ESICM 2025 part 2

The volumn of resuscitation fluid + ROSE concept

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The Four (or Six) D's

The European definition **states that shock :**

Imbalance between **oxygen delivery (DO_2)** and **oxygen consumption (VO_2)**
→ <u>anaerobic metabolism</u> and <u>lactate production</u>

$$DO_2 \quad = \quad CO \quad x \quad CaO_2$$

$$= HR\ x\ SV\ x\ (Hgb\ x\ SaO_2\ x\ 1.34 + pO_2\ x\ 0.0034)$$

CaO_2 = Arterial Oxygen Content

Malbrain, M.L.N.G. et al. (2024). The 4-indications of Fluid Therapy: Resuscitation, Replacement, Maintenance and Nutrition Fluids, and Beyond.

The Four (or Six) D's

Cardiac output is

amount of blood the heart pumps **into the body** each minute

1 $$CO = HR \, x \, SV$$

2 $$CO = HR \, x \, (EDV - ESV) \quad , \quad LVEF = \frac{EDV - ESV}{EDV} \rightarrow LVEF \, x \, EDV = \frac{EDV - ESV}{EDV} x \, EDV$$

3 $$CO = HR \, x \, LVEF \, x \, EDV$$

The Four (or Six) D's

Cardiac output is

amount of blood the heart pumps **into the body** each minute

1 $$\boldsymbol{CO = HR\ x\ LVEF\ x\ EDV}$$

2 $$\boldsymbol{MAP = (CO\ x\ SVR^{**}) + CVP^{*} = \frac{(2\ x\ DBP)+SBP}{3}}$$

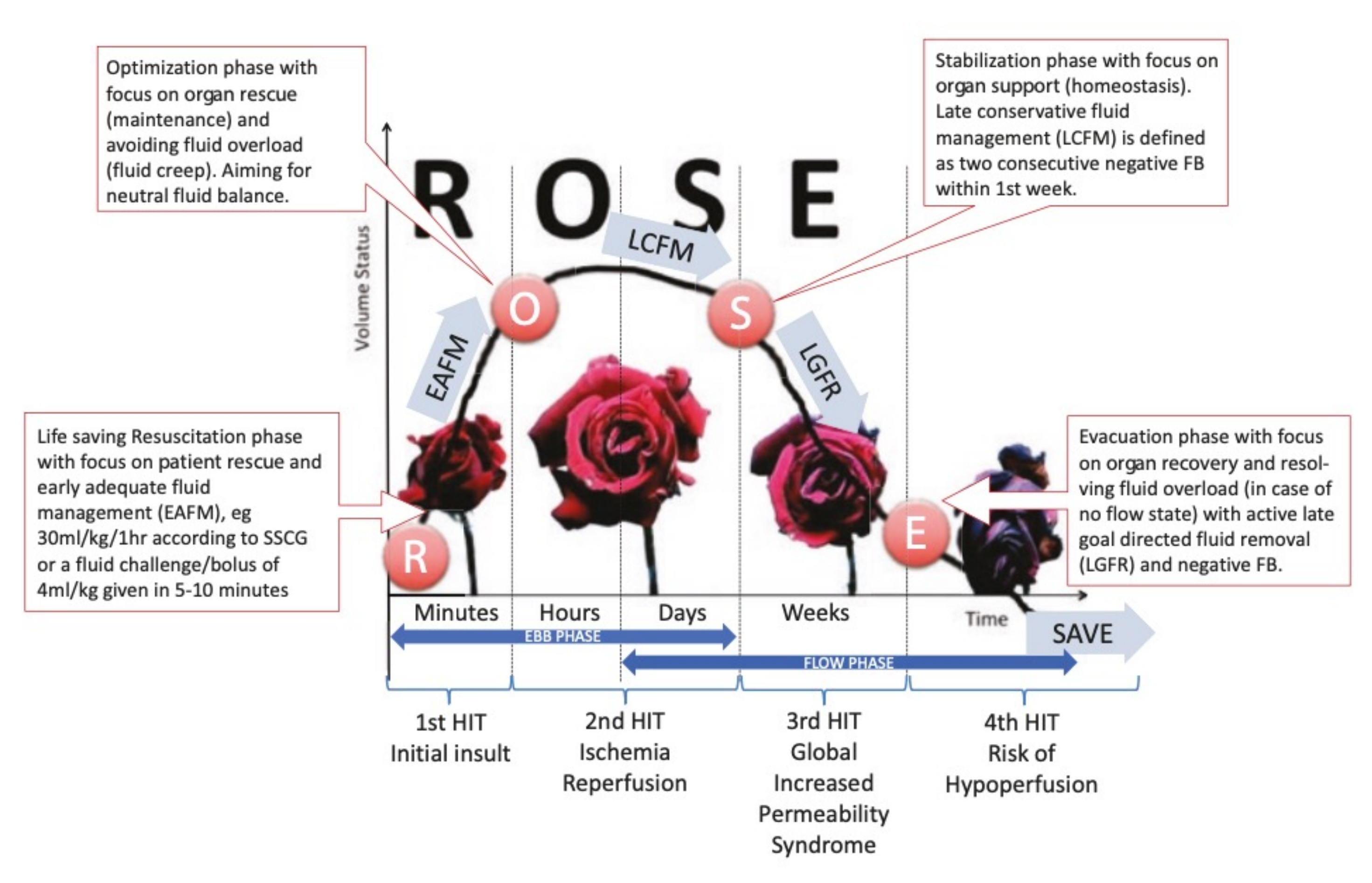
$$\boxed{\boldsymbol{MAP = LVEF\ x\ EDV\ x\ HR\ x\ SVR}}$$

*CVP is usually at or near 0 mmHg

**SVR = [(MAP-CVP)/CO] x 80

Calculation of Systemic Vascular Resistance (SVR)
Using Pressures Measured from **Swan-Ganz Catheter**

ROSE concept



Malbrain, M.L.N.G. et al. (2024). The 4-indications of Fluid Therapy: Resuscitation, Replacement, Maintenance and Nutrition Fluids, and Beyond.

Resuscitation
- "When to start fluid therapy?"
- **Aim** "restoration of the organ perfusion"

Optimization
- "When to stop fluid therapy?"
- **Aim** "avoid fluid overload"

Stabilization
- Absence of shock
- **Aim** "maintenance and replacement fluids"

Evacuation
- Recovery from shock
- **Aim** "directed fluid removal"

ROSE concept

Table 8.5 The ROSE concept avoiding fluid overload (adapted from Malbrain et al. with permission [28])

	Resuscitation	**O**ptimization	**S**tabilization	**E**vacuation
Hit sequence	First hit	Second hit	Second hit	Third hit
Time frame	Minutes	Hours	Days	Days to weeks
Underlying mechanism	Inflammatory insult	Ischemia and reperfusion	Ischemia and reperfusion	Global increased permeability syndrome
Clinical presentation	Severe shock	Unstable shock	Absence of shock or threat of shock	Recovery from shock, possible Global Increased Permeability Syndrome
Goal	Early adequate goal-directed fluid management	Focus on organ support and maintaining tissue perfusion	Late conservative fluid management	Late goal-directed fluid removal (de-resuscitation)
Fluid therapy	Early administration with fluid boluses, guided by indices of fluid responsiveness	Fluid boluses guided by fluid responsiveness indices and indices of the risk of fluid administration	Only for normal maintenance and replacement	Reversal of the positive fluid balance, either spontaneous or active
Fluid balance	Positive	Neutral	Neutral to negative	Negative
Primary result of treatment	Salvage or patient rescue	Organ rescue	Organ support (homeostasis)	Organ recovery
Main risk	Insufficient resuscitation	Insufficient resuscitation and fluid overload (e.g., pulmonary edema, intra-abdominal hypertension)	Fluid overload (e.g., pulmonary edema, intra-abdominal hypertension)	Excessive fluid removal, possibly inducing hypotension, hypoperfusion, and a "fourth hit"

Malbrain, M.L.N.G. et al. (2024). The 4-indications of Fluid Therapy: Resuscitation, Replacement, Maintenance and Nutrition Fluids, and Beyond.

ESICM 2025 part 2

The volumn of resuscitation fluid

ESICM 2025 part 2

Objective :

Provided guideline with evidence base on the **volume** of early resuscitation for **critical-ill adult patients**

Methods :

Reviews literature and reanalyze, presented with PICO and applied **grade approach**

"we recommendation" = strong recommedation
"we suggest" = weak recommendation
"best practice" = Ungraded
"no recommendation" = very low evidence

Result :

10 PICO question

- SEPSIS	3 question
- Hemorrhagic shock	3 question
- Obstructive shock	2 question
- Left-side cardiogenic shock	1 question
- ARDS	1 question

Sepsis – Q1

Question 1	Should 30 ml/kg fluid volume be used versus other approaches for initial resuscitation of circulatory failure in critically ill patients with sepsis or septic shock?		
Recommendation	*In adults with sepsis or septic shock who require fluid resuscitation for circulatory failure, we suggest administering up to 30 ml/kg of intravenous crystalloids in the initial phase (when hemodynamic monitoring is not yet available, typically within the first 3 h), with adjustments based on clinical context and frequent reassessments*	*Conditional Recommendation, For*	*Very Low certainty of evidence*
Remark	*Clinicians may choose to administer different volumes of crystalloids based on their clinical judgment, individual patient characteristics and clinical context*, such as the origin of sepsis (e.g., lung versus abdomen), cardiovascular comorbidities, or the presence or not of fluid losses		

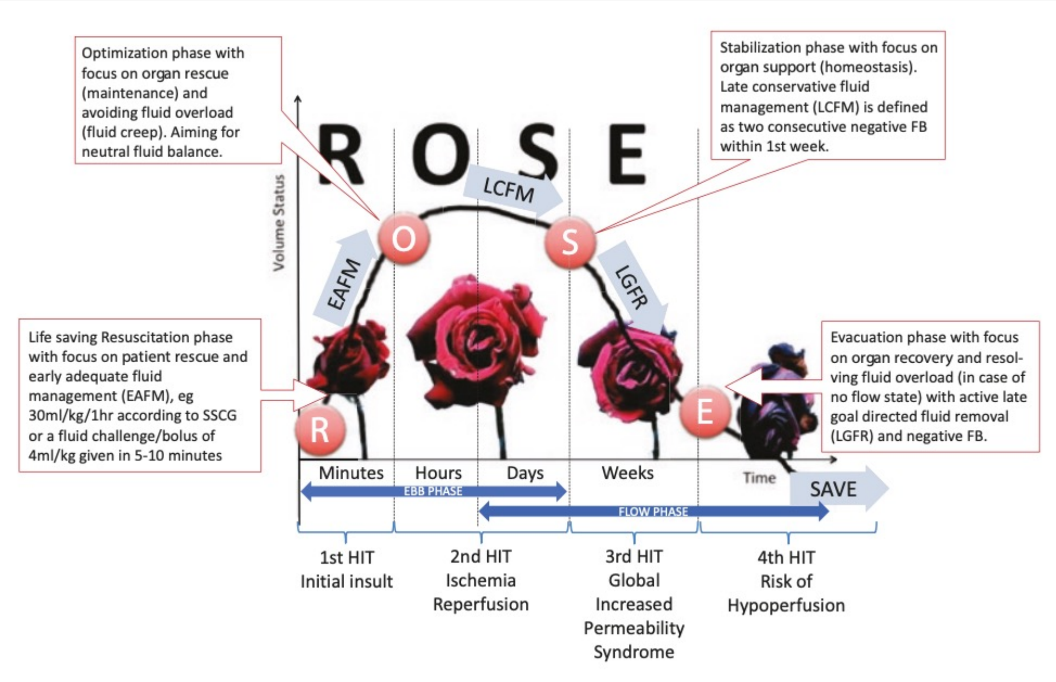
Sepsis – Q1

Initial phase :

- 1 – 6 hr of Treatment or within 3 hr (high income countries)

*SCC suggest at least initial fluid 30 ml/kg

> Several observsional study → Harm form positive cumulative fluid balance (High mortality)



Sepsis – Q2

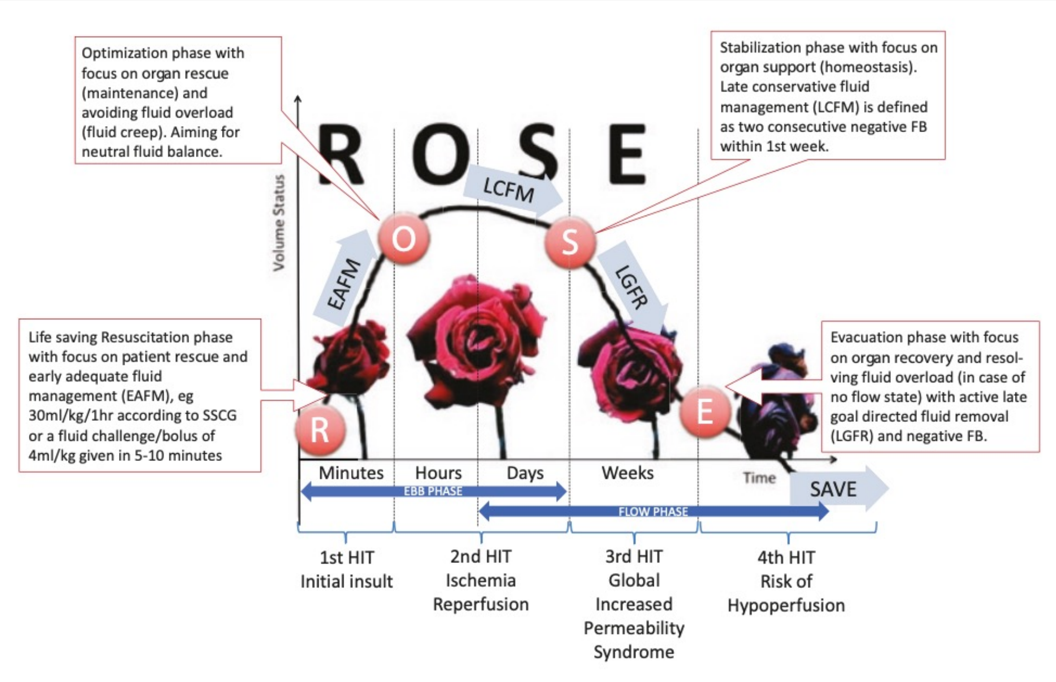
Question 2	Should a liberal vs. restrictive strategy be used in the optimization phase of resuscitation of circulatory failure in critically ill patients with sepsis or septic shock?		
Recommendation	*In adults with sepsis or septic shock who need fluid resuscitation for circulatory failure, we cannot recommend for or against systematic restrictive or liberal fluid administration*	*No recommendation*	*Moderate Certainty of evidence*
Remark	*In randomized trials, the use of a systematic restrictive strategy versus a systematic liberal strategy in the optimization phase of resuscitation had similar effects on patient-relevant outcomes (moderate certainty of evidence)*		

Sepsis – Q2

Otimization phase :

- 24 hr of Treatment

*SCC, **<u>insufficient evidence</u>** to recomened restrictive or liberal fluid strategy in patient who has sign of hypoperfusion



Sepsis – Q3

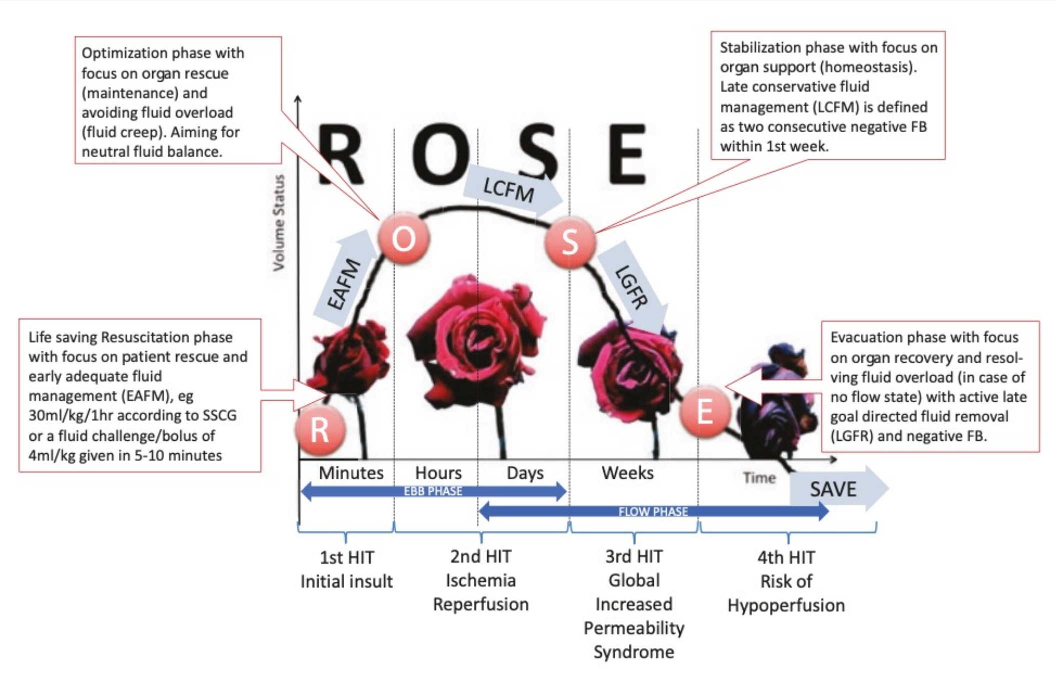
Question 3	Should an individualized approach vs a non-individualized approach be used for the optimization phase of resuscitation of circulatory failure in critically ill patients with sepsis or septic shock?		
Recommendation	*In adults with sepsis or septic shock who require fluid resuscitation for circulatory failure, we suggest using an individualized approach compared with a non-individualized approach during the optimization phase*	*Conditional recommendation, For*	*Very low certainty of evidence*

Sepsis – Q3

Otimization phase :

- 24 hr of Treatment
- Individualize or non-individualize approach → **Recommened individualization**
- Aim improve preload/systemic blood flow and reserving tissue perfusion

*Inviduallization usually perform in ICU due to requires hemodynamic monitoring (CO_2 Gab, $SCVO_2$, lactate, Cap-refill)



Hemorrhagic shock – Q4

Penetrating trauma

Question 4	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with hemorrhagic shock following penetrating trauma?		
Recommendation	*In adults with hemorrhagic shock after penetrating trauma, we suggest using a restrictive fluid resuscitation strategy (as part of a permissive hypotension approach) compared with a liberal fluid resuscitation strategy prior to definitive hemorrhage control*	*Conditional recommendation, For*	*Moderate Certainty of evidence*
Remark	*This recommendation does not apply to the intraoperative management of these patients. In patients with penetrating trauma and associated traumatic brain injury, there are insufficient data to make a recommendation*		

- **Decrease mortality rate** (RR = 0.80; 95% CI [0.65,0.90])
- **Permissive hypotension (SBP 80-90 mmHg, MAP 50-60 mmHg):**
    - Lower BP → May slow rate of bleeding
    - Reduce hydrostatic pressure → Prevent dislodgement of formed hemostasis clot
    - Limiting volume resuscitate → Prevent dilutional coagulopathy amd hypothermia

*In **TBI** keep SBP 100-110 mmHg or MAP at least 80 mmHg

Hemorrhagic shock – Q5

Blunt trauma

Question 5	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with hemorrhagic shock following blunt trauma?		
Recommendation:	*In adults with hemorrhagic shock following blunt trauma, we suggest a restrictive fluid resuscitation strategy (as part of a permissive hypotensive approach) compared with a liberal fluid resuscitation strategy before definitive hemorrhage control*	*Conditional recommendation, For*	*Low Certainty of evidence*
Remark	*This recommendation does not apply to the intraoperative management of these patients. In patients with blunt trauma and associated traumatic brain injury, there is insufficient data to make a recommendation*		

- Permissive hypotension (SBP 80-90 mmHg, MAP 50-60 mmHg):

- Lower BP → May slow rate of bleeding
- Reduce hydrostatic pressure → Prevent dislodgement of formed hemostasis clot
- Limiting volume resuscitate → Prevent dilutional coagulopathy amd hypothermia

*In **TBI** keep SBP 100-110 mmHg or MAP at least 80 mmHg

Hemorrhagic shock – Q4-5

Penetrating and Blunt trauma with TBI

■ **Table 7-12: Optimal Values in TBI Management.**

Optimal Values in TBI Management		
Category	**Parameter**	**Optimal Value**
Clinical Parameters	Systolic blood pressure	≥100 mm Hg
	Mean arterial pressure	>80 mm Hg
	Temperature	36–38°C
	Pulse oximetry	≥94%
Laboratory Parameters	Glucose	100–180 mg/dL
	Hemoglobin	> 7 g/dl
	International normalized ratio (INR)	≤1.4
	Serum sodium	135–145 meq/dL
	Serum osmolality	≤320 mOsm
	PaO_2	80–100 mm Hg
	$PaCO_2$	35–45 mm Hg
	pH	7.35–7.45
	Platelets	≥75 X 103 mm^3
Neurologic Monitoring Parameters	Cerebral perfusion pressure	60–70 mm Hg*
	Intracranial pressure	<22 mm Hg*
	$PbtO_2$	≥15 mm Hg

TBI, Traumatic brain injury; PbtO2, Partial brain tissue oxygenation.

American College of Surgeons Committee on Trauma. Advanced Trauma Life Support (ATLS) Student Course Manual. 11th ed. Chicago: American College of Surgeons; 2025.

Hemorrhagic shock – Q6
Non trauma

Question 6	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with hemorrhagic shock of non-traumatic origin?		
Recommendation:	*The panel recommends (ungraded best practice statement) that in adults with hemorrhagic shock of non-traumatic origin, fluid administration should be guided by hemodynamic and biochemical parameters in the context of the primary disease state prior to definitive hemorrhage control*	*Best Practice Statement*	*Ungraded*
Remark	*The biochemical parameters that the clinician should aim to correct include metabolic acidosis, hypothermia, platelet counts and coagulation factors*		

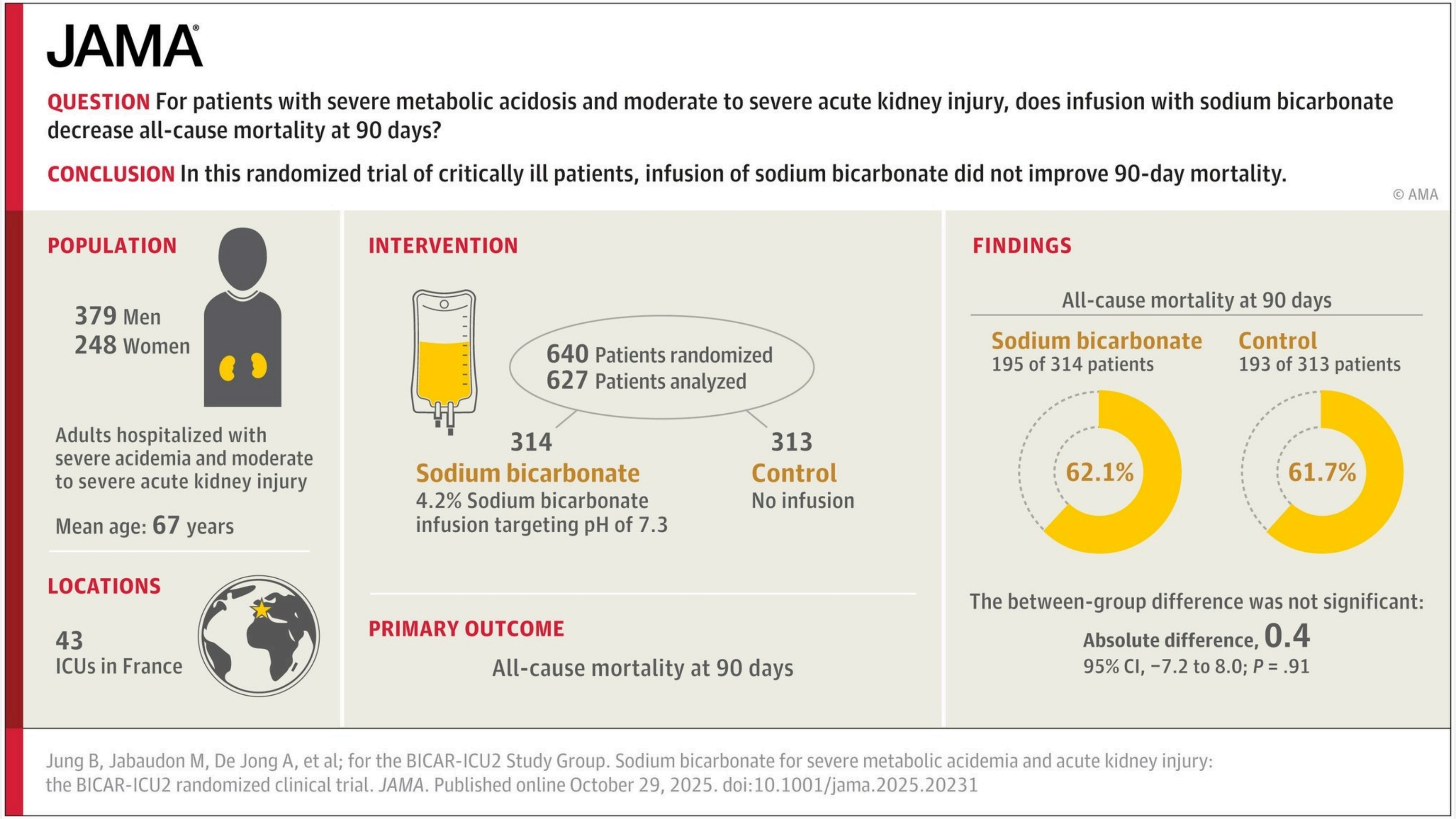
- **Use of vasopressors is controversial**
- Early administration vasopressors in high doses → increase mortality

- Should be correct several condition : metabolic acidosis, hypothermia and coagulopathy

Hemorrhagic shock – Q6

Non trauma

- Should be correct several condition : metabolic acidosis, hypothermia and coagulopathy



- Septic Shock 55 vs 53%

- Hemorrhagic Shock 14 vs 14%

Obstructive shock – Q7
Pulmonary embolism

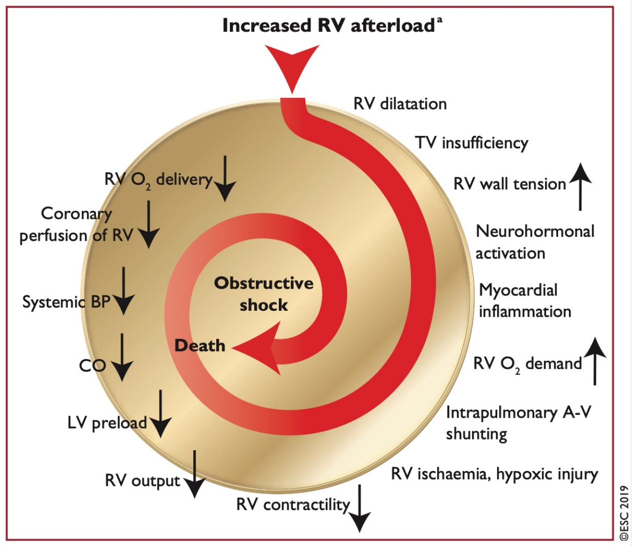
Question 7	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with pulmonary embolism?
Recommendation:	*The panel recommends (ungraded best practice statement) that in adult patients with circulatory failure due to acute pulmonary embolism, clinicians should be cautious about administering fluids and should base their decision on measured surrogate markers of right heart congestion* — *Best Practice Statement* — *Ungraded*

- **Circulatory failure** is The major cause of death in patient with **massive pulmonary embolism**

- Use of fluid resuscitation in intermediate and high-risk is **controversial**

- Any signed of severe right side heart congestion (CVP > 10 mmHg, RV dilate, VEXUS >1)

→ **Not recommened fluid resuscitate**



Obstructive shock – Q8
Cardiac temponade

Question 8	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with cardiac tamponade?		
Recommendation:	*The panel recommends (ungraded best practice statement) that in adult patients with circulatory failure due to cardiac tamponade, fluid should be given cautiously as a temporary measure until definitive management can be undertaken*	*Best Practice Statement*	*Ungraded*

- **ESC guideline** recommended volume resuscitation and discourage the use of vasodilators and diuretic (IIC)
- **Fluid boluses**
  - Maintain systemic venous return
  - Correct hypovolemia
  - Prevent right ventricular diastolic collapse despite very high right atrial pressure

- **Must not delay** pericardial drainage

Left sided cardiogenic shock – Q9

Question 9	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with left-sided cardiogenic shock?		
Recommendation:	*In adults with circulatory failure due to left-sided cardiogenic shock, the panel recommends (ungraded best practice statement) that fluid resuscitation should not be the primary treatment*	*Best Practice Statement*	*Ungraded*
Remark	*If fluids are administered, the patient should be monitored closely, especially for pulmonary edema*		

- **Characterized** by inability of the heart to pump enough blood to meet metabolic demands

- **Primary goal** of fluid administration to **improve cardiac output and oxygen delivery**
- Fluid administration can exacerbate heart failure and lead pulmonary edema

- **Tailored approach**

- Close monitoring of the patient's hemodynamic status (Advanced hemodynamic monitoring may be used) and adjustment of fluid therapy based on the observed individual response

ARDS – Q10

Question 10	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with acute respiratory distress syndrome (ARDS)?		
Recommendation:	*In adults with circulatory failure and ARDS, we cannot make a recommendation about the volume of fluid administration*	*No recommendation*	*Very Low certainty of evidence*
Remark	*Future trials should focus on patients with circulatory failure and ARDS, taking into account its different subtypes*		

- **Characterized** by varying degrees of alteration in pulmonary capillary permeability → Pulmonary edema

- **Requiring Fluid resuscitate** due to hypovolumia and hemodynamic instability associated with ARDS

- **ARDS** cause fluid leakage from the intravascular space
- **Fluid accumulation** associated with Higher mortality rate

Q & A

Ref data

Calculation of Systemic Vascular Resistance (SVR)
Using Pressures Measured from **Swan-Ganz Catheter**

Shock simulation