Advances and Challenges in Fluid Resuscitation in Pediatric Shock

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- **The approach to fluid therapy must be individualized based on the cause of shock as well as the patient's major diagnosis, comorbidities and hemodynamic and respiratory status.**

- **A conservative, physiologically guided approach to fluid resuscitation likely improves patient outcomes.**

Ideal fluid:

- use of **balanced crystalloids like Ringer lactate or PlasmaLyte** during resuscitation is associated with a lower risk of hyperchloremic acidosis, acute kidney injury (AKI), and overall mortality compared to crystalloids with higher chloride concentrations like 0.9% normal saline (NS).

- Current **SSC 2020 guidelines** have also recommended the use of balanced salt solution over NS as bolus fluid therapy.

- **Synthetic colloids**, particularly hydroxyethyl starch solutions, have been associated with increased risk of acute kidney injury, coagulopathy, and death in patients with septic shock.

- Use of **albumin** is associated with *better outcomes* and is recommended in conditions with large fluid losses in third spaces, like dengue .
- The latest guidelines recommend against the use of **colloids** in the management of sepsis and septic shock.

Volume of fluid bolus:

- Aggressive fluid resuscitation using fluid boluses of **40–60 mL/kg** during the initial phase of septic shock has been advocated by various guidelines, including the latest **ACCM guidelines**, and has been consistently shown to be associated with reduced mortality.

- The concept behind using such large volumes is to mitigate the hypovolemia due to the massive capillary leak associated with sepsis.

- However, the use of this approach has been questioned lately by the **Fluid Expansion as Supportive Therapy (FEAST) trial**, which has reported poor outcomes with bolus fluid administration, particularly in those with severe anemia, malnutrition, and malaria.

- The **SSC 2020 guidelines** have recommended that, based on the availability of intensive care resources, **40–60 mL/kg** of bolus fluid (10–20 mL/kg per bolus) in 1 h can be given in the presence of intensive care facilities,

- The **SSC 2020 guidelines** have recommended only **40 mL/kg** of bolus fluid in 1 h if hypotension is present, and no fluid bolus, if hypotension is not present **where intensive care facilities are not available**.

- The **Crystalloid Liberal or Vasopressors Early Resuscitation in Sepsis (CLOVERS) trial** compared the effects of a restrictive fluid strategy (with early use of vasopressors) to a liberal fluid strategy.

- The conclusion was that a restrictive fluid strategy used during the first 24 hours of resuscitation for sepsis-induced hypotension would lead to lower mortality before discharge home by day 90 than a liberal fluid strategy.

- **Severe anemia** – Patients with septic shock accompanied by severe anemia should receive blood transfusion.
- Children in **resource-limited settings** with nonhemorrhagic shock and severe anemia (eg, hemoglobin **<6 g/dL** [PCV/HCT <18 percent] or, in malaria-endemic regions, **≤5 g/dL** [PCV/HCT <15 percent]) require blood transfusion.

- **Severe malnutrition** – Patients with septic shock and severe acute malnutrition typically receive fluid resuscitation that is at the lower end of the recommended volume and rate (eg, 10 to 15 mL/kg of BCS over 60 minutes).

- **Cardiogenic shock**- Fluid resuscitation should only be indicated in patients with cardiogenic shock after clinical assessment (preload insufficiency); it is advised that echocardiographic evaluation be used during such assessment (strong agreement).

- If there are evidences of dehydration in **cardiogenic shock**, use small fluid boluses (5-10mL/kg) for volume expansion.

- Fluid resuscitation with colloids and/or crystalloids should not be used in patients with cardiogenic shock (strong agreement).

- In the **FEAST study**, despite specific comorbid conditions compared to those seen in industrialized countries, the increased mortality of children receiving fluid boluses was found to be due to cardiac events (cardiogenic shock) related to fluid overload.

Method of fluid administration:

- The rapidity with which a fluid bolus can be administered is still unknown, with the recommendations for pushing fluids as fast as possible in the presence of hypotension.

- **In two pediatric RCTs**, greater rates of intubation, mechanical ventilation, and hepatomegaly were observed in the group where bolus fluid was administered over 5–10 min compared to when administered over 15–20 min. However, there was no difference in mortality in both groups.

- According to a study, the **USFR** (Ultrasound-guided Fluid Resuscitation) protocol reduces the occurrence of fluid overload and leads to a lower mortality rate at 72 hours compared to the ACCM fluid resuscitation protocol.

- The **current recommendations** advocate a slower rate of fluid bolus administration, particularly in resource-limited settings.

Assessing fluid overload:

- While early fluid resuscitation in septic shock improves organ perfusion, it leads to fluid accumulation in later stages, causing fluid overload.
- Studies have revealed that cumulative fluid overload **> 10%** is associated with increased mortality.

- Apart from usual clinical signs, point-of-care ultrasound, and echocardiography are being increasingly used for assessment of fluid status, cardiac function, and fluid overload.

- Because excess fluid causes an increased risk of death in children with shock in resource-limited settings, monitoring for fluid overload should occur frequently during rapid fluid administration (eg, every **15** minutes) and then no less than **every hour** until the patient is no longer in shock.

- Once shock is reversed and tissue perfusion is restored, the patient continues to require regular assessment (eg, every 2 to 4 hours during IV fluid therapy) during the first 24 hours.

Fluid responsiveness Assessment:

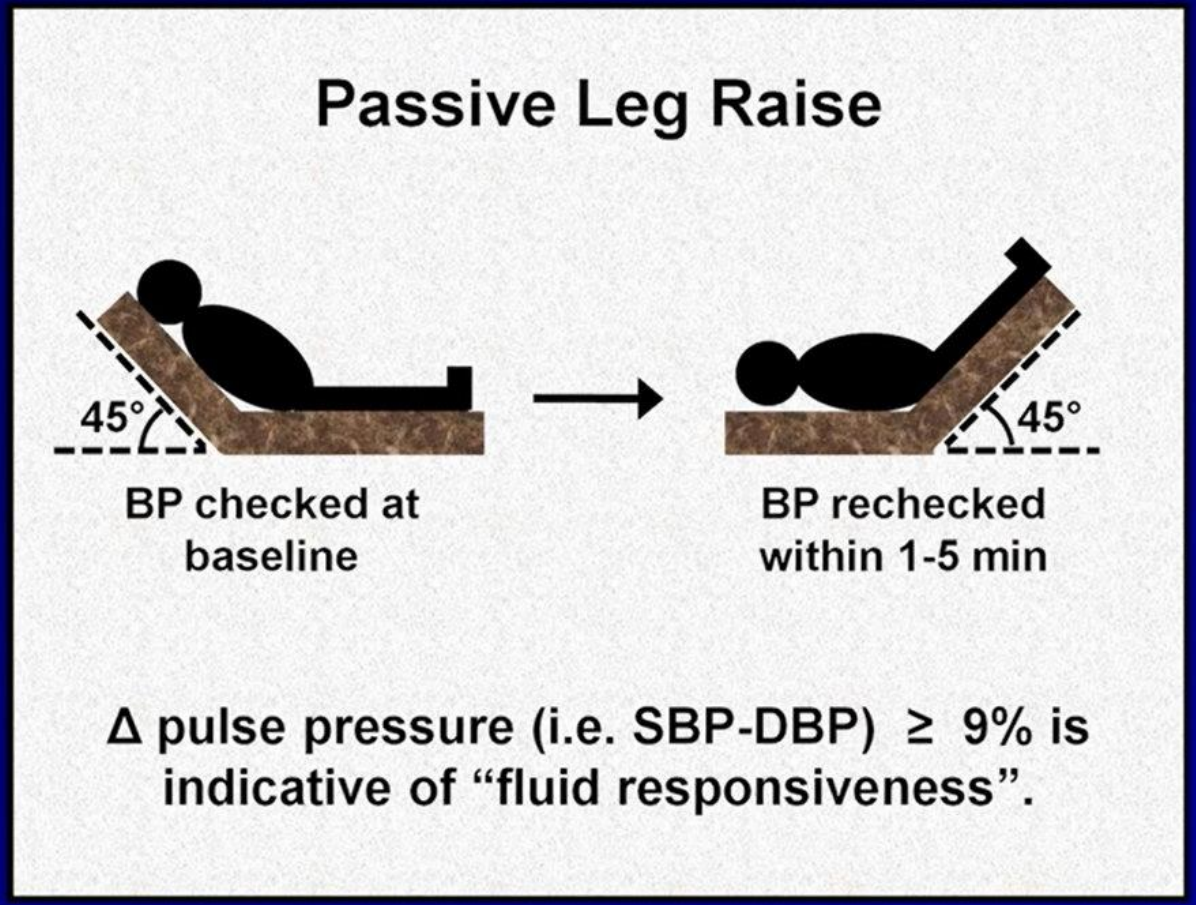
- In a study a 15% change in **ICON(index of contractility)** had an excellent predictive performance for the fluid responsiveness among their cohort of pediatric shock.

- Banothu et al. demonstrated that in hands of Pediatric intensivists, both **ΔIVC** (inferior vena cava distensibility index) and **ΔVpeak** (respiratory variation in peak aortic blood flow velocity) are good predictors of fluid responsiveness among mechanically ventilated children with shock.

- **Passive leg raising test**: the decision to administer fluid must always be made individually on the basis of the mandatory presence of the three following situations:

1. **Hemodynamic instability or signs of circulatory shock (or both)**
2. **Preload responsiveness (positive PLR test)**
3. **Limited risks of fluid overload**

Passive Leg Raise as a Substitute for CVP



Passive leg raise as a predictor of fluid responsiveness:

Sensitivity = 79%

Specificity = 85%

Préau S, et al. Passive leg raising is predictive of fluid responsiveness in spontaneously breathing patients with severe sepsis or acute pancreatitis. Crit Care Med. 2010; 38 : 819-25.

- Also, a **negative PLR test** should contribute mainly to the decision to stop or discontinue fluid infusion, in order to avoid fluid overload, suggesting that hemodynamic instability should be corrected by means other than fluid administration.

Thank you