Fluid therapy in septic shock

DR. SHORAFA

PEDIATRIC INTENSIVIST

objective

History of fluid therapy

How much?

When?

What type? tonicity/ balanced fluid/ composition

Maintenance ?

Definition

Table. The Phoenix Sepsis Score[a]

Variables	0 Points	1 Point	2 Points	3 Points
Respiratory, 0-3 points				
	Pao_2:Fio_2 ≥400 or Spo_2:Fio_2 ≥292[b]	Pao_2:Fio_2 <400 on any respiratory support or Spo_2:Fio_2 <292 on any respiratory support[b,c]	Pao_2:Fio_2 100-200 and IMV or Spo_2:Fio_2 148-220 and IMV[b]	Pao_2:Fio_2<100 and IMV or Spo_2:Fio_2 <148 and IMV[b]
Cardiovascular, 0-6 points				
		1 Point each (up to 3)	2 Points each (up to 6)	
	No vasoactive medications[d]	1 Vasoactive medication[d]	≥2 Vasoactive medications[d]	
	Lactate <5 mmol/L[e]	Lactate 5-10.9 mmol/L[e]	Lactate ≥11 mmol/L[e]	
Age based[f]				
	Mean arterial pressure, mm Hg[g]			
<1 mo	>30	17-30	<17	
1 to 11 mo	>38	25-38	<25	
1 to <2 y	>43	31-43	<31	
2 to <5 y	>44	32-44	<32	
5 to <12 y	>48	36-48	<36	
12 to 17 y	>51	38-51	<38	

Coagulation (0-2 points)[h]			
		1 Point each (maximum 2 points)	
	Platelets ≥100 × 10^3/μL	Platelets <100 × 10^3/μL	
	International normalized ratio ≤1.3	International normalized ratio >1.3	
	D-dimer ≤2 mg/L FEU	D-dimer >2 mg/L FEU	
	Fibrinogen ≥100 mg/dL	Fibrinogen <100 mg/dL	
Neurological (0-2 points)[i]			
	Glasgow Coma Scale score >10; pupils reactive[j]	Glasgow Coma Scale score ≤10[j]	Fixed pupils bilaterally
Phoenix sepsis criteria			
Sepsis	Suspected infection and Phoenix Sepsis Score ≥2 points		
Septic shock	Sepsis with ≥1 cardiovascular point(s)		

Abbreviations: FEU, fibrinogen equivalent units; IMV, invasive mechanical ventilation; INR, international normalized ratio of prothrombin time; MAP, mean arterial pressure; Pao_2:Fio_2, arterial partial pressure of oxygen to fraction of inspired oxygen ratio; Spo_2, oxygen saturation measured by pulse oximetry (only Spo_2 of ≤97%).

SI conversion factor: To convert lactate from mmol/L to mg/dL, divide by 0.111.

[a] The score may be calculated in the absence of some variables (eg, even if lactate level is not measured and vasoactive medications are not used, a cardiovascular score can still be ascertained using blood pressure). It is expected that laboratory tests and other measurements will be obtained at the discretion of the medical team based on clinical judgment. Unmeasured variables contribute no points to the score. Ages are not adjusted for prematurity, and the criteria do not apply to birth hospitalizations, neonates whose postconceptional age is younger than 37 weeks, or those 18 years of age or older.

[d] Vasoactive medications include any dose of epinephrine, norepinephrine, dopamine, dobutamine, milrinone, and/or vasopressin (for shock).

[e] Lactate reference range is 0.5 to 2.2 mmol/L. Lactate can be arterial or venous.

[f] Age is not adjusted for prematurity, and the criteria do not apply to birth hospitalizations, children whose postconceptional age is younger than 37 weeks, or those 18 years or older.

[g] Use measured MAP preferentially (invasive arterial if available or noninvasive oscillometric), and if measured MAP is not available, a calculated MAP (1/3 × systolic + 2/3 × diastolic) may be used as an alternative.

[h] Coagulation variable reference ranges: platelets, 150 to 450 × 10^3/μL; D-dimer, <0.5 mg/L FEU; fibrinogen, 180 to 410 mg/dL. The INR reference range is based on the local reference prothrombin time.

[i] The neurological dysfunction subscore was pragmatically validated in both

Pediatric sepsis incidence and mortality are, respectively, 25.2 million and 3.4 million worldwide in 2017

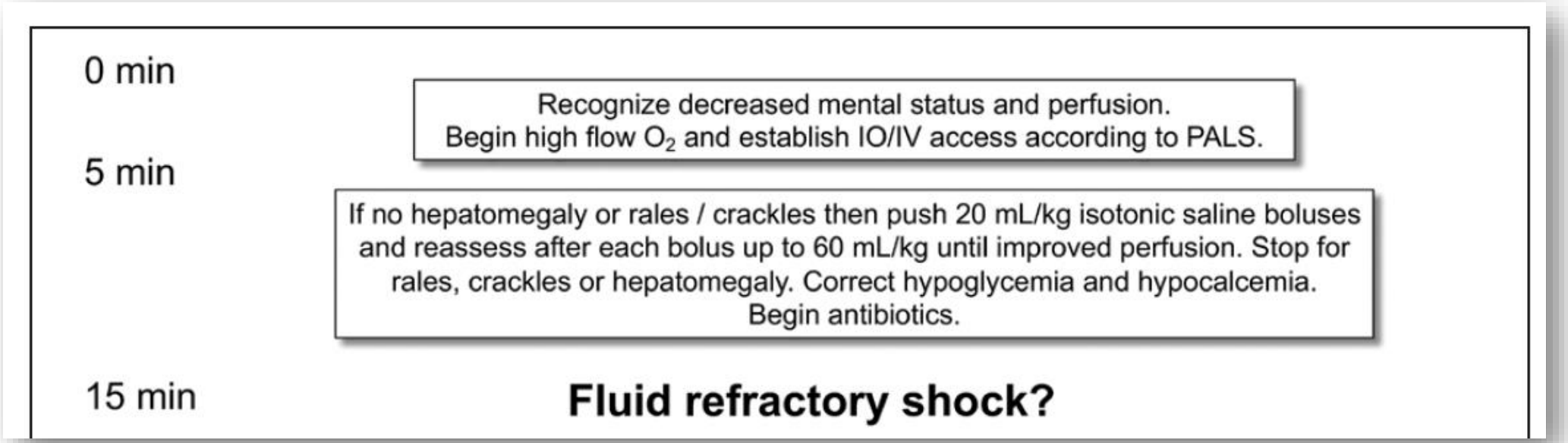
World Health Organization (WHO) recommendation in the 1990s to perform aggressive fluid bolus therapy reduced tenfold the mortality of pediatric sepsis

Clinical signs of poor tissue perfusion are tachycardia, altered mental status, decreased urine output (below 1 ml/kg/h) and abnormalities in capillary refill time (flash < 1 s or prolonged > 3 s), skin (mottled, cool or flushed, ruddy) and pulses (weak or bounding)

Fluid bolus therapy in pediatric sepsis: a narrative review

European Journal of Medical Research (2022) 27:246
https://doi.org/10.1186/s40001-022-00885-8

American College of Critical Care Medicine Clinical Practice Parameters for Hemodynamic Support of Pediatric and Neonatal Septic Shock



Intensive Care Med (2018) 44:2242–2244
https://doi.org/10.1007/s00134-018-5401-8

EDITORIAL

How I treat septic shock

Jean-Louis Vincent*

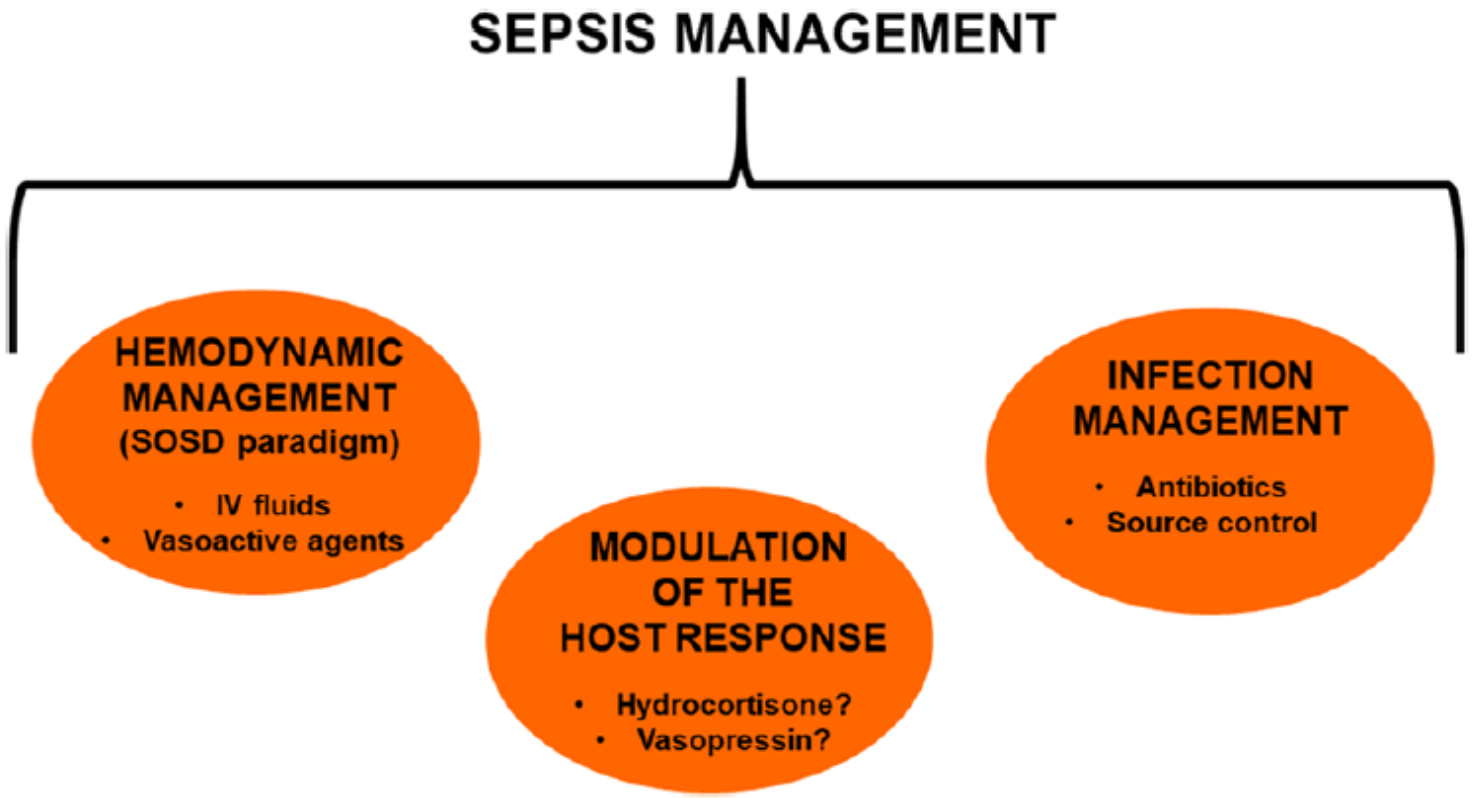


Fig. 1 The three components of septic shock management. *SOSD* salvage, optimization, stabilization, and de-escalation

Effects of saline or albumin fluid bolus in resuscitation: evidence from re-analysis of the FEAST trial

Michael Levin, Aubrey J Cunnington*, Clare Wilson, Simon Nadel, Hans Joerg Lang, Nelly Ninis, Mignon McCulloch, Andrew Argent, Heloise Buys, Christopher A Moxon, Abigail Best, Ruud G Nijman, Clive J Hoggart*

Summary

Background Fluid resuscitation is the recommended management of shock, but increased mortality in febrile African children in the FEAST trial. We hypothesised that fluid bolus-induced deaths in FEAST would be associated with

Lancet Respir Med 2019; 7: 581–93

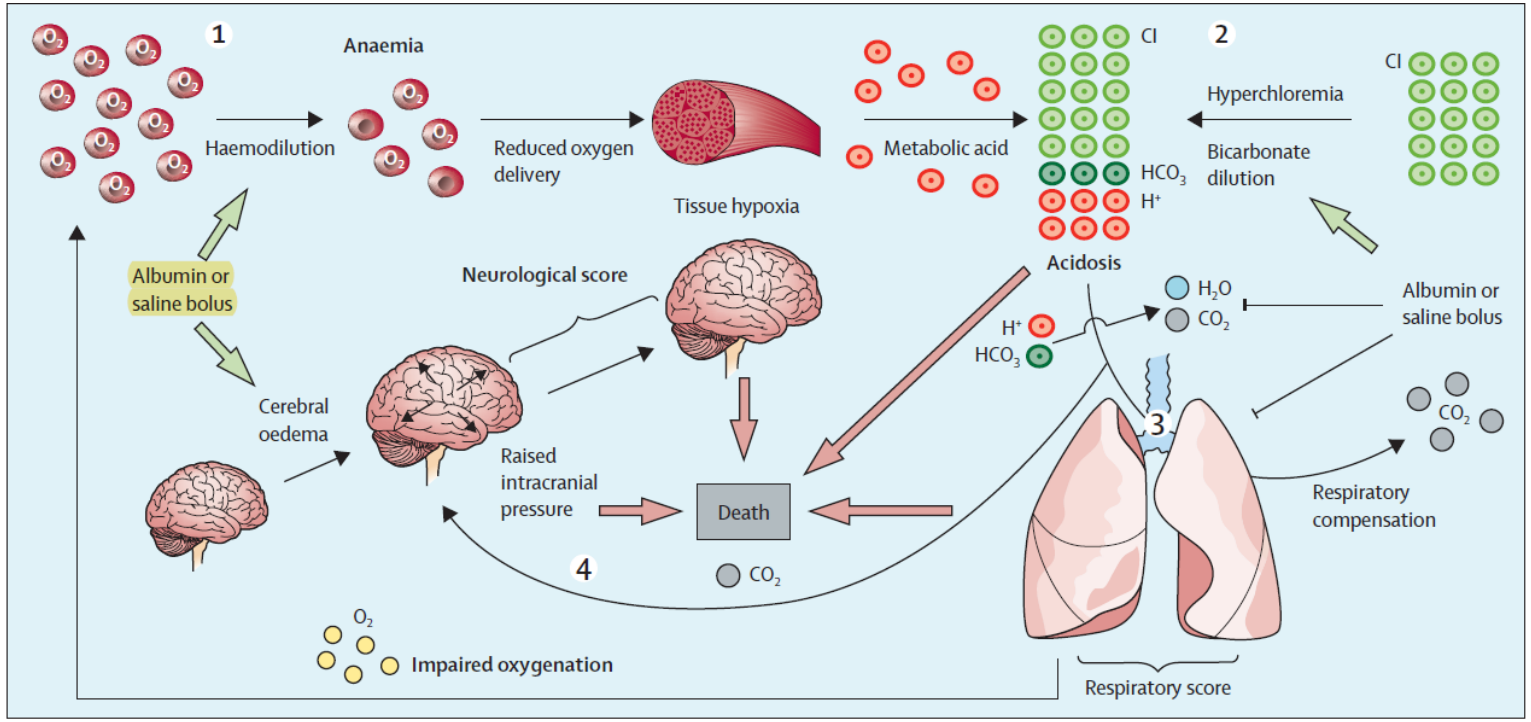


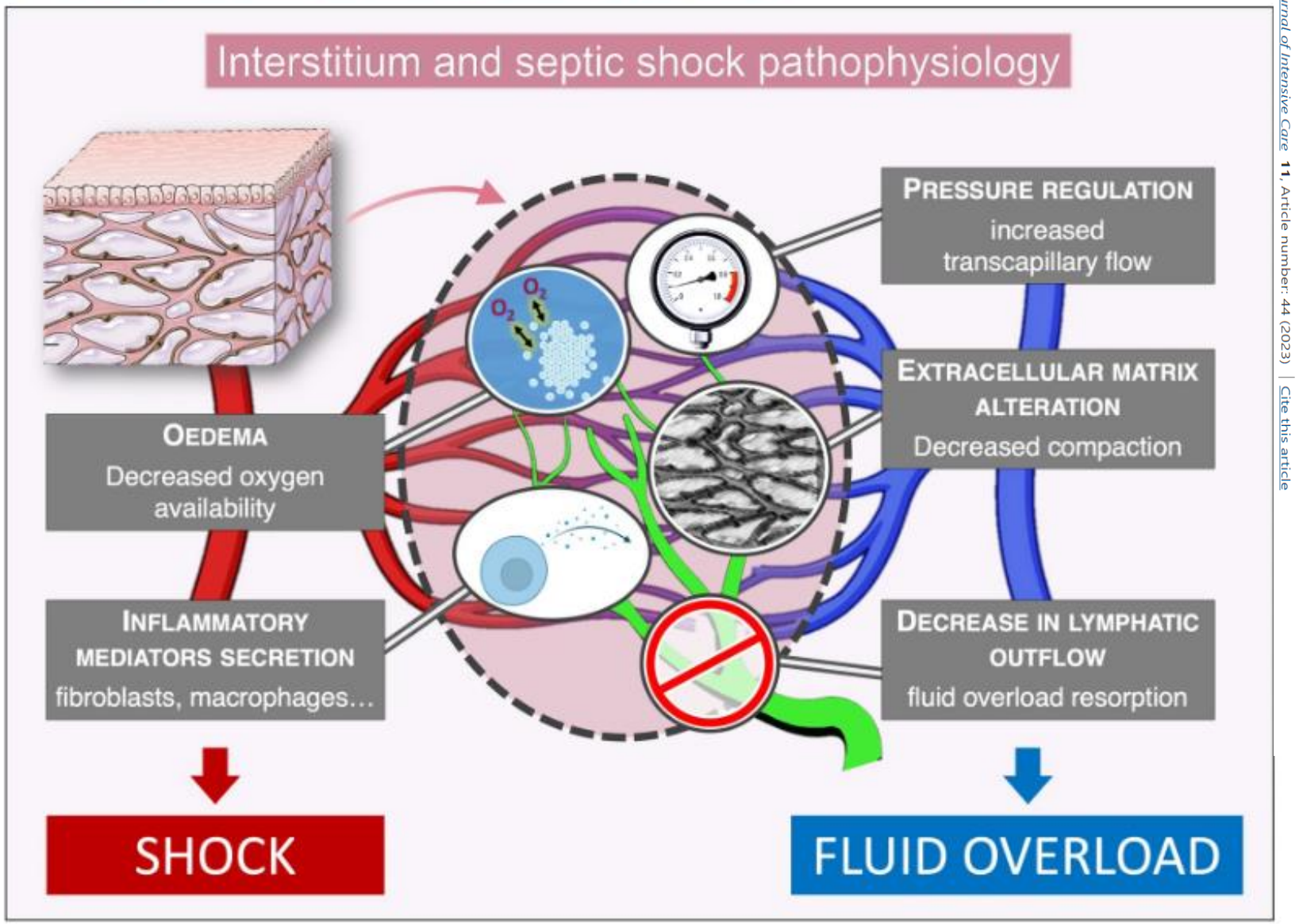
Figure 5: **Proposed physiological model of the adverse effects of fluid bolus**

Bolus fluid reduces haemoglobin concentration, resulting in decreased tissue oxygenation, increasing anaerobic metabolism, and metabolic acidosis. According to the Stewart model, maintenance of normal plasma pH is controlled by (1) the strong ion difference (charge difference between strong cations (Na^+, K^+, Ca^{2+}, and Mg2+), and strong anions (Cl– and lactate–); (2) pCO_2 and (3) charge from weak acids (phosphate, albumin).[28,29] Bolus of normal saline or 5% albumin (which have similar electrolyte content) caused hyperchloraemia and dilution of bicarbonate, resulting in a reduction in the strong ion difference. Hyperchloraemic acidosis increases the need for respiratory compensation through increased carbon dioxide excretion to maintain pH. Worsening of respiratory function due to bolus results in hypoxia (as evidenced by low oxygen saturation and increased respiratory score). This outcome, together with an inability to increase respiratory rate, impairs excretion of carbon dioxide (not shown in our study). Increasing carbon dioxide causes cerebral vasodilation, resulting in increased intracranial pressure. Fluid bolus might also directly cause cerebral oedema. The combination of adverse effects on haemoglobin concentration, acidosis, and respiratory and neurological function induced by modest albumin or saline fluid boluses might overwhelm compensatory mechanisms in the most severely ill patients, resulting in increased mortality.

Overall, we have identified five potential intersections between septic shock pathophysiology and the interstitium: 1. increase of oedema formation, interacting with organ function and metabolites diffusion; 2. interstitial pressure regulation, increasing transcapillary flow; 3. alteration of the extracellular matrix; 4. interstitial secretion of inflammatory mediators; 5. decrease of lymphatic outflow.

Sepsis-induced oedema is aggravated by fluid therapy and is mostly referred to as fluid overload. It has been identified in recent years as a major prognostic factor for morbidity and mortality in patients with septic shock

From: Role of the interstitium during septic shock: a key to the understanding of fluid dynamics?



Proposed mechanisms by which interstitium may interact with sepsis pathophysiology. Diagram representing the interstitial compartment, surrounding the capillary bed (red: arterial side, blue: venous side). Lymphatic vessels appear in green

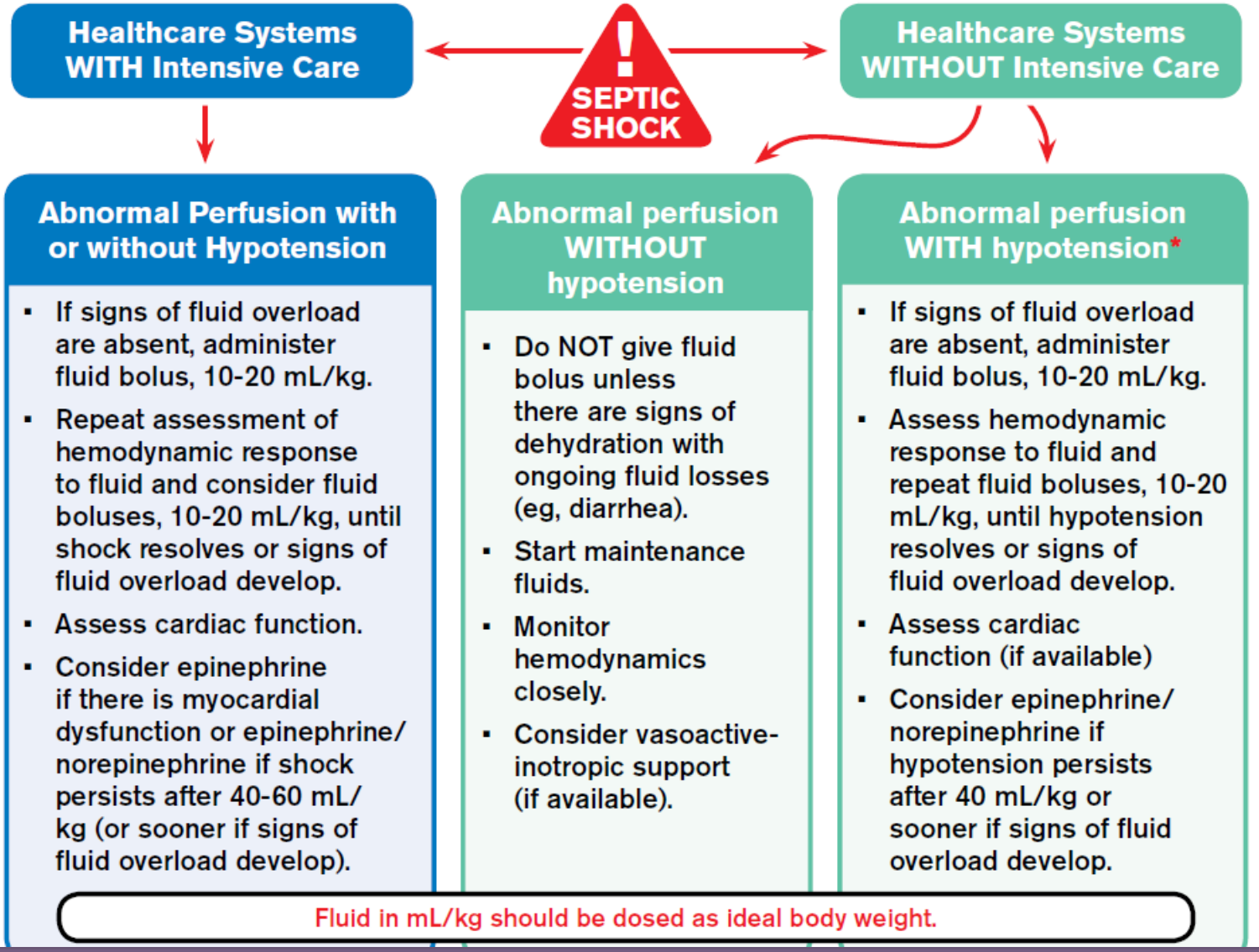
Review | Open access | Published: 10 October 2023
Role of the interstitium during septic shock: a key to the understanding of fluid dynamics?
Auguste Dargent, Hugo Dumargne, Marie Labruyère, Stéphane Brezillon, Sylvie Brassart-Pasco, Mathieu Blot, Pierre-Emmanuel Charles, Isabelle Fournel, Jean-Pierre Quenot & Marine Jacquier
Journal of Intensive Care 11, Article number: 44 (2023) | Cite this article

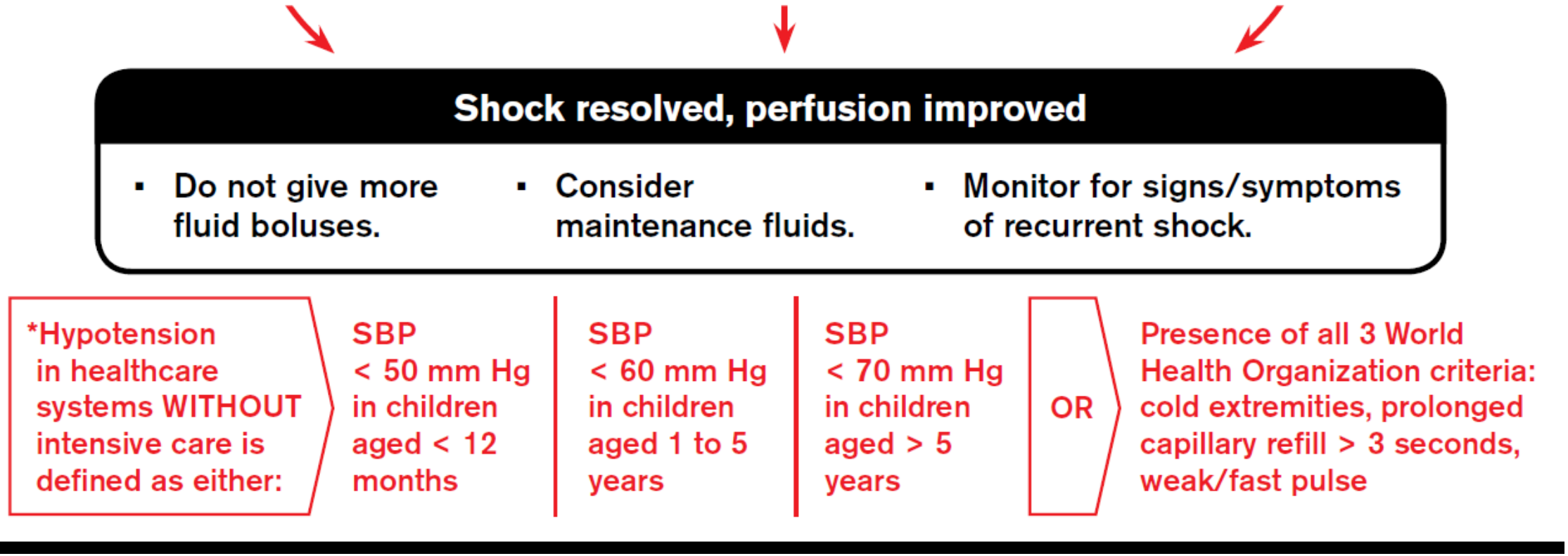
Interstitial oedema increases intercellular spaces and has long been recognized as a critical factor for tissue oxygenation

How much?

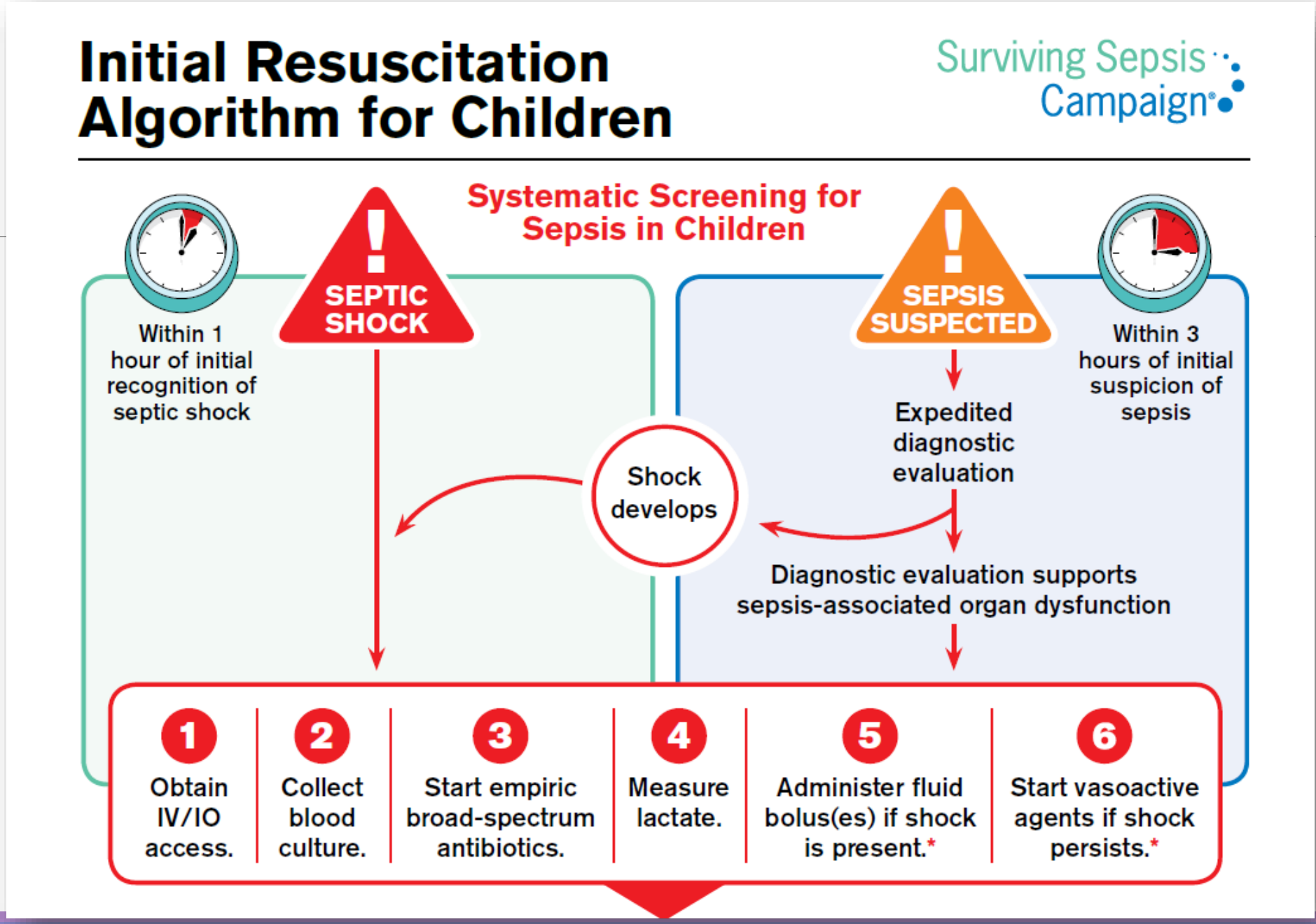
Fluid and Vasoactive-Inotrope Management Algorithm For Children

Surviving Sepsis Campaign




Shock resolved, perfusion improved
▪ Do not give more fluid boluses.
▪ Consider maintenance fluids.
▪ Monitor for signs/symptoms of recurrent shock.
*Hypotension in healthcare systems WITHOUT intensive care is defined as either:
SBP < 50 mm Hg in children aged < 12 months
SBP < 60 mm Hg in children aged 1 to 5 years
SBP < 70 mm Hg in children aged > 5 years
OR
Presence of all 3 World Health Organization criteria: cold extremities, prolonged capillary refill > 3 seconds, weak/fast pulse

When?


Initial Resuscitation Algorithm for Children
Surviving Sepsis Campaign
Systematic Screening for Sepsis in Children
SEPTIC SHOCK
SEPSIS SUSPECTED
Within 1 hour of initial recognition of septic shock
Within 3 hours of initial suspicion of sepsis
Expedited diagnostic evaluation
Shock develops
Diagnostic evaluation supports sepsis-associated organ dysfunction
1 Obtain IV/IO access.
2 Collect blood culture.
3 Start empiric broad-spectrum antibiotics.
4 Measure lactate.
5 Administer fluid bolus(es) if shock is present.*
6 Start vasoactive agents if shock persists.*

What type? tonicity/ balanced fluid/ composition

The Surviving Sepsis Campaign recommends, with very low quality of evidence, balanced crystalloids rather than normal saline, as the first-line for fluid bolus therapy in pediatric sepsis [13]. The latest guidelines of the European Resuscitation Council have recently extended this recommendation to all childhood circulatory failures

Table 1 Composition of commonly used crystalloids

From: Fluid bolus therapy in pediatric sepsis: a narrative review

	Human plasma	Normal saline	Hartmann's solution	Ringer's lactate	Ringer's acetate	Plasma-Lyte	Sterofundin
Sodium	140 ± 5	154	131	130	130	140–141	145
Chloride	102 ± 8	154	111	109	112	98	127
Potassium	4.5 ± 1	0	5	4	5	5	4
Calcium	2.4 ± 0.2	0	2	1.4	1	0	2.5
Magnesium	0.9 ± 0.1	0	0	0	1	1.5	1
Bicarbonate	28 ± 4	0	0	0	0	0	0
Lactate	< 2	0	29	28	0	0	0
Gluconate	0	0	0	0	0	23	0
Acetate	0	0	0	0	27	27	24
Malate	0	0	0	0	0	0	5
Osmolarity	285 ± 10	308	278	273	276	295	309
pH	7.4 ± 0.02	4.5–7.0	5.0–7.0	6.0–7.5	6.0–8.0	6.5–8.0	5.1–5.9
SID	40 ± 2	0	27	27	25	50	27
Na/Cl ratio	1.21–1.54	1	1.18	1.19	1.16	1.43	1.14

All variables are expressed in mmol/L except for osmolarity (mosm/L) and pH. *SID* strong ion difference

Review | Open access | Published: 12 November 2022
Fluid bolus therapy in pediatric sepsis: a narrative review
Julian San Gerotea, Michaël Levy, Julien Gotchac, Olivier Brissaud & Stéphane Dauger
European Journal of Medical Research 27, Article number: 246 (2022) | Cite this

TABLE 1 Composition of Commonly Used Maintenance IVFs

Fluid	Glucose, g/dL	Sodium	Chloride	Potassium, mEq/L	Calcium	Magnesium	Buffer	Osmolarity,[a] mOsm/L
Human plasma	0.07–0.11	135–145	95–105	3.5–5.3	4.4–5.2	1.6–2.4	23–30 bicarbonate	308[b]
Hypotonic solutions								
D_5 0.2% NaCl	5	34	34	0	0	0	0	78
D_5 0.45% NaCl	5	77	77	0	0	0	0	154
Isotonic and/or near-isotonic solutions								
D_5 0.9% NaCl	5	154	154	0	0	0	0	308
D_5 lactated Ringer	5	130	109	4	3	0	28 lactate	273
PlasmaLyte[c,d]	0	140	98	5	0	3	27 acetate and 23 gluconate	294

[a] The osmolarity calculation excludes the dextrose in the solution because dextrose is rapidly metabolized on infusion.

[b] The osmolality for plasma is 275–295 mOsm/kg.

[c] Multiple electrolytes injection, type 1 *United States Pharmacopeia*, is the generic name for PlasmaLyte.

[d] PlasmaLyte with 5% dextrose is not available in the United States from Baxter Healthcare Corporation in Deerfield, Illinois.

Clinical Practice Guideline: Maintenance Intravenous Fluids in Children

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN™

RECOMMENDATION #20	STRENGTH & QUALITY OF EVIDENCE
We ***suggest*** using crystalloids, rather than albumin, for the initial resuscitation of children with septic shock or other sepsis-associated organ dysfunction. **Remarks:** Although there is no difference in outcomes, this recommendation takes into consideration cost and other barriers of administering albumin compared with crystalloids.	• Weak • Moderate-Quality of Evidence

RECOMMENDATION #22	STRENGTH & QUALITY OF EVIDENCE
We ***recommend against*** using starches in the acute resuscitation of children with septic shock or other sepsis-associated organ dysfunction.	• Strong • Moderate-Quality of Evidence

RECOMMENDATION #23	STRENGTH & QUALITY OF EVIDENCE
We ***suggest against*** using gelatin in the resuscitation of children with septic shock or other sepsis-associated organ dysfunction.	• Weak • Low-Quality of Evidence

Predicting Fluid Responsiveness in Critically Ill Children: So Many Tools and So Few Answers*

Pediatric Critical Care Medicine www.pccmjournal.org 77

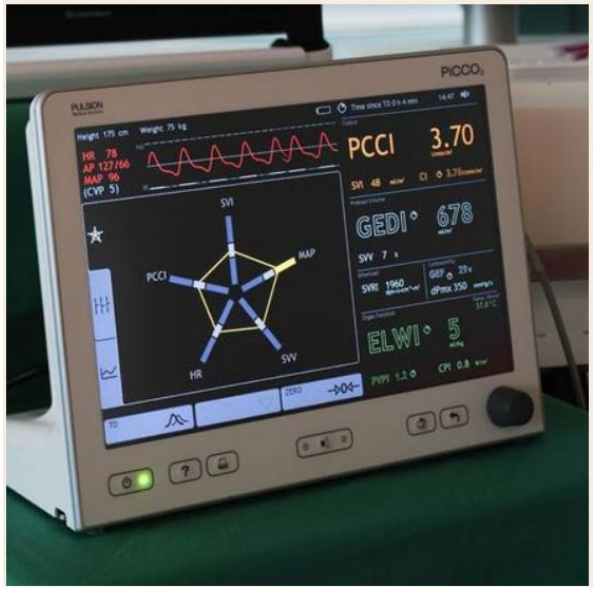
prediction of which patients will benefit from additional fluid resuscitation

Numerous techniques using:
cardiac and vascular ultrasound
arterial waveform analysis
pulse plethysmography
central venous pressure
thermodilution
near-infrared spectroscopy
and other novel devices have been developed to estimate intravascular volume status and to assess both static and dynamic hemodynamic responses to fluid challenges

Existing systematic reviews and meta-analyses of predictors of fluid responsiveness in children have demonstrated moderate-to-good prediction with respiratory variation in aortic blood flow peak velocity measured by ultrasound, but reviews consistently demonstrate poor predictive ability of other measures and substantial heterogeneity among included studies and patient populations

meta-analysis for all includedtools, with most studies defining fluid responsiveness based on an increase in ultrasound-assessed stroke volume, stroke volume index, or cardiac index by 10-15% from the pre-bolus value

USCOM 1A is a non-invasive, transcutaneous Doppler ultrasound device designed to simplify acquisition and storage of high-fidelity measurement and trending information of cardiovascular performance



PiCCO™ is a tool for advanced hemodynamic monitoring. It uses transpulmonary thermodilution and pulse contamination analysis to derive various parameters of the cardiovascular system

A plethysmograph is an instrument for measuring changes in volume within an organ or whole body (usually resulting from fluctuations in the amount of blood or air it contains). A photoplethysmograph (PPG) is a plethysmograph that uses optical techniques. A pulse oximeter measures oxygen saturation level (SpO2) and is also a PPG. It can measure the change in the volume of arterial blood with each pulse beat

Variability in the Hemodynamic Response to Fluid Bolus in Pediatric Septic Shock

CONCLUSIONS: The hemodynamic response to fluid bolus in pediatric septic shock was variable and unpredictable. We failed to find a relationship between mean arterial pressure and cardiac index changes. The adverse effects of fluid bolus extended beyond fluid overload and, in some cases, was associated with reduced mean arterial pressure, perfusion pressures and higher vasoactive support. Mean arterial pressure-nonresponders had increased mortality. The response to the initial fluid bolus may be helpful to understand each patient's individualized physiologic response and guide continued hemodynamic management.

Intensive Care Med (2022) 48:1482–1494
https://doi.org/10.1007/s00134-022-06808-9

REVIEW

How can assessing hemodynamics help to assess volume status?

Fig. 2 Integrative interpretation of volume status and extravascular lung water measurements. Volume status can be estimated by volumetric, pressure, or combination of both measurements. Extravascular lung water (EVLW) can be measured either by transpulmonary thermodilution, lung ultrasounds or even estimated by X-rays

Intensive Care Med (2022) 48:1482–1494
https://doi.org/10.1007/s00134-022-06808-9

REVIEW

How can assessing hemodynamics help to assess volume status?

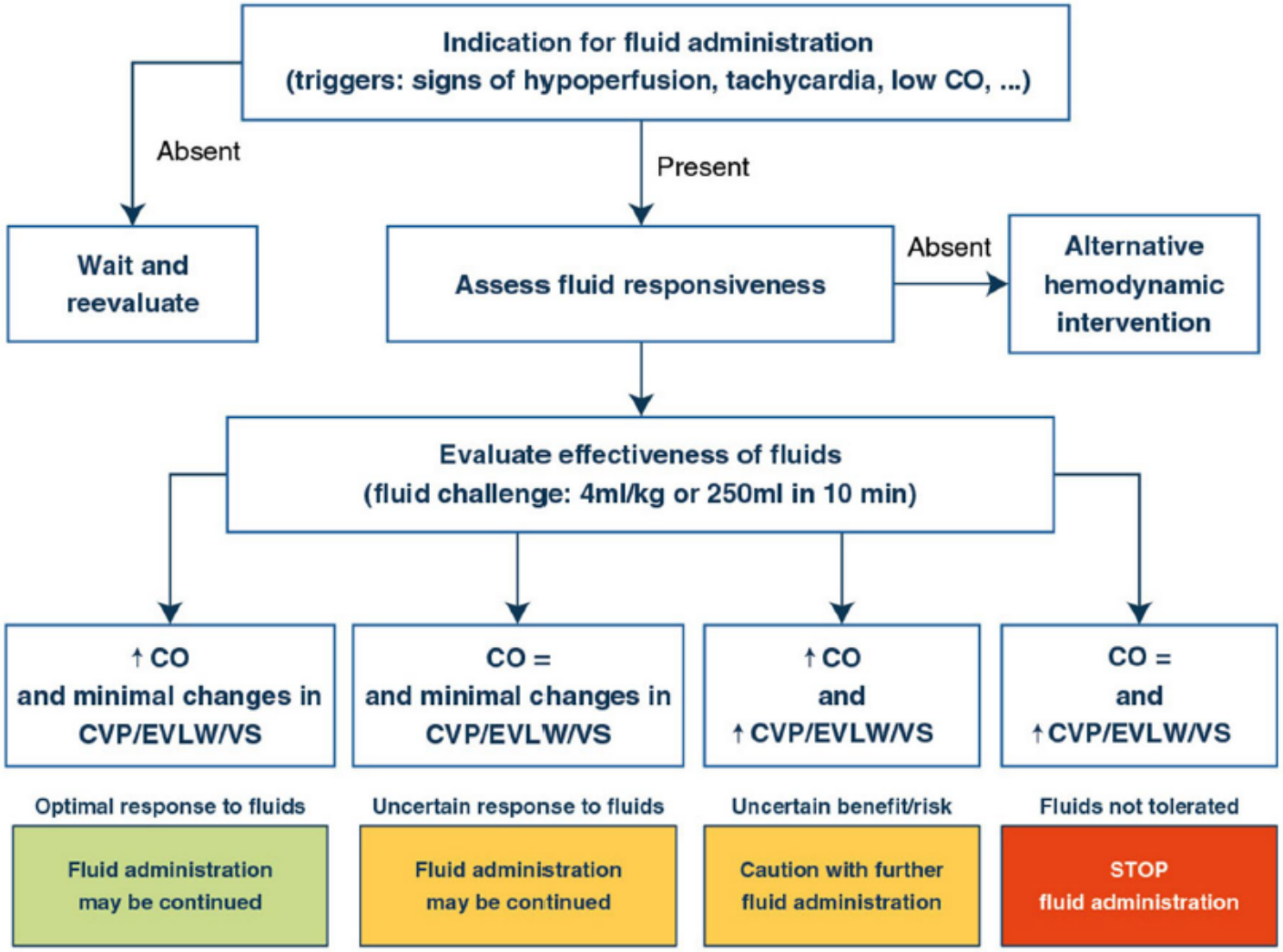
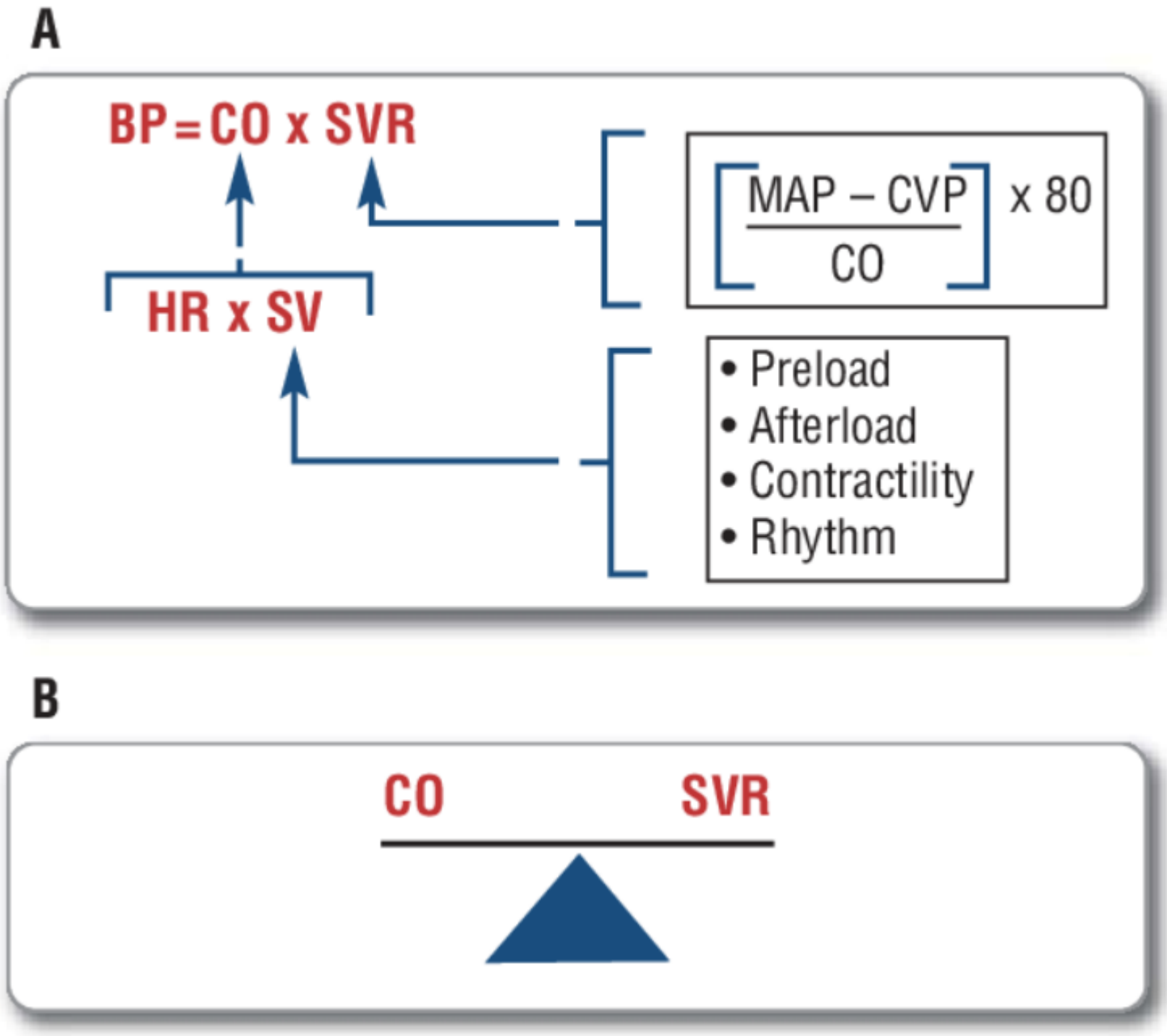


Fig. 4 Optimized fluid management. The optimal fluid management is based on defining the indication (trigger), predicting fluid responsiveness and evaluating the response to fluids both in terms of increase in perfusion but also taking into account tolerance to fluids. *CRT* capillary refill time, *CO* cardiac output, *CVP* central venous pressure, *EVLW* lung edema (estimated by various ways including transpulmonary thermodilution or lung ultrasounds, *VS* venous stasis


A
BP = CO x SVR
HR x SV
MAP – CVP / CO x 80
• Preload
• Afterload
• Contractility
• Rhythm
B
CO
SVR

Defining Maintenance

- "Maintenance" = volume of fluid required to meet daily metabolic needs, such as normal water and electrolyte losses, and maintain homeostasis.
- During acute illness, "maintenance" rates often do not reflect the true water and electrolyte needs of the patient due to increased losses due to factors such as:
  - Fever
  - Emesis
  - Diarrhea
  - Tachypnea

Incorrect Use of Maintenance IV Fluids

Do not use maintenance IV fluids…

- To replace abnormal or ongoing fluid losses including:
  - Bleeding
  - Surgical drain output
  - Emesis
  - Diarrhea
- To replete intravascular volume or for volume resuscitation

Calculate maintenance fluids and ongoing losses separately.

Do not adjust the calculated maintenance rate to account for ongoing losses.

Level of evidence: Expert Opinion

Seattle Children's
HOSPITAL • RESEARCH • FOUNDATION

Source	Na^+	K^+	Cl^-	HCO_3^-
Blood	140	4	100	25
Normal sweat	22	9	18	0
Bile	150	10	100	20
Gastric	50	15	125	0
Pancreatic	140	10	100	45
Small bowel	140	8	60	70
Diarrhoeal stool	40	50	25	65
These are illustrative mid-range values but there is considerable variation in individual values.				

Saline Content

- For patients at risk for increased ADH secretion, use normal saline (0.9% NS = 154 mEq/L NaCl).
- For patients not at risk for increased ADH secretion, use ½ normal saline (0.45% NS = 77 mEq/L NaCl).
- Do not use less than ½ NS (e.g., ¼ NS) for maintenance fluid in any age group on this pathway.

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Recommendations

- Maintenance IV fluids are appropriate for euvolemic patients who cannot take adequate enteral fluids
- Calculate hourly maintenance fluid rates using standard weight-based formula (4-2-1 rule)
- Do not use maintenance IV fluids at rates above calculated maintenance, and calculate replacement for ongoing fluid losses separately from maintenance
- In patients older than 28 days who do not meet exclusion criteria, use isotonic fluids
- Use caution and select fluids on a case-by-case basis for patients with the following conditions: Renal disease/renal dysfunction, endocrine disorders causing electrolyte abnormalities, neurosurgery or brain injury, severe cardiac disease, ICU Level of Care (PICU or NICU), severe malnutrition, known metabolic disease, sickle cell patients, liver failure/hepatic dysfunction, high extrarenal water loss
- Do not use ¼ NS for maintenance fluids outside the neonatal period
- Add 5% dextrose to maintenance fluids for patients with limited or no oral nutritional intake
- Add potassium to maintenance fluids unless contraindicated
- Check serum electrolytes (with attention to sodium, chloride, bicarbonate) at 24 hours after initiation of maintenance IV fluids for patients receiving >75% of maintenance needs via IV; re-check serum electrolytes as indicated
- Monitor strict intake and output, weight, blood pressure, and signs of fluid overload daily in patients receiving maintenance IV fluids
- Discontinue maintenance IV fluids as soon as patients can take adequate enteral fluids

Deficit Replacement:

- Use isotonic fluid (0.9% NS) for fluid deficit replacement / boluses

**Use caution in patients receiving large volumes of IV fluids for deficit replacement (e.g. AGE) and consider checking labs more frequently (at least q 24 hours) in these patients. In patients receiving higher than maintenance rate of IV fluids, consider using a more physiologic electrolyte solution like LR or Plasmalyte.*

PICO1—Indication: Does IV-MFT versus other hydration therapies (none, oral or enteral route) impact on clinical outcomes?

PICO2—Tonicity: Do isotonic solutions versus hypotonic solutions (as IV-MFT) impact on clinical outcomes?

PICO3—Balanced fluids: Do balanced solutions versus non-balanced solutions (as IV-MFT) impact on clinical outcomes?

PICO4—Composition: Does the composition of IV-MFT in terms of glucose, electrolytes (P, Mg, Ca, K), vitamins and trace elements impact on clinical outcomes?

PICO5—Amounts: Does the use of a restrictive IV-MFT volume versus the standard Holliday and Segar calculated volume impact on clinical outcomes?

Population, Intervention, Control, and Outcome(s) (PICO)

ESPNIC clinical practice guidelines: intravenous maintenance fluid therapy in acute and critically ill children— a systematic review and meta-analysis

Table 1 Intravenous maintenance fluid therapy (IV-MFT) recommendations, level of evidence according to SIGN grading, and consensus within the expert group

Recommendations	Level of evidence	Consensus
PiCO 1: IV-MFT indications		
In acutely ill children, the enteral or oral route for the delivery of maintenance fluid therapy should be considered, if tolerated, to reduce the failure rate of hydration access and costs	C	Strong consensus
In critically ill children with improving hemodynamic state, the enteral or oral route for the delivery of maintenance fluid therapy should be considered, if tolerated, to reduce length of stay in term neonates	GCP	Strong consensus
PiCO 2: use of isotonic fluids		
In acutely and critically ill children, isotonic maintenance fluid should be used to reduce the risk of hyponatremia	A	Strong consensus
PiCO 3: use of balanced solutions		
In critically ill children, balanced solutions should be favoured when prescribing intravenous maintenance fluid therapy to slightly reduce length of stay	B	Strong consensus

PiCO 4: IV-MFT fluid composition (Ca, Mg, P, Micronutrients, Glucose)		
In acutely and critically ill children, glucose provision in intravenous maintenance fluid therapy should be considered in sufficient amount and guided by blood glucose monitoring (at least daily) to prevent hypoglycaemia	GCP	Consensus
In critically ill children, glucose provision in intravenous maintenance fluid therapy should not be excessive and guided by blood glucose monitoring (at least daily) to prevent hyperglycaemia	B	Consensus
In acutely and critically ill children, there is insufficient evidence to recommend routine supplementation of magnesium, calcium and phosphate in intravenous maintenance fluid therapy	GCP	Strong consensus
In acutely and critically ill children, an appropriate amount of potassium should be considered and added to intravenous maintenance fluid therapy, based on the child's clinical status and regular potassium level monitoring to avoid hypokalemia	GCP	Consensus
In acutely and critically ill children, there is insufficient evidence to recommend routine supplementation of vitamins and trace elements in intravenous maintenance fluid therapy, in the absence of signs of deficiency	GCP	Strong consensus

PiCO 5: volume of IV-MFT administered		
In acutely and critically ill children, in order to prevent fluid creep and reduce fluid intake, the total daily amount of maintenance fluid therapy should be considered including: IV fluids, blood products, all IV medications (both infusions and bolus drugs), arterial and venous line flush solutions and enteral intake, but does not include replacement fluids and massive transfusion	D	Strong consensus
In acutely and critically ill children, avoidance of fluid overload and cumulative positive fluid balance should be considered, to avoid prolonged mechanical ventilation and length of stay	D	Strong consensus
In acutely and critically ill children, who are at risk of increased endogenous secretion of ADH, restriction of total intravenous maintenance fluid therapy volume (calculated by Holliday and Segar formula) should be considered to some extent, to avoid a decrease in natremia but the amount and duration of this restriction is uncertain	C	Strong consensus
In acutely and critically ill children who are at risk of increased endogenous secretion of ADH, restricting maintenance fluid therapy volume to between 65–80% of the volume calculated by the Holliday and Segar formula should be considered to avoid fluid overload In children at greater risk of oedematous states, e.g., heart failure, renal failure or hepatic failure, restricting maintenance fluid therapy volume to between 50% to 60% of the volume calculated with the Holiday and Segar formula should be considered to avoid fluid overload	GCP	Strong consensus
Whilst receiving intravenous maintenance fluid therapy, re-assessment of acutely and critically ill children should be considered at least daily in terms of fluid balance and clinical status and regularly regarding electrolytes, especially sodium level	D	Consensus

ADH anti-diuretic hormone; *GCP* good clinical practice; *IV-MFT* intravenous maintenance fluid therapy; Consensus (expert votes): 90% < agreement < 95%; Strong consensus: > 95% agreement

Long rationales are available for each recommendation in supplemental materials 7–11

objective

History of fluid therapy

How much?

When?

What type? tonicity/ balanced fluid/ composition

Maintenance ?

Thanks for your attention