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[1] :**

Imbalance between **oxygen delivery ($\mathbf{DO_2}$)** and **oxygen consumption ($\mathbf{VO_2}$)** → anaerobic metabolism and lactate production

$$\boldsymbol{DO_2 \quad = \quad CO \quad x \quad CaO_2}$$

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

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

CaO_2 = Arterial Oxygen Content

The Four (or Six) D's

Cardiac output is

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

1 $$\boldsymbol{CO = HR\ x\ SV}$$

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

3 $$\boldsymbol{CO = HR\ x\ LVEF\ x\ EDV}$$

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

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

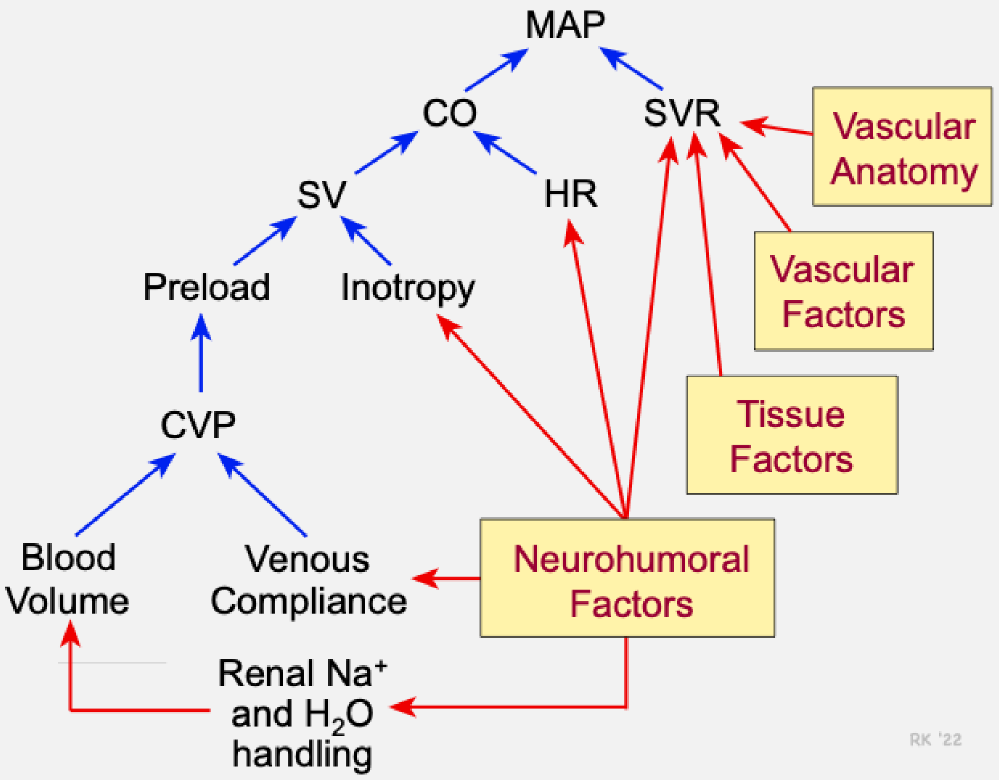
*CVP is usually at or near 0 mmHg

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

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

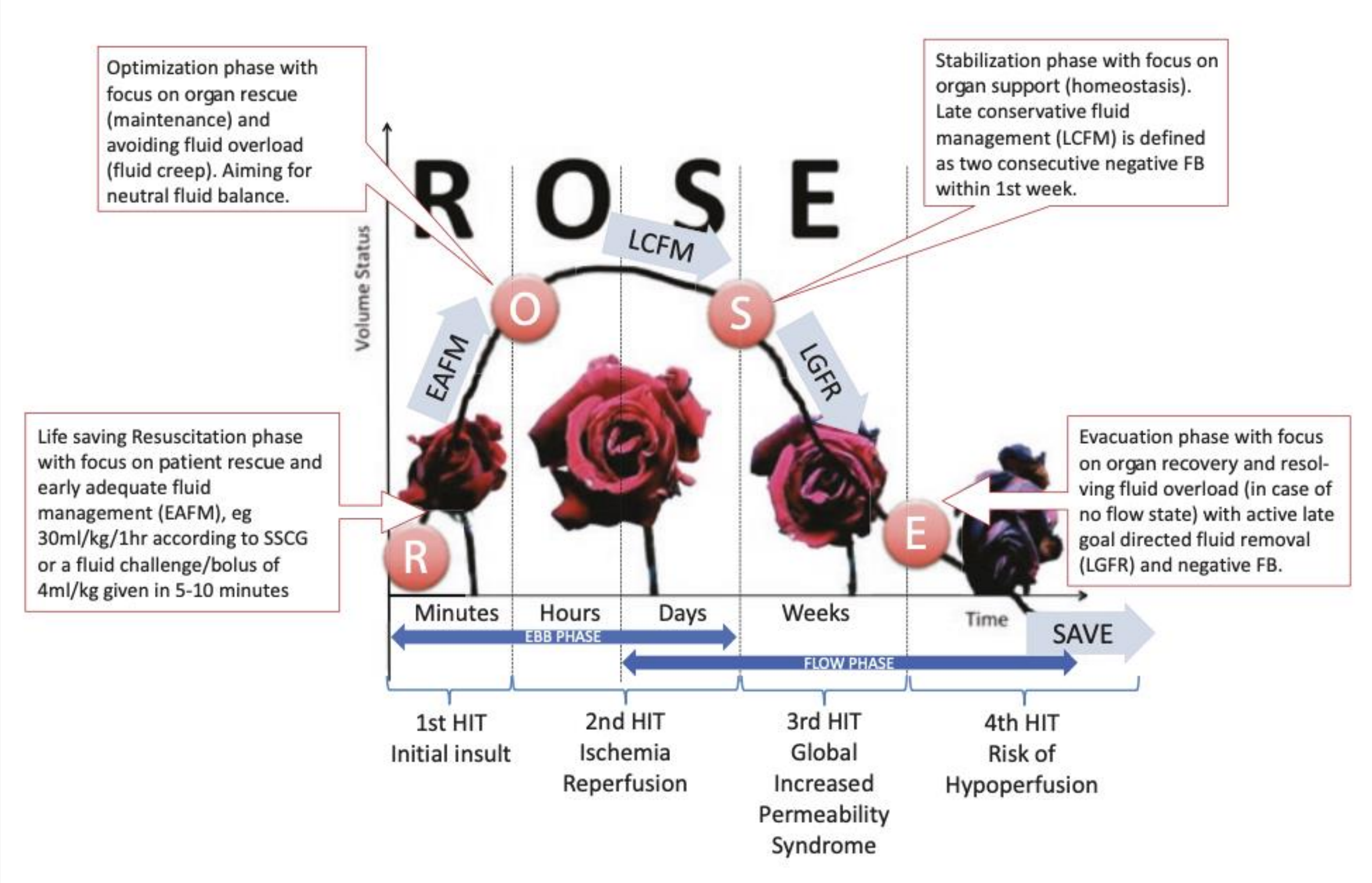
The Four (or Six) D's

$$MAP = LVEF \times EDV \times HR \times SVR$$



Klabunde RE. Factors Regulating Arterial Blood Pressure [Internet]. Cardiovascular Physiology Concepts. [cited 2025 Nov 17]. Available from: https://cvphysiology.com/blood-pressure/bp022

ROSE concept



Resuscitation

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

Optimization

- **Aim** "avoid fluid overload with retain perfusion"

Stabilization

- Absence of shock
- "When to stop fluid therapy?"
- **Aim** "maintenance and replacement fluids"

Evacuation

- Recovery from shock
- When to Start/Stop Fluid Removal?
- **Aim** "directed fluid removal"

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

ROSE concept

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

	Resuscitation	Optimization	Stabilization	Evacuation
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"

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

	Resuscitation	Optimization	Stabilization	Evacuation
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)

(EAFM) is the **initial hemodynamic resuscitation** of patients with septic shock by administering adequate fluids during the first 6 h after the initiation of therapy. [Up to 30 ml/hr in 1st 3 hr (SSC,2016)]

(LCFM) is defined as **2 consecutive days of negative**[2] fluid balance within the first week of the ICU stay.

(LGFR) is defined as **active fluid removal**[3] with Diuretics or Renal replacement therapy with net ultrafiltration and started within the first week of ICU stay also referred to as de-resuscitation

[2]Murphy CV, Schramm GE, Doherty JA, Reichley RM, Gajic O, Afessa B, et al. The importance of fluid management in acute lung injury secondary to septic shock. Chest. 2009;136(1):102–9.

[3]Malbrain ML, Marik PE, Witters I, Cordemans C, Kirkpatrick AW, Roberts DJ, et al. Fluid overload, de-resuscitation, and outcomes in critically ill or injured patients: a systematic review with suggestions for clinical practice. Anaesthesiol Intensive Ther. 2014;46(5):361–80.

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

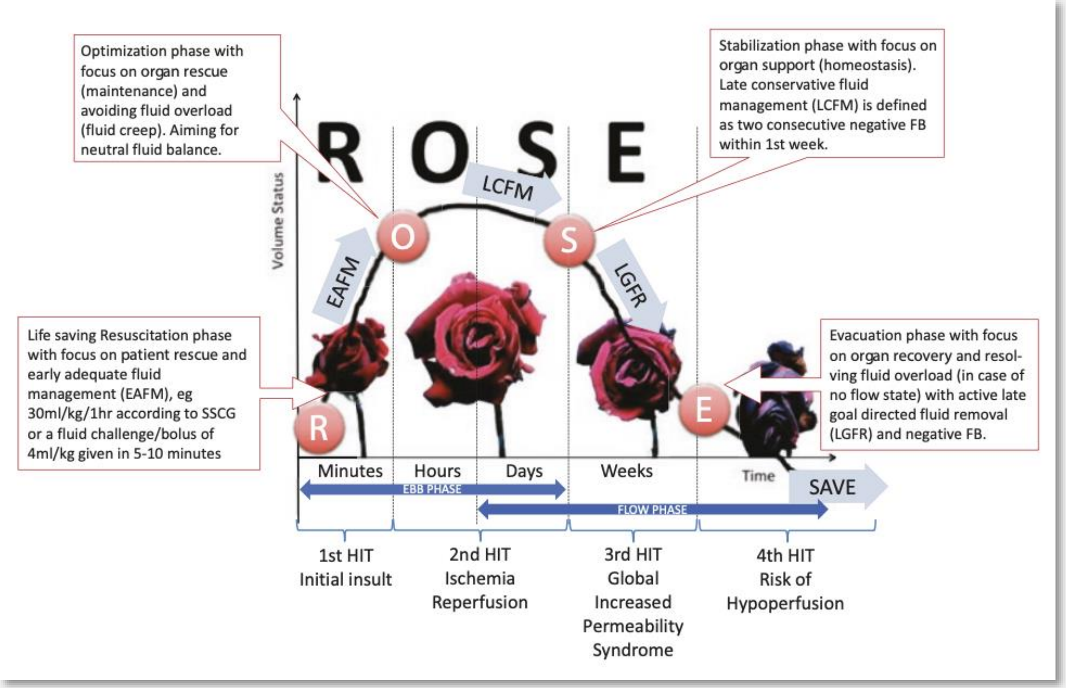
Question 1 Should 30 ml/kg fluid volume be used versus other approaches for initial resuscitation of circulatory failure in critically ill patients with sepsis or septic shock?

Initial phase :

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

*SSC[4] suggest at least initial fluid 30 ml/kg

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



[4]Evans L, Rhodes A, Alhazzani W et al (2021) Surviving sepsis campaign: international guidelines

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?

Support [SSC[4]]

5. For patients with sepsis induced hypoperfusion or septic shock we **suggest** that at least 30 mL/kg of intravenous (IV) crystalloid fluid should be given within the first 3 h of resuscitation

Weak recommendation, low-quality evidence

A retrospective analysis of adults presenting to an emergency department with sepsis or septic shock showed that failure to receive 30 ml/kg of crystalloid fluid therapy within 3 h of sepsis onset was associated with increased odds of in-hospital mortality,

PROCESS [64], ARISE [65] and PROMISE [66] trials, the average volume of fluid received pre-randomisation was also in the range of 30 ml/kg, suggesting that this fluid volume has been adopted in routine clinical practice [67].

[4]Evans L, Rhodes A, Alhazzani W et al (2021) Surviving sepsis campaign: international guidelines

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?

Support [SSC[4]]

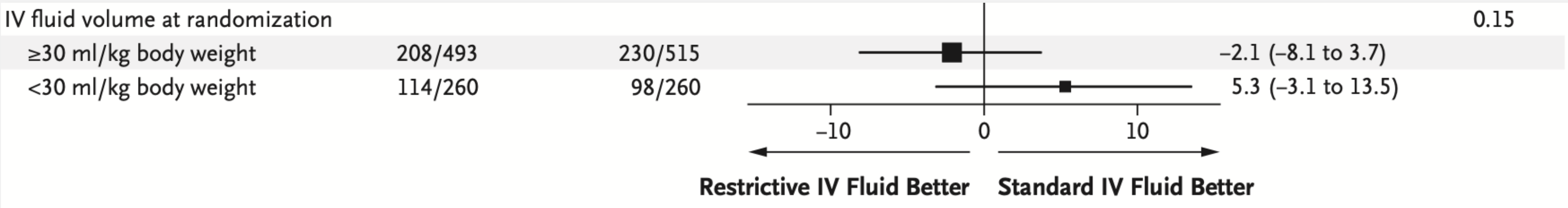
5. For patients with sepsis induced hypoperfusion or septic shock we **suggest** that at least 30 mL/kg of intravenous (IV) crystalloid fluid should be given within the first 3 h of resuscitation
Weak recommendation, low-quality evidence

Question or Against (CLASSIC[5] and CLLOVERS[6] trials)

- Meyhoff TS et al[5] = Cumulative fluid balance **mean(mL)** standard vs restrictive : 3,117 vs 2,302 ; **diff 815 mL**
- Shapiro NI et al[6] = **Median(mL)** volume via iv over 24 hr. liberal vs restrictive : 3,400 vs 1,267 ; **diff 2134 mL**

BOTH trials Not significantly lower (or higher) mortality

[2]CLASSICS study(Subgroup analysis), Group recieve iv fluid < 30 ml/kg **prefer Liberal fluid strategies**



[4]Evans L, Rhodes A, Alhazzani W et al (2021) Surviving sepsis campaign: international guidelines

[5]Meyhoff TS, Hjortrup PB, Wetterslev J et al (2022) Restriction of intravenous fluid in ICU patients with septic shock. N Engl J Med 386:2459–2470.

[6]Shapiro NI, Douglas IS, Brower RG et al (2023) Early restrictive or liberal fluid management for sepsis-induced hypotension. N Engl J Med 388:499–510.

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?

Question or Against

- Jorda A et al[8] : 2nd analysis of the CLOVERS trial [included, eGFR of less than 30 mL/min/1.73 m2]

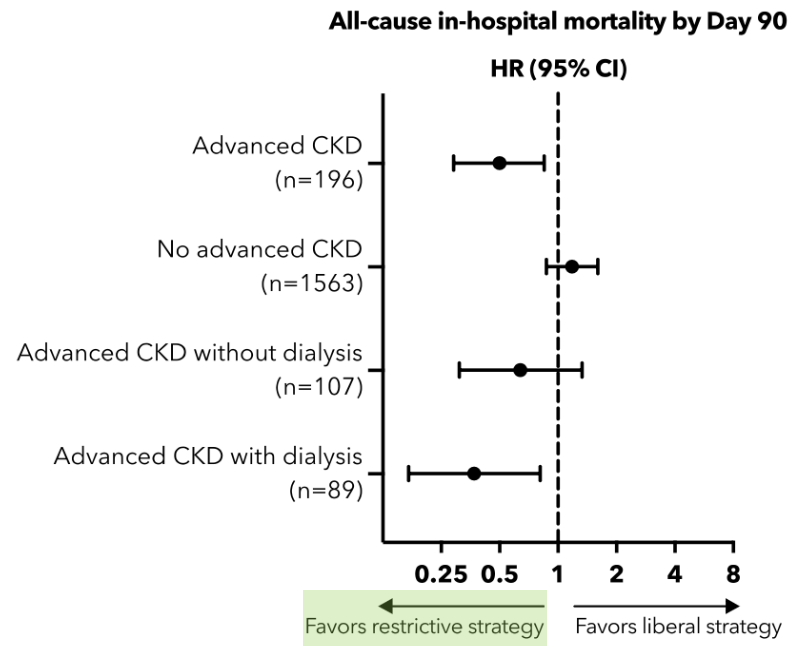


Fig. 3 Effect estimates of the primary outcome (death from any cause before discharge en the restrictive

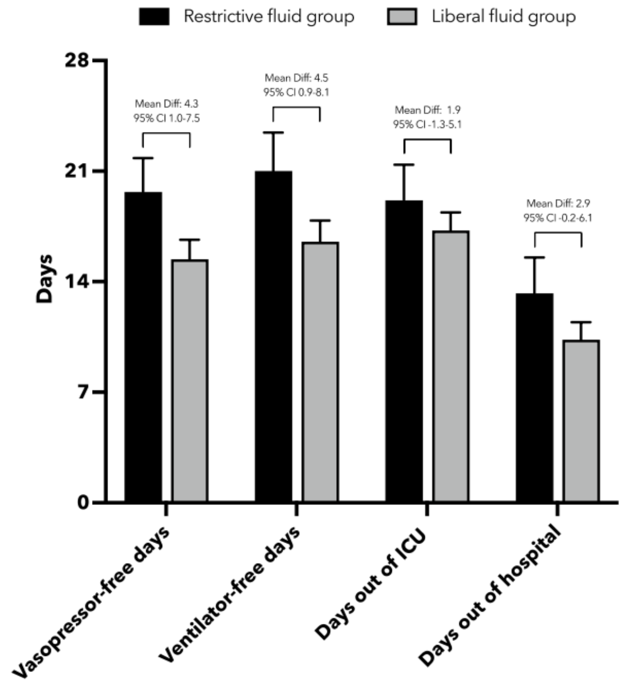


Fig. 4 Key secondary outcomes in number of days by day 28

[8]Jorda A, Douglas IS, Staudinger T et al (2024) Fluid management for sepsis-induced hypotension in patients with advanced chronic kidney disease: a secondary analysis of the CLOVERS trial. Crit Care Lond Engl

Sepsis – Q1

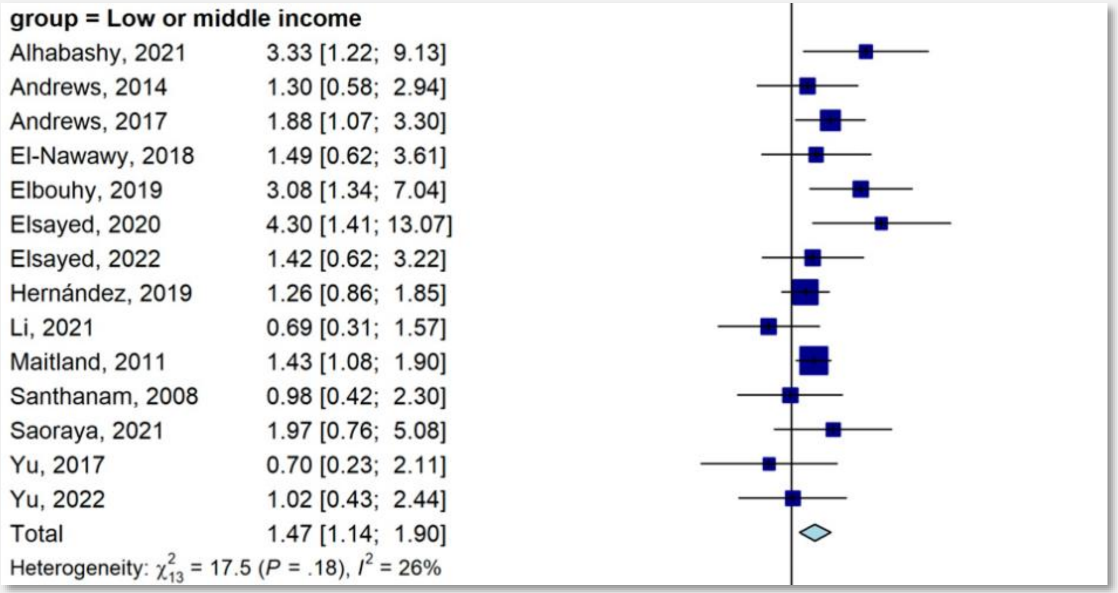
Question 1 Should 30 ml/kg fluid volume be used versus other approaches for initial resuscitation of circulatory failure in critically ill patients with sepsis or septic shock?

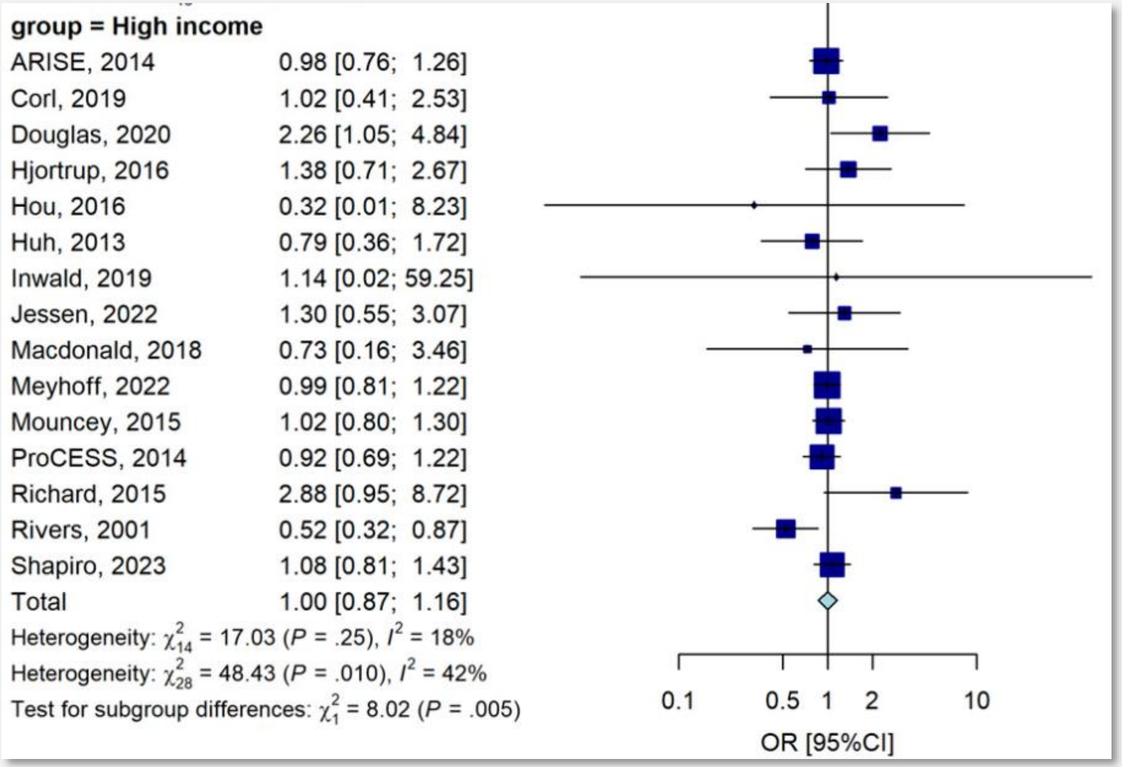
Question or Against

- Gendreau S et al[7] **:** Income group significantly interacted with the effect of fluid volume on mortality

>> Higher fluid volume was associated with Higher mortality in **LMICs*** but not in **HICs****

LMICs OR=1.47,(95% CI) vs **HICs** OR=1.00 ,(95% CI)





*low- and middle-income countries [LMICs] **high-income countries [HICs]

[7]Gendreau S, Frapard T, Carteaux G et al (2024) Geo-economic influence on the effect of fluid volume for sepsis resuscitation: a meta-analysis. Am J Respir Crit Care Med 209:517–528.

Sepsis – Q2

Question 2	Should a liberal vs. restrictive strategy be used in the optimiza-tion 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 resuscita-tion had similar effects on patient-relevant outcomes (moderate certainty of evidence)*		

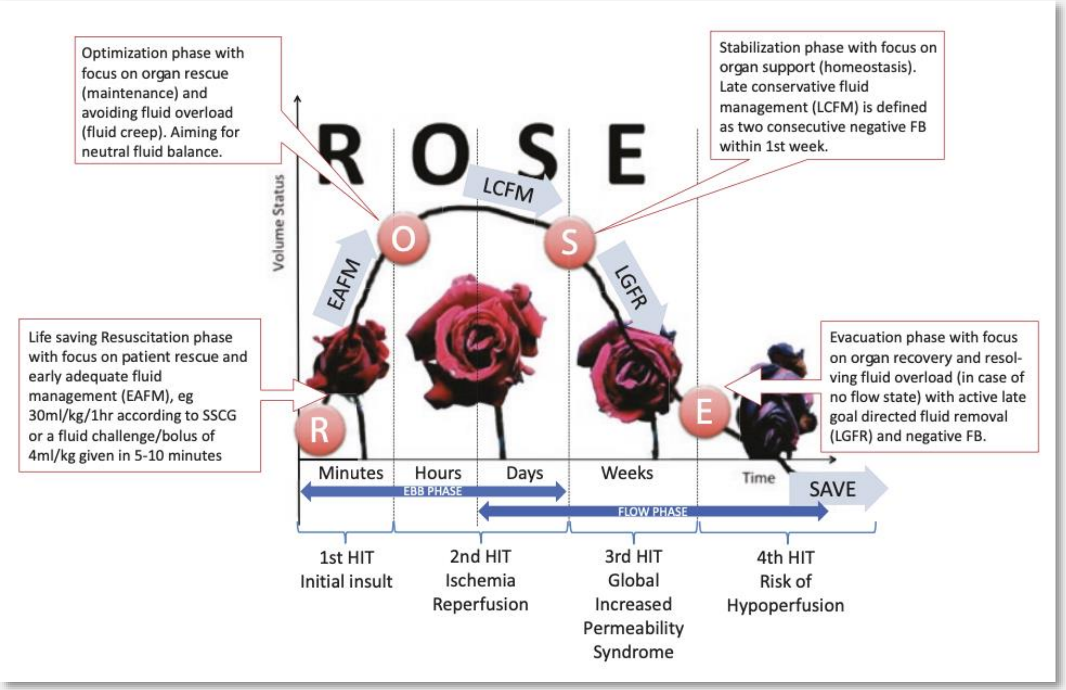
Sepsis – Q2

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?

Otimization phase :

- 24 hr of Treatment

*SSC[4], **insufficient evidence** to recomened restrictive or liberal fluid strategy in patient who has sign of hypoperfusion



[4]Evans L, Rhodes A, Alhazzani W et al (2021) Surviving sepsis campaign: international guidelines

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?

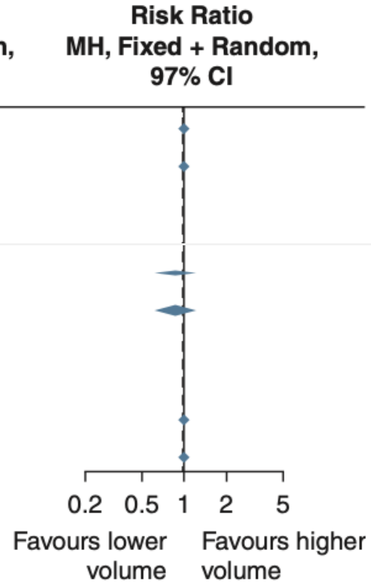
Summary of evidence

- Sivapalan P et al[8] **:** Among adult patients with sepsis

- **Lower IV fluid** probably result in little to **No difference in all-cause mortality** compared with **higher IV fluid**
- Suggests **lower IV fluid volumes** result in little to **No difference in serious adverse events**

	Study or subgroup	Lower volume Events	Lower volume Total	Higher volume Events	Higher volume Total	Weight (fixed)	Weight (random)	Risk Ratio MH, Fixed + Random, 97% CI
Low risk 8 studys	Fixed effect model		1,802		1,824	90.4%	--	0.99 [0.89; 1.10]
	Random effects model					--	90.5%	0.99 [0.90; 1.10]
	Heterogeneity: $\tau^2 = 0$; $\chi^2 = 1.76$, $df = 7$ ($P = .97$); $I^2 = 0\%$							
high risk 5 studys	Fixed effect model		203		149	9.6%	--	0.87 [0.63; 1.20]
	Random effects model					--	9.5%	0.87 [0.63; 1.20]
	Heterogeneity: $\tau^2 \leq 0.0001$; $\chi^2 = 3.67$, $df = 4$ ($P = .45$); $I^2 = 0\%$							
	Fixed effect model		2,005		1,973	100.0%	--	0.98 [0.89; 1.08]
	Random effects model					--	100.0%	0.98 [0.89; 1.08]

Heterogeneity: $\tau^2 = 0$; $\chi^2 = 6.12$, $df = 12$ ($P = .91$); $I^2 = 0\%$
Test for overall effect (fixed effect): $Z = -0.40$ ($P = .69$)
Test for overall effect (random effects): $Z = -0.42$ ($P = .68$)
Test for subgroup differences (fixed effect): $\chi^2 = 0.72$, $df = 1$ ($P = .40$)
Test for subgroup differences (random effects): $\chi^2 = 0.68$, $df = 1$ ($P = .4$)



[8]Sivapalan P, Ellekjaer KL, Jessen MK et al (2023) Lower vs higher fluid volumes in adult patients with sepsis: an updated systematic review with meta-analysis and trial sequential analysis. Chest 164:892–912

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 optimi-zation phase*	*Conditional recommendation, For*	*Very low certainty of evidence*

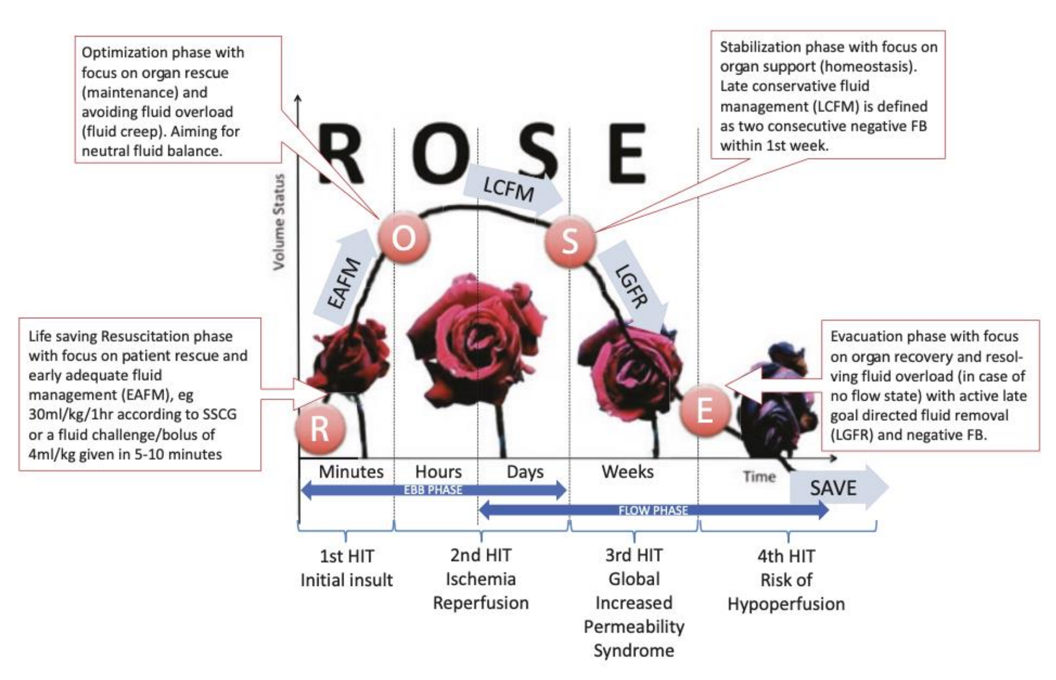
Sepsis – Q3

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?

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)



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?

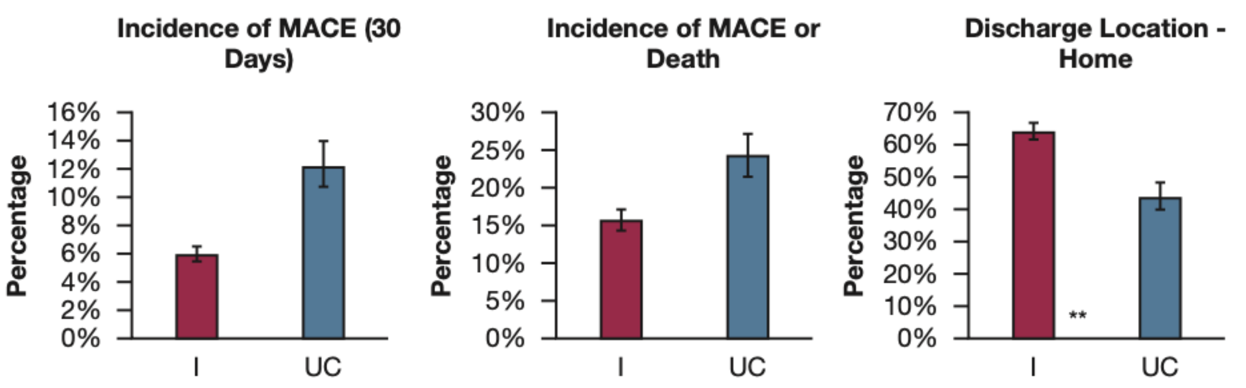
Summary of evidence

- Douglas IS et al[9]**:** Intervention with **passive leg raise-induced stroke volume change**

- Dynamic assessments to guide fluid administration

→ may Improve outcomes for patients with septic shock compared with usual care **(Favors Intervention, not Sig.)**

- The use of the **passive leg raise-induced stroke volume change** to guide management of septic shock is safe



9.3.1 Hemodynamic Collection Methods

Starling SV: Following the Instructions for Use, the Starling SV device will be connected to the subject by placing four of the system's sensors on the subject's chest: left and right mid-clavicle and left and right mid-last ribs. The device will undergo 1 minute of autocalibration after which measurements will begin to be obtained. Data from the device is available as a visible read-out on the monitor screen and stored internally. At the conclusion of the data collection period, the data will be downloaded and provided to the sponsor or designee.

[9]Douglas IS, Alapat PM, Corl KA et al (2020) Fluid response evaluation in sepsis hypotension and shock: a randomized clinical trial. Chest 158:1431–1445

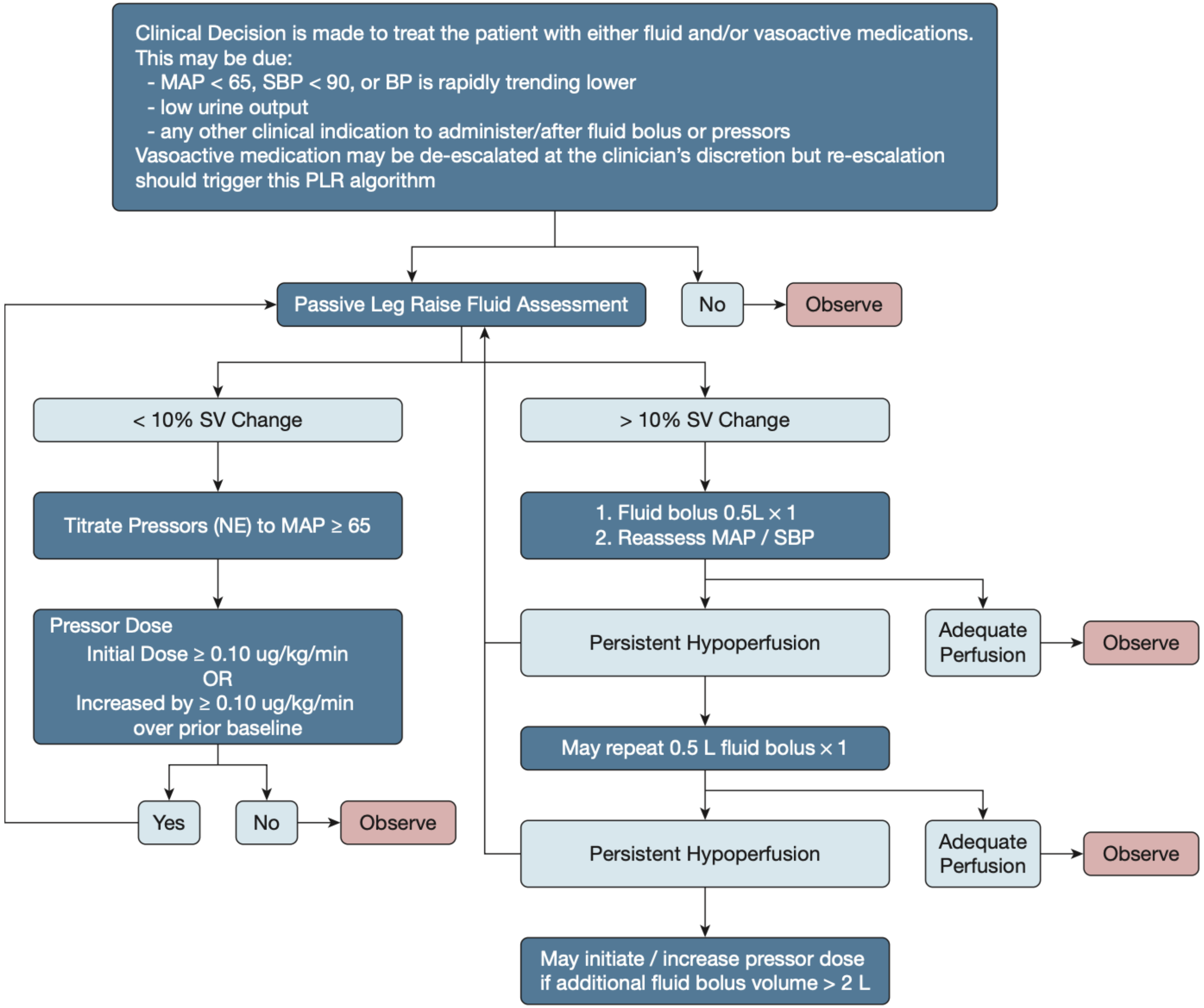


Figure 1 – *Flow chart model of the algorithm used to guide treatment in the Fluid Responsiveness Evaluation in Sepsis-associated Hypotension study. MAP = mean arterial pressure; NE = norepinephrine; PLR = passive leg raise; SBP = systolic BP; SV = stroke volume.*

[9]Douglas IS, Alapat PM, Corl KA et al (2020) Fluid response evaluation in sepsis hypotension and shock: a randomized clinical trial. Chest 158:1431–1445

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?

Summary of evidence

Fluid Response Evaluation in Sepsis Hypotension and Shock
A Randomized Clinical Trial

- Dynamic assessments to guide fluid administration may Improve outcomes for patients with septic shock compared with usual care

[Clinical value of early liquid resuscitation guided by passive leg-raising test combined with transthoracic echocardiography in patients with septic shock]

[Article in Chinese]
Gang Li [1], Fengning Wei, Guoqiang Zhang, Lichao Sun, Rui Lian

- PLR combined with TTE, could Better improve perfusion and oxygenation level of tissues and organs, avoid pulmonary edema caused by rapid fluid replacement

- **No significant effect on hospital mortality**

[9]Douglas IS, Alapat PM, Corl KA et al (2020) Fluid response evaluation in sepsis hypotension and shock: a randomized clinical trial. Chest 158:1431–1445

[10]Li G, Wei F, Zhang G et al (2019) Clinical value of early liquid resuscitation guided by passive leg-raising test combined with transthoracic echocardiography in patients with septic shock. Zhonghua Wei Zhong Bing Ji Jiu Yi Xue 31:413–417

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 – 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?

Summary of evidence

- Natthida O et al, siriraj[11]**:** 2114 studies, 30 were selected for this meta-analysis

- **Significant decrease in mortality** was observed in the hypotensive resuscitation group

risk ratio [RR]: 0.50; 95% confidence interval [CI]: 0.40–0.61

	Hypotensive		Normal			Risk Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% CI	Year
Bickell WH. 1994	86	289	116	309	15.3%	0.79 [0.63, 1.00]	1994
Dutton 2002	4	55	4	55	2.2%	1.00 [0.26, 3.80]	2002
Carrick 2016	18	86	21	82	8.2%	0.82 [0.47, 1.42]	2015
HUANG Ting 2015	2	40	9	40	1.9%	0.22 [0.05, 0.96]	2015
Chen Yuan-bing 2015	5	71	11	71	3.6%	0.45 [0.17, 1.24]	2015
Schreiber 2015	8	96	15	95	5.0%	0.53 [0.23, 1.19]	2015
CHEN Mianzhan 2015	4	24	7	24	3.1%	0.57 [0.19, 1.70]	2015
XU Guoping 2015	7	60	17	60	5.0%	0.41 [0.18, 0.92]	2015
WEN Zhen-jie 2015	3	29	7	22	2.5%	0.33 [0.09, 1.12]	2015
YAO Jian-hui 2015	4	43	12	43	3.3%	0.33 [0.12, 0.95]	2015
DAI Yulong 2016	0	41	4	41	0.5%	0.11 [0.01, 2.00]	2016
Wang Fengyong 2016	1	46	10	46	1.0%	0.10 [0.01, 0.75]	2016
Total (95% CI)		**1473**		**1482**	**100.0%**	**0.50 [0.40, 0.61]**	
Total events	210		394				

Heterogeneity: Tau² = 0.06; Chi² = 31.54, df = 23 (P = 0.11); I² = 27%
Test for overall effect: Z = 6.53 (P < 0.00001)

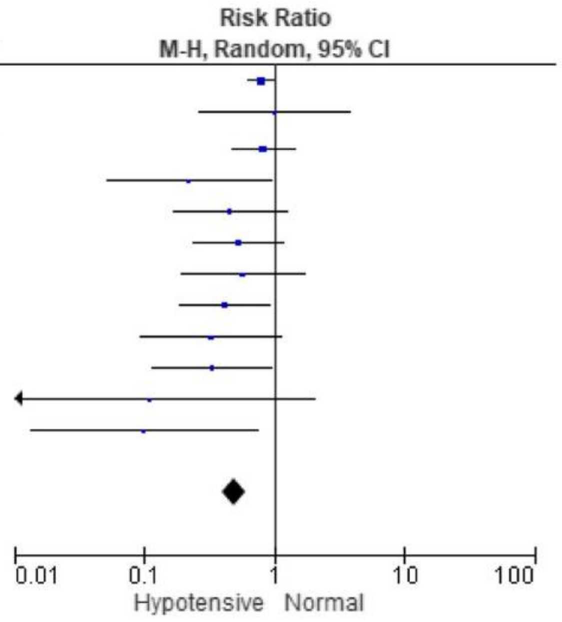


Fig. 4 Forest plot of association between hypotensive resuscitation and normal resuscitation, relative to mortality

[11]Owattanapanich N, Chittawatanarat K, Benyakorn T, Sirikun J (2018) Risks and benefits of hypotensive resuscitation in patients with traumatic hemorrhagic shock: a meta-analysis. Scand J Trauma Resusc Emerg Med 26:107

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

Summary of evidence

- Rossaint R et al[12]:

The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition

III. Tissue oxygenation, volume, fluids and temperature

Volume replacement and target blood pressure

Recommendation 13 In the initial phase following trauma, we recommend the use of a restricted volume replacement strategy with a target systolic blood pressure of 80–90 mmHg (mean arterial pressure 50–60 mmHg) until major bleeding has been stopped without clinical evidence of brain injury (Grade 1B).

In patients with severe TBI (GCS $\leq$ 8), we recommend that a mean arterial pressure $\geq$ 80 mmHg be maintained (Grade 1C).

[12]Rossaint R, Afshari A, Bouillon B et al (2023) The European guideline on management of major bleeding and coagulopathy following trauma: sixth edition. Crit Care Lond Engl 27:80.

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.

[13]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

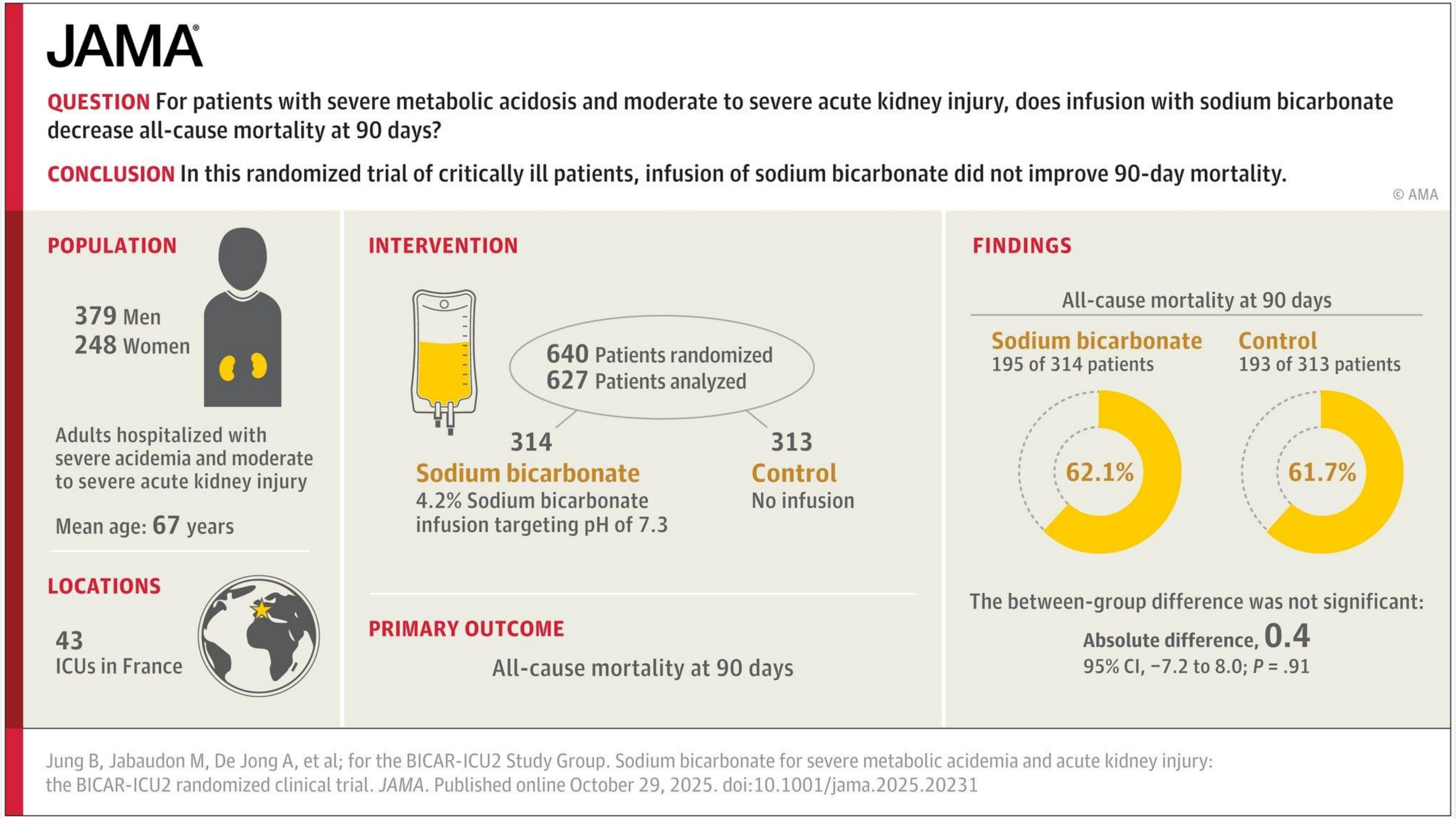
Question 6	Should a restrictive or liberal strategy be used for fluid resuscitation of circulatory failure in critically ill patients with hemorrhagic shock of non-traumatic origin?		
Recommendation:	*The panel recommends (ungraded best practice statement) that in adults with hemorrhagic shock of non-traumatic 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



Population
- Septic Shock 55 vs 53%

- Hemorrhagic Shock 14 vs 14%

[14] Jung B, Jabaudon M, De Jong A, et al. Sodium Bicarbonate for Severe Metabolic Acidemia and Acute Kidney Injury: The BICARICU-2 Randomized Clinical Trial. JAMA. Published online October 29, 2025.

Hemorrhagic shock – Q6

Non trauma

- Should be Correct several condition : metabolic acidosis, hypothermia and coagulopathy
- **Lu B et al[15] :**

  A study of 51 patients found that Conservative fluid resuscitation was **beneficial** in patients with hemorrhagic shock due to **acute upper gastrointestinal hemorrhage**

Table 3 Clinical efficacy and complication rates

Groups	Number	ARDS, absolute numbers (%)	Multiple organ dysfunction syndrome, absolute numbers (%)	Sepsis, absolute numbers (%)	Mortality, absolute numbers (%)	Average hospitalization, days	Average hospitalization costs, Chinese yuan
Conventional group	24	3 (12.5 %)	2 (8.33 %)	1 (4.17 %)	2 (8.33 %)	7.83	26,538.3
Limited fluid resuscitation (study) group	27	1 (3.7 %)*	1 (3.7 %)*	0 (0 %)*	0 (0 %)	5.12	19,256.8

* $p < 0.05$ versus conventional group

[15]Lu B, Li MQ, Li JQ. The Use of Limited Fluid Resuscitation and Blood Pressure-Controlling Drugs in the Treatment of Acute Upper Gastrointestinal Hemorrhage Concomitant with Hemorrhagic Shock. Cell Biochem Biophys. 2015 Jun;72(2):461-3.

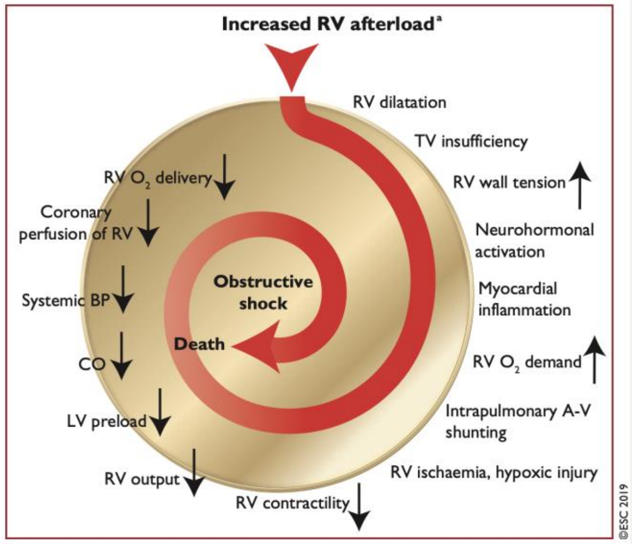
Obstructive shock – Q7
Pulmonary embolism

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**



[16]Konstantinides SV, Meyer G, Becattini C et al (2020) 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J 41:543–603.

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?

Summary of evidence

- 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism[16]

6.1.2 Pharmacological treatment of acute right ventricular failure

Acute RV failure with resulting low systemic output is the leading cause of death in patients with high-risk PE. The principles of acute right heart failure management have been reviewed in a statement from the Heart Failure Association and the Working Group on Pulmonary Circulation and Right Ventricular Function of the ESC.[68] An overview of the current treatment options for acute RV failure is provided in *Table* 9.

If the central venous pressure is low, modest (≤500 mL) fluid challenge can be used as it may increase the cardiac index in patients with acute PE.[238] However, volume loading has the potential to over-distend the RV and ultimately cause a reduction in systemic CO.[239] Experimental studies suggest that aggressive volume expansion is of no benefit and may even worsen RV function.[240] Cautious volume

[16]Konstantinides SV, Meyer G, Becattini C et al (2020) 2019 ESC Guidelines for the diagnosis and management of acute pulmonary embolism developed in collaboration with the European Respiratory Society (ERS). Eur Heart J 41:543–603.

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[20] 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

[20] Adler Y, Charron P, Imazio M et al (2015) 2015 ESC Guidelines for the diagnosis and management of pericardial diseases: the Task Force for the Diagnosis and Management of Pericardial Diseases of the European Society of Cardiology (ESC)Endorsed by: The European Association for Cardio-Thoracic Surgery (EACTS). Eur Heart J 36:2921–2964

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?

Summary of evidence

- **Singh V et al[17]:** Rapid infusion of as little as 250 ml intravenous normal saline may improve the cardiac haemodynamics

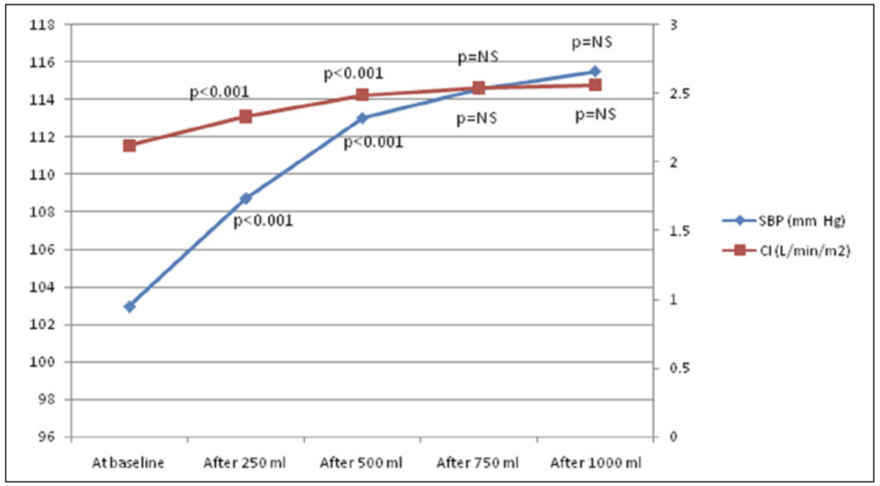


Figure 1. *p*-values for SBP and CI with graded volume expansion, indicating the significance of difference with immediate prior value.
Left Y-axis, systolic blood pressure (SBP); right Y-axis, cardiac index (CI).

Table 3. Significance of mean differences of outcome measures at baseline and with different amounts of volume expansion with normal saline.

Comparison	SBP (mmHg)	DBP (mmHg)	Intrapericardial pressure (mmHg)	RA pressure (mmHg)	PASP (mmHg)	PCWP (mmHg)	CO (l/min)	CI (l/min/m²)
Baseline vs.:								
250 ml	p<0.001	0.013	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
500 ml	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
750 ml	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1000 ml	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
250 ml vs.:								
500 ml	p<0.001	0.013	0.001	0.001	p<0.001	p<0.001	p<0.001	p<0.001
750 ml	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
1000 ml	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
500 ml vs.:								
750 ml	0.146	0.115	p<0.001	0.028	0.001	0.041	0.446	0.484
1000 ml	0.003	0.088	p<0.001	p<0.001	p<0.001	p<0.001	0.109	0.126
750 ml vs.:								
1000 ml	0.647	1.000	0.123	0.006	0.114	0.048	0.940	0.941

p-values obtained using Tukey test.
CI, cardiac index; CO, cardiac output; PASP, pulmonary artery systolic pressure; PCWP, pulmonary capillary wedge pressure; RA, right atrial; SBP, systolic blood pressure.

[17]Singh V, Dwivedi SK, Chandra S et al (2014) Optimal fluid amount for haemodynamic benefit in cardiac tamponade. Eur Heart J Acute Cardiovasc Care 3:158–164

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

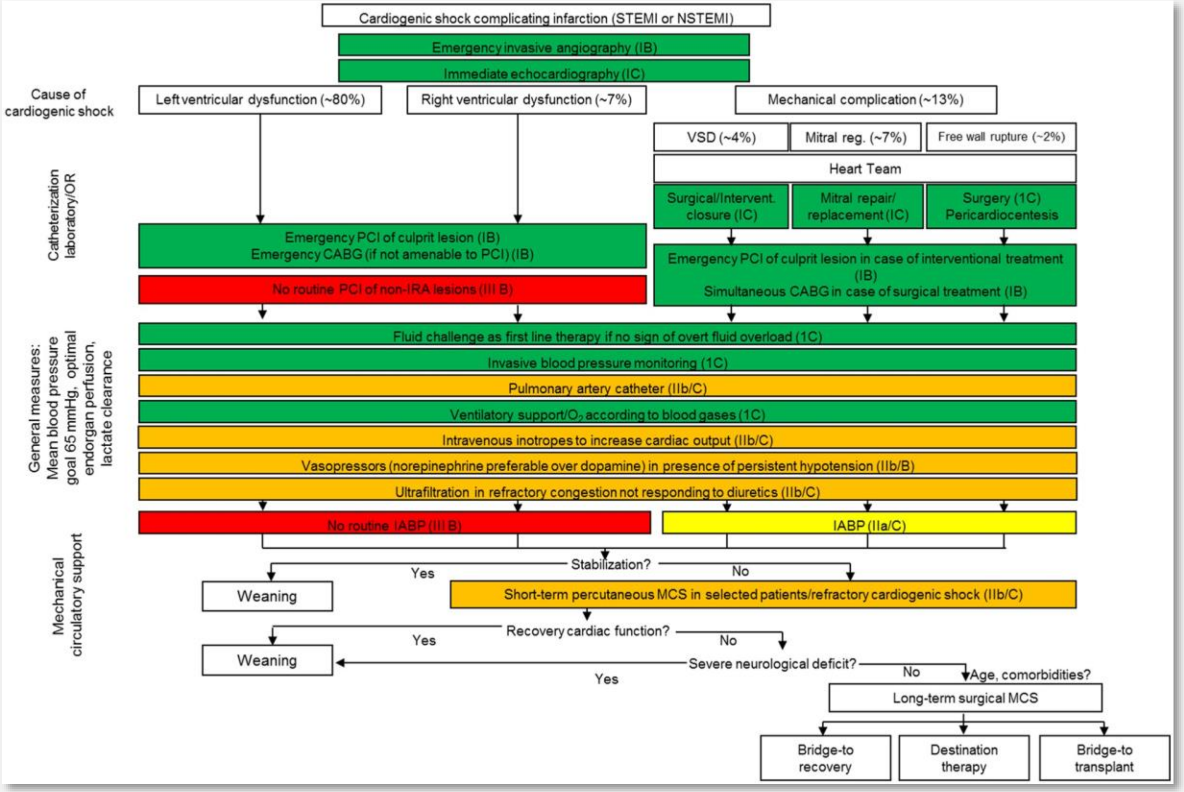
- **Tailored approach**
- Close monitoring of the patient's hemodynamic status (Advanced hemodynamic monitoring may be used) and adjustment of fluid therapy based on the observed individual response

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?

Summary of evidence

- Thiele H[18] : Some patients with cardiogenic shock may benefit from a cautious fluid challenge



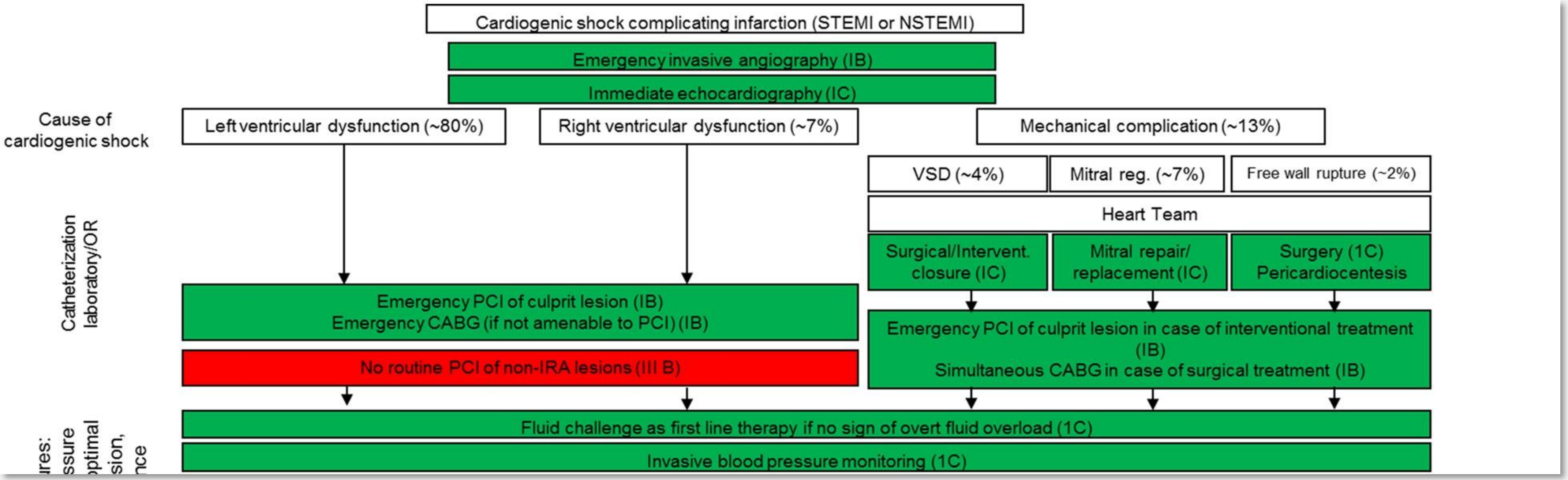
[18]Thiele H, Ohman EM, de Waha-Thiele S et al (2019) Management of cardiogenic shock complicating myocardial infarction: an update 2019. Eur Heart J 40:2671–2683

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?

Summary of evidence

- Thiele H[18] : Some patients with cardiogenic shock may benefit from a cautious fluid challenge



[18]Thiele H, Ohman EM, de Waha-Thiele S et al (2019) Management of cardiogenic shock complicating myocardial infarction: an update 2019. Eur Heart J 40:2671–2683

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*		

- **ARDS** cause fluid leakage from the intravascular space
- **Characterized** by varying degrees of alteration in pulmonary capillary permeability → Pulmonary edema

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

- **Fluid accumulation** associated with Higher mortality rate

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)?

Summary of evidence

- The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network[19]

Table 3. Main Outcome Variables.*

Outcome	Conservative Strategy	Liberal Strategy	P Value
Death at 60 days (%)	25.5	28.4	0.30
Ventilator-free days from day 1 to day 28†	14.6±0.5	12.1±0.5	<0.001
ICU-free days†			
Days 1 to 7	0.9±0.1	0.6±0.1	<0.001
Days 1 to 28	13.4±0.4	11.2±0.4	<0.001
Organ-failure–free days†‡			
Days 1 to 7			
Cardiovascular failure	3.9±0.1	4.2±0.1	0.04
CNS failure	3.4±0.2	2.9±0.2	0.02
Renal failure	5.5±0.1	5.6±0.1	0.45
Hepatic failure	5.7±0.1	5.5±0.1	0.12
Coagulation abnormalities	5.6±0.1	5.4±0.1	0.23

Table 3. Main Outcome Variables.*

Outcome	Conservative Strategy	Liberal Strategy	P Value
Days 1 to 28			
Cardiovascular failure	19.0±0.5	19.1±0.4	0.85
CNS failure	18.8±0.5	17.2±0.5	0.03
Renal failure	21.5±0.5	21.2±0.5	0.59
Hepatic failure	22.0±0.4	21.2±0.5	0.18
Coagulation abnormalities	22.0±0.4	21.5±0.4	0.37
Dialysis to day 60			
Patients (%)	10	14	0.06
Days	11.0±1.7	10.9±1.4	0.96

[19]National Heart Lung and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network (2006) Comparison of two fluid-management strategies in acute lung injury. N Engl J Med 354:2564–2575

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)?

Summary of evidence

- The National Heart, Lung, and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network[19]

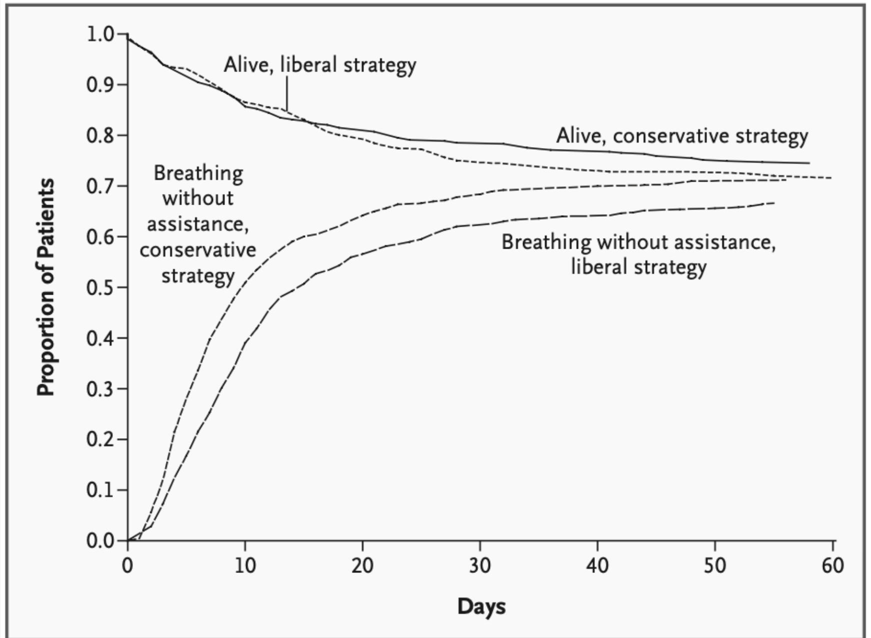


Figure 3. **Probability of Survival to Hospital Discharge and of Breathing without Assistance during the First 60 Days after Randomization.**

[19]National Heart Lung and Blood Institute Acute Respiratory Distress Syndrome (ARDS) Clinical Trials Network (2006) Comparison of two fluid-management strategies in acute lung injury. N Engl J Med 354:2564–2575

Q & A

Ref data

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

Shock simulation