygen saturation (SvO2) reflects adequacy of perfusion of the brain and upper extremities, and requires insertion of a central line;
Central and mixed venous oxygen saturation
Balance between oxygen delivery and oxygen consumption
An increase in tissue CO$_2$ is reflected by an increase in central venous CO$_2$, and an elevated P(v-a)CO$_2$ (greater than 6 mmHg) may therefore be a marker of inadequate resuscitation.
HOW TO MANAGE FLUIDS IN SHOCK?
SHALL WE CONTINUE WITH EGDT?
MANAGEMENT OF SHOCK

• Get oxygen in the fluid
• Get fluid in the circuit
• Maintain adequate perfusion pressure:
  • Maintain pump pressure
  • Optimise circuit resistance
Cardiac Preload is Volume, NOT Pressure

Volume management requires volume measurement

RAEDV  RVEDV  PBV  LAEDV  LVEDV
Qual o copo?

CERVEJA

Usa-se uma taça alta e fina, chamada de "flûte". Esse formato mantém por muito mais tempo a efervescentes da bebida. Outros vinhos espumantes também são servidos no mesmo tipo de taça.

CHAMPAGNE

Pedem copos maiores por serem consumidos em grande quantidade e rapidamente, em geral com muito galo. No caso de refeições ou belas usa-se copo menor e não se utiliza o galo.

REFRIGERANTE

O modelo clássico é o copo mais baixo. Apesar do teor alcoólico elevado, são servidos com gelo. Assim o copo não precisa ser alto, mas deve ser largo para acomodar as pedras e ter fundo gasto para evitar que a bebida esquente.

WHISKY

Servido após a refeição, dada sua ação digestiva, pode um copo pequeno que receba apenas alguns goles da bebida, que é quase sempre bem doce. Alguns modelos possuem pê, como o da foto.

Vinho Tinto

É servido em taças maiores e mais bojadas do que as de vinho branco, por não ser consumido-galado. O copo é segurar a taça pelo pé. Mes, no caso do vinho tinto, não se pode considerar um erro segurar na própria taça.

Vinho Branco

Como pode ser consumido galado, o vinho branco pode ser servido em taças menores, para o líquido não esquentar. Segure a taça pelo pé, para evitar contato do calor das mãos com a bebida, o que altera o sabor. Para vinho rosé, o mesmo copo.

Água Mineral

Os copos de água são mais facilmente identificáveis: são sempre os maiores e podem ou não ter pé. Em belas é comercial, admite-se o uso do mesmo tipo de copo de refrigerantes para servir a água mineral.

SUCO

Sucos de frutas pedem um tipo de copo pouco menor que o de refrigerantes. O formato é ideal para bebida fresca e concentrada, uma vez que abriga menos líquido. Alguns modelos, como o da foto, possuem pé.
HOW MUCH FLUID?
William C. Shoemaker
Based on the analysis of data from survivors and non-survivors

Established minimal targets of Do2 and Vo2, behind which survival would be almost impossible

The concept of pre-emptive therapeutic targets
Balance between oxygen delivery and oxygen consumption

![Graph showing oxygen consumption vs. oxygen delivery](image-url)
The Max Weil concept:

“sequential optimization tests”
Max Harry Weil, MD, PhD (1927-.....)

"I perceive that the most consistent pursuits of successful innovators and leaders in Medicine, as in all endeavors, come from aspirations generated by serendipitous dreams rather than by hope or by fate alone; from the excitement with which the dreamer attracts collaborators who have prepared minds and skillful hands; they join talents and destinies to convert the dream to expert plans. Contingent on the vigor, the persistence, and on the attention to detail with which they commit to the execution of their plans, they secure the advances that contribute to the social goods and bring ultimate success to all who have joined destinies to seriously pursue those dreams."

Max Harry Weil, 1994
Fluid Responsiveness is a dynamic parameter that reflects the degree by which the CO responds to changes in preload.
Small therapeutic margin
Do you want to take the risks associated with having bovine collagen on your blood?
PRAC recommends suspending marketing authorisations for infusion solutions containing hydroxyethyl-starch

The European Medicines Agency’s Pharmacovigilance Risk Assessment Committee (PRAC) has concluded following a review of the available evidence that the benefits of infusion solutions containing hydroxyethyl-starch (HES) no longer outweigh their risks and therefore recommended that the marketing authorisations for these medicines be suspended.
MORTALITY DETERMINANTS - HOST

- Genetic background (inflammatory response)
- Age
- Prior diseases

Imune response
Cardiovascular reserve

- Acute disease (Bug)
- Time of intervention (Doctor)

Acute physiological dysfunction

Outcome

45% of prognosis
20% of prognosis
35% of prognosis

Moreno R. SAPS 3 Score: Sepsis Model
Role of Collaboration
"Science never proves a hypothesis. It offers various levels of disproof."

Karl Popper
Updated Bundles in Response to New Evidence

The leadership of the Surviving Sepsis Campaign (SSC) has believed since its inception that both the SSC Guidelines and the SSC performance improvement indicators (1) will evolve as new evidence that improves our understanding of how best to care for patients with severe sepsis and septic shock becomes available.

With publication of 3 trials (2,3,4) that do not demonstrate superiority of required use of a central venous catheter (CVC) to monitor central venous pressure (CVP) and central venous oxygen saturation (ScvO₂) in all patients with septic shock who have received timely antibiotics and fluid resuscitation compared with controls or in all patients with lactate >4 mmol/L, the SSC Executive Committee has revised the improvement bundles as follows:
TO BE COMPLETED WITHIN 3 HOURS OF TIME OF PRESENTATION*:

1. Measure lactate level
2. Obtain blood cultures prior to administration of antibiotics
3. Administer broad spectrum antibiotics
4. Administer 30ml/kg crystalloid for hypotension or lactate ≥4mmol/L

* “Time of presentation” is defined as the time of triage in the emergency department or, if presenting from another care venue, from the earliest chart annotation consistent with all elements of severe sepsis or septic shock ascertained through chart review.

TO BE COMPLETED WITHIN 6 HOURS OF TIME OF PRESENTATION:

5. Apply vasopressors (for hypotension that does not respond to initial fluid resuscitation) to maintain a mean arterial pressure (MAP) ≥65mmHg
6. In the event of persistent hypotension after initial fluid administration (MAP < 65 mm Hg) or if initial lactate was ≥4 mmol/L, re-assess volume status and tissue perfusion and document findings according to Table 1.
7. Re-measure lactate if initial lactate elevated.
Thank You