



Clinical Critical Care

E-ISSN 2774-0048

VOLUME 34 NUMBER 1
JANUARY-DECEMBER 2026

Editor-in-Chief :
Suthat Rungruanghiranya

Five common echocardiographic pitfalls in septic shock

Mohamed Achref Boubaker

Department of Anaesthesiology and Intensive Care Medicine, Bethanien Hospital Moers, Moers, Germany

OPEN ACCESS



Citation:

Boubaker MA. Five common echocardiographic pitfalls in septic shock. Clin Crit Care 2026; 34: e260029.

Received: August 11, 2026

Revised: September 24, 2026

Accepted: September 25, 2026

Copyright:

© 2026 The Thai Society of Critical Care Medicine. This is an open-access article distributed under the terms of [Creative Commons Attribution-NonCommercial License \(CC BY-NC 4.0\)](#). The use, distribution or reproduction in other forums is permitted, provided the original author(s) and the copyright owner(s) are credited and that the original publication in this journal is cited, in accordance with accepted academic practice. No use, distribution or reproduction is permitted which does not comply with these terms.

Data Availability Statement:

Not applicable. No new data or code were generated or analyzed for this narrative review.

Funding:

No external funding was received for this work.

Competing interests:

The author has no conflicts of interest to declare.

Corresponding author:

Mohamed Achref Boubaker
Department of Anaesthesiology and Intensive Care Medicine, Bethanien Hospital Moers, Moers, Germany
E-mail: boubaker.med.achref@gmail.com

ABSTRACT:

Bedside echocardiography is increasingly used to guide haemodynamic management in septic shock, but its value depends on correct interpretation and integration with the patient's evolving physiology. This narrative review examines five recurrent pitfalls that may lead to inappropriate fluid administration, delayed recognition of ventricular dysfunction, or suboptimal vasoactive treatment. The review was informed by a focused search of PubMed and major critical care and echocardiography guidance documents, prioritising systematic reviews, consensus statements, and clinically relevant observational studies. The five pitfalls are: relying on left ventricular ejection fraction alone; failing to assess right ventricular function systematically; administering fluid without evaluating venous congestion; using static preload indices instead of validated dynamic tests of fluid responsiveness; and treating echocardiography as a single diagnostic event rather than a serial monitoring tool. A structured corrective approach is proposed for each pitfall. Particular emphasis is placed on integrated biventricular assessment, cautious interpretation of inferior vena cava indices, distinction between fluid responsiveness and fluid tolerance, and repeated reassessment after therapeutic interventions. Echocardiography should not be used as an isolated number-generating exercise. Its principal clinical value lies in combining ventricular function, flow, loading conditions, congestion, and treatment response into a coherent bedside haemodynamic phenotype. A systematic approach to these pitfalls may improve decision-making and reduce avoidable harm in patients with septic shock.

Keywords: Critical care; Echocardiography; Fluid therapy; Point-of-care systems; Septic shock; Ventricular dysfunction

INTRODUCTION

Septic shock produces rapidly changing interactions among vasoplegia, preload, ventricular function, pulmonary vascular load, and microcirculatory perfusion. Physical examination and static pressure measurements alone often fail to identify the dominant hemodynamic phenotype. Critical care ultrasonography can provide immediate information about ventricular function, flow, pericardial disease, volume responsiveness, and venous congestion, and contemporary guidance supports its use in adults with septic shock [1,2]. Focused cardiac ultrasound is a goal-directed, limited bedside examination used to answer time-sensitive questions such as gross biventricular function, pericardial effusion, and major chamber-size abnormalities. It does not replace comprehensive echocardiography. Quantitative LV outflow tract velocity-time integral (LVOT VTI), diastolic indices, detailed right ventricular (RV) quantification, pulmonary pressure estimation, valvular assessment, and venous Doppler/VEUS generally require additional training, standardized acquisition, and awareness of method-specific limitations [1-3].

Five echocardiographic pitfalls in septic shock

01 LVEF alone

PITFALL A normal or hyperdynamic LVEF does not establish adequate forward flow.

BETTER Integrate LV size, serial LVOT VTI, biventricular function and perfusion.

02 The right ventricle is overlooked

PITFALL LV findings alone can miss RV pressure overload or RV systolic dysfunction.

BETTER Assess RV size, function, septal shape and reversible RV afterload.

03 Fluid is given without checking congestion

PITFALL Fluid responsiveness can coexist with poor fluid tolerance.

BETTER Consider RV function, lung ultrasound, venous congestion and fluid balance.

04 Static indices are used to predict response

PITFALL A single CVP or IVC diameter poorly predicts a rise in stroke volume.

BETTER Choose a dynamic test suited to rhythm and ventilation; measure flow.

05 One echocardiogram is treated as definitive

PITFALL Vasopressors, ventilation and resuscitation can change the shock phenotype.

BETTER Repeat focused views and comparable measurements after major changes.

Before giving fluid, answer three separate questions

1

Is more flow clinically needed?

2

Will flow increase with fluid?

3

Can this patient tolerate fluid?

Reassess flow, perfusion and congestion after intervention.

LVEF: left ventricular ejection fraction | LVOT VTI: left ventricular outflow tract velocity-time integral

LV/RV: left/right ventricle | CVP: central venous pressure | IVC: inferior vena cava

Focused echo supports decisions; advanced findings require appropriate expertise.



Summarized infographic: Boubaker MA. Clin Crit Care 2026; 34: e260029

The principal limitation is not access to images but interpretation. A technically adequate examination may still lead to an incorrect intervention if a single variable is treated as a definitive answer. The same left ventricular ejection fraction may represent very different hemodynamic states depending on afterload; a patient may be fluid responsive but unable to tolerate additional fluid; and an initially reassuring examination may become obsolete after vasopressor escalation, mechanical ventilation, or further resuscitation. This review focuses on five common, clinically actionable errors relevant to intensivists using focused bedside echocardiography.

MATERIALS AND METHODS

A focused narrative literature search was conducted in PubMed from database inception through 15 July 2026. The websites and guidance documents of the Surviving Sepsis Campaign, the European Society of Intensive Care Medicine, and the European Association of Cardiovascular Imaging were also consulted. Representative search concepts included septic shock, critical care echocardiography, septic cardiomyopathy, left ventricular ejection fraction, right ventricular dysfunction, fluid responsiveness, passive leg raising, inferior vena cava, venous congestion, and venous excess ultrasound. English-language publications involving adults and addressing echocardiographic assessment in sepsis or septic shock, ventricular function, fluid responsiveness, or venous congestion were eligible when they had direct bedside relevance. Pediatric studies, publications unrelated to septic shock or echocardiography, non-English-language publications, and conference abstracts without accessible full text were excluded. The author screened titles and abstracts, reviewed the full texts of potentially relevant publications, and selected the guidelines, consensus statements, systematic reviews, meta-analyses, and observational studies considered most relevant to the five predefined pitfalls. Reference lists of key publications were also examined. Because this was a narrative review, no formal systematic-review protocol, risk-of-bias assessment, or meta-analysis was performed.

Pitfall 1: Relying on left ventricular ejection fraction alone

Left ventricular ejection fraction (LVEF) is the most familiar echocardiographic descriptor of systolic function, but it is strongly influenced by loading conditions. Vasoplegic septic shock commonly presents with low systemic vascular resistance and normal or increased cardiac output. A normal or hyperdynamic LVEF therefore does not, by itself, indicate low forward flow. However, a hyperdynamic LVEF may also occur in a severely underfilled, small left ventricle, particularly with tachycardia; a small end-diastolic volume can be ejected almost completely while absolute stroke volume remains low. Conversely, reduced LVEF does not necessarily indicate inadequate cardiac output when ventricular dilatation preserves stroke volume. Low flow should be demonstrated rather than inferred, using serial LVOT VTI or another cardiac-output measure together with clinical perfusion variables. Septic cardiomyopathy may also involve diastolic dysfunction, RV dysfunction, and abnormal ventricular-arterial coupling rather than isolated LV systolic impairment [4,5].

KEY MESSAGES:

- Left ventricular ejection fraction should never be interpreted in isolation during septic shock.
- Right ventricular function and congestion should be assessed when feasible and without delaying urgent resuscitation.
- Neither fluid responsiveness nor fluid tolerance alone is an indication for fluid administration; dynamic tests are generally preferred when their technical prerequisites are met.
- Serial examinations should compare the same core views and measurements after major interventions or hemodynamic changes.

The corrective approach is to interpret LVEF within an integrated hemodynamic examination. LV size and filling, LVOT VTI, mitral inflow, tissue Doppler, RV size and function, valvular lesions, and the clinical response to treatment should be considered together. LVOT VTI is sensitive to sample-position and alignment errors and varies with heart rate, rhythm, LV outflow obstruction, and aortic regurgitation; serial values should therefore be acquired from the same window and location. E/e' is not a universally reliable estimate of filling pressure in tachycardia, atrial fibrillation, mitral valve disease, or rapidly changing loading conditions [6]. LVEF should describe one component of the phenotype, not determine therapy by itself.

Pitfall 2: Failing to assess the right ventricle systematically

The right ventricle is frequently underexamined despite its central role in septic shock. RV systolic dysfunction, RV pressure overload, and acute cor pulmonale are related but distinct phenotypes. Acute respiratory distress syndrome, hypoxemia, hypercapnia, pulmonary embolism, pulmonary microvascular injury, high positive end-expiratory pressure, and excessive tidal volume can increase pulmonary vascular resistance; chronic pulmonary hypertension may provide a different baseline. Acute cor pulmonale classically combines acute RV dilatation with septal dyskinesia in the setting of increased RV afterload. Fluid loading may enlarge the RV, shift the interventricular septum, reduce LV filling, and worsen systemic output. RV dysfunction is common in early sepsis and is associated with worse outcomes [7-10].

Every examination should therefore include RV size, qualitative contractility, tricuspid annular plane systolic excursion (TAPSE), tissue Doppler S' velocity, fractional area change (FAC) when feasible, septal configuration, and tricuspid regurgitation. Common reference limits such as TAPSE <17 mm, S' <9.5 cm/s, and FAC <35% can support recognition of RV systolic dysfunction, but these longitudinal indices are load dependent and may not represent global RV performance in critical illness [11]. Findings must be integrated with RV/LV size, ventilator settings, gas

exchange, pulmonary pressures, chronic disease, and venous congestion. Echocardiography may support consideration of inotropy when persistent low forward flow and organ hypoperfusion coexist with RV systolic impairment after adequate systemic pressure and preload have been established and reversible causes of RV afterload have been addressed. An isolated abnormal TAPSE or S' is not an indication for an inotrope. Agent selection and dose should reflect blood pressure, arrhythmia risk, and the response of flow and perfusion to a monitored trial [12,13].

Pitfall 3: Giving fluid without assessing venous congestion

Fluid resuscitation may increase stroke volume when the circulation is preload responsive, but benefit depends on whether the additional volume is tolerated and whether increased flow is clinically needed. Venous congestion may impair renal, hepatic, and gastrointestinal function even when arterial pressure is acceptable. Inferior vena cava (IVC) dilatation alone does not establish systemic venous congestion because it is affected by ventilation, intra-abdominal pressure, RV function, and chronic cardiopulmonary disease. The venous excess ultrasound (VExUS) framework combines IVC assessment with hepatic, portal, and intrarenal venous Doppler [14]. Congestion and fluid responsiveness can coexist [15,16], but VExUS thresholds, feasibility, reproducibility, and patient-centered outcome benefit remain uncertain in septic shock. VExUS should inform rather than determine fluid decisions.

The corrective approach separates three questions: will stroke volume increase, can additional volume be tolerated, and is there a clinical indication to increase flow with fluid? Neither responsiveness nor tolerance alone constitutes an indication. A fluid bolus is reasonable only when a preload deficit is plausible, improved flow is expected to benefit tissue perfusion, and the risk of fluid accumulation is acceptable. Fluid tolerance should integrate RV function, central venous pressure trends when available, sonographic congestion markers, lung ultrasound, oxygenation, and cumulative balance; central venous pressure alone is not a reliable predictor of responsiveness. If hypotension coexists with a positive responsiveness test and established congestion, routine fluid loading should be avoided. The clinician should reassess the mechanism of hypotension, optimize vasopressor support and ventilation, reduce reversible RV afterload, and consider monitored inotropy only for documented low-output ventricular dysfunction. If a compelling preload deficit remains, a small, closely monitored fluid challenge may be used and stopped if perfusion fails to improve or congestion worsens [17].

Pitfall 4: Using static indices instead of dynamic tests of fluid responsiveness

Central venous pressure, a single IVC diameter, and ventricular end-diastolic dimensions are poor stand-alone predictors of whether stroke volume will rise after fluid administration. Dynamic tests are generally preferred over static preload indices when their technical prerequisites are met [18]. Passive leg raising (PLR) requires real-time measurement of flow, ideally LVOT VTI or a validated cardiac-output monitor. Pulse-pressure variation (PPV)

and stroke-volume variation (SVV) require controlled mechanical ventilation, regular rhythm, minimal spontaneous effort, a sufficient tidal-volume-induced cardiopulmonary interaction, and the absence of major RV failure. End-expiratory occlusion (EEO) requires controlled ventilation and a reliable, sufficiently responsive flow signal. Atrial fibrillation and other arrhythmias limit Doppler averaging and invalidate PPV/SVV, although PLR may remain usable if flow is measured over several beats.

PLR produces a reversible endogenous fluid challenge and is useful across a broad range of clinical conditions when performed correctly [19,20]. An increase in stroke volume or LVOT VTI of approximately 10% is often used, but the threshold depends on the measurement method and must exceed its measurement error. EEO, tidal-volume challenge, PPV/SVV, and mini-fluid challenge can be used only in appropriate conditions [18,21]. The selected test should match the patient's rhythm, ventilatory mode, spontaneous breathing activity, RV function, and available signal. A positive result predicts an increase in flow, not a clinical benefit from fluids; perfusion need and fluid tolerance must still be evaluated. This interpretation is consistent with sepsis guidance favoring dynamic over static assessment during resuscitation [22].

Pitfall 5: Treating echocardiography as a single event

Septic shock is dynamic. The initial hyperdynamic state can evolve into LV systolic or diastolic dysfunction, acute RV failure, or mixed shock. Vasopressors alter afterload; fluids alter biventricular loading; intubation and positive-pressure ventilation alter venous return and RV afterload; and source control may rapidly change vascular tone. A single examination is therefore a time-stamped physiologic observation rather than a definitive diagnosis [23,24].

Echocardiography should be repeated when hemodynamic status changes, after major interventions, when the observed response is discordant with expectations, or when vasoactive support is escalated. Serial measurements are most useful when the same core variables, views, patient position, acquisition methods, respiratory phase, and clinical context are compared. Whenever feasible, the same trained operator or a documented standardized protocol should be used. The purpose is not to repeat a comprehensive echocardiogram each time, but to answer a focused question and determine whether the proposed mechanism and treatment response remain coherent.

Practical bedside integration

A useful sequence begins with the clinical question (Figure 1). In persistent shock, immediately reversible obstructive causes should first be excluded. The clinician should then define the dominant phenotype by integrating biventricular size and function, LVOT flow, pericardium, lung ultrasound, and venous congestion. If additional flow may benefit tissue perfusion and a preload deficit is plausible, a technically appropriate dynamic test is selected. A positive test is followed by a separate assessment of fluid tolerance. Treatment is then matched to the phenotype and followed by standardized reassessment of the same variables.

Bedside echocardiography in persistent septic shock

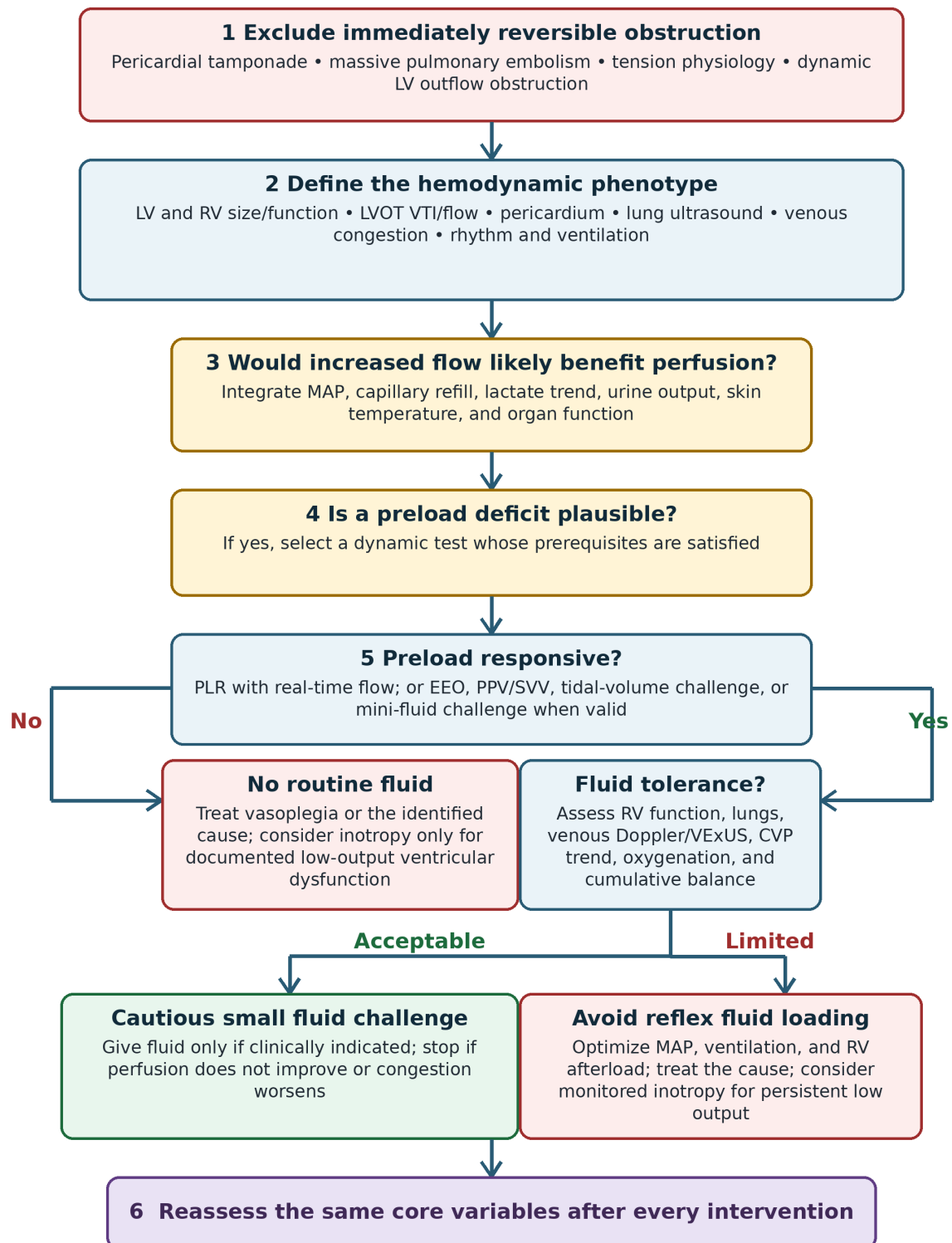


Figure 1. Stepwise bedside echocardiography algorithm for persistent septic shock. The algorithm separates the need for increased flow, preload responsiveness, and fluid tolerance, then requires reassessment of the same core variables after intervention. **Abbreviations:** CO: cardiac output; CVP: central venous pressure; EEO: end-expiratory occlusion; LV: left ventricle; LVOT: left ventricular outflow tract; MAP: mean arterial pressure; PLR: passive leg raising; PPV: pulse-pressure variation; RV: right ventricle; VExUS: venous excess ultrasound; SVV: stroke-volume variation; VTI: velocity-time integral.

For example, consider a patient with persistent septic shock despite norepinephrine. A small hyperdynamic LV, LVOT VTI of 11 cm, preserved RV size and function, a 14% VTI increase during PLR, and no pulmonary or systemic venous congestion support a cautious small fluid challenge, provided impaired perfusion is present. The same positive PLR result in a patient with RV dilatation, septal flattening, diffuse B-lines, and abnormal venous Doppler should not trigger automatic fluid administration. In that phenotype, priority shifts to vasopressor optimization, ventilator and RV-afterload adjustment, and treatment of the cause; inotropy is considered only if low forward flow and hypoperfusion persist after pressure, preload, and afterload have been addressed (Table 1).

Limitations

Focused cardiac ultrasound is operator dependent and is limited by image acquisition, measurement variability, body habitus, mechanical ventilation, dressings, positioning, arrhythmia, and tachycardia. Basic focused assessment should not be extended beyond the operator's competence; advanced Doppler measurements, quantitative RV assessment, VExUS, and structural or valvular diagnosis may require expert or comprehensive echocardiography. Thresholds derived from stable cardiology populations may not perform identically in critical illness. VExUS and dynamic

tests have context-specific limitations, and a numerical threshold should not override discordant physiology. Serial examinations require standardized acquisition and documentation with image storage whenever possible. Comprehensive echocardiography should not be delayed when endocarditis, major valvular disease, structural pathology, or unexplained ventricular dysfunction is suspected. Finally, this was a non-systematic, single-author narrative review; selective reference inclusion and the absence of formal risk-of-bias assessment may introduce selection bias.

CONCLUSION

The principal danger of bedside echocardiography in septic shock is not failure to obtain a number but failure to integrate physiology. LVEF alone is insufficient; RV phenotype and congestion must be considered; fluid responsiveness, fluid tolerance, and the indication for fluids are separate questions; and dynamic tests are preferred only when their prerequisites are satisfied. Focused cardiac ultrasound should remain within the operator's competence and trigger comprehensive assessment when required. Standardized serial reassessment after intervention is central to matching treatment to the evolving shock phenotype.

Table 1. Summary of common echocardiographic pitfalls and corrective actions.

Pitfall	Misleading interpretation	Corrective action	Key parameters	Key limitations/caveats
LVEF alone	Normal or hyperdynamic LVEF equals adequate flow	Integrate biventricular function, flow, diastolic findings, perfusion, and loading conditions	LVEF; LV size; serial LVOT VTI; mitral in-flow; E/e'; RV function	LVEF and VTI are load and technique dependent; E/e' is unreliable in several ICU conditions
RV not assessed	Absence of LV failure excludes a cardiac contribution to shock	Distinguish RV systolic dysfunction, pressure overload, and acute cor pulmonale; address reversible afterload	RV/LV ratio; TAPSE; S'; FAC; septal flattening; TR; venous congestion	TAPSE and S' are load-dependent longitudinal indices and do not represent global RV function alone
Fluid without congestion assessment	Fluid responsiveness implies fluid safety or an indication for fluid	Assess responsiveness, tolerance, and clinical need separately	PLR with flow; RV function; IVC; venous Doppler; lung ultrasound; cumulative balance	IVC dilatation alone does not establish congestion; VExUS thresholds and outcome benefit in sepsis remain uncertain
Static preload indices	CVP or IVC diameter predicts response to fluid	Prefer a validated dynamic test when prerequisites are met	PLR; VTI/CO change; EEO; PPV/SVV; mini-fluid challenge	PLR needs real-time flow; PPV/SVV require controlled ventilation and regular rhythm; thresholds must exceed measurement error
Single examination	The initial phenotype remains valid throughout resuscitation	Repeat a standardized focused examination after clinical changes and major interventions	Same views; ventricular size/function; flow; lungs; loading; congestion	Operator dependence and inconsistent acquisition reduce comparability; obtain comprehensive echocardiography when indicated

Common abnormal reference values include TAPSE <17 mm, S' <9.5 cm/s, and FAC <35%, but all values require integrated interpretation and locally accepted echocardiography standards. **Abbreviations:** CO: cardiac output; CVP: central venous pressure; EEO: end-expiratory occlusion; FAC: fractional area change; IVC: inferior vena cava; LV: left ventricle; LVEF: left ventricular ejection fraction; LVOT: left ventricular outflow tract; PLR: passive leg raising; PPV: pulse-pressure variation; RV: right ventricle; S': tissue Doppler systolic velocity; SVV: stroke-volume variation; TAPSE: tricuspid annular plane systolic excursion; TR: tricuspid regurgitation; VexUS: venous excess ultrasound; VTI: velocity-time integral.

Acknowledgement: None

Ethical Statement: Ethics committee review and informed consent were not applicable because this narrative review synthesizes previously published literature only and involved no human participants, identifiable personal information, patient-level data, biological material, or animals.

CRedit Author Contributions: M.A.B.: Conceptualization, Methodology, Writing - Original Draft, Writing - Review & Editing, and Visualization. The author has read and approved the final manuscript and accepts accountability for all aspects of the work.

Generative AI Statement: ChatGPT (OpenAI, GPT-5-series models) and Claude (Anthropic, Claude Sonnet models) were used as assistive tools for language editing, manuscript organization, and drafting support during preparation and revision of the manuscript. AI tools were not used to generate or analyze original study data. The author critically reviewed the full manuscript, independently verified the scientific content and references, and assumes full responsibility for the accuracy, originality, and integrity of the final work.

REFERENCES

- Díaz-Gómez JL, Sharif S, Ablordepey E, Lanspa MJ, Basmaji J, Carver T, et al. Society of Critical Care Medicine guidelines on adult critical care ultrasoundography: focused update 2024. *Crit Care Med*. 2025;53(2):e447-e458. doi: <https://doi.org/10.1097/CCM.00000000000006530>.
- Vieillard-Baron A, Millington SJ, Sanfilippo F, Chew M, Diaz-Gomez J, McLean A, et al. A decade of progress in critical care echocardiography: a narrative review. *Intensive Care Med*. 2019;45(6):770-788. doi: <https://doi.org/10.1007/s00134-019-05604-2>.
- Neskovic AN, Skinner H, Price S, Via G, De Hert S, Stankovic I, et al. Focus cardiac ultrasound core curriculum and core syllabus of the European Association of Cardiovascular Imaging. *Eur Heart J Cardiovasc Imaging*. 2018;19(5):475-481. doi: <https://doi.org/10.1093/ehjci/jej006>.
- Lukić I, Mihić D, Canecki Varžić S, Selthofer Relatić K, Zibar L, Loinjak D, et al. Septic cardiomyopathy. *Rev Cardiovasc Med*. 2024;25(1):23. doi: <https://doi.org/10.31083/j.rcm2501023>.
- Sanfilippo F, Corredor C, Fletcher N, Landesberg G, Benedetto U, Foex P, et al. Diastolic dysfunction and mortality in septic patients: a systematic review and meta-analysis. *Intensive Care Med*. 2015;41(6):1004-1013. doi: <https://doi.org/10.1007/s00134-015-3748-7>.
- Nagueh SF, Smiseth OA, Appleton CP, Byrd BF 3rd, Dokainish H, Edvardsen T, et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography: an update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. *J Am Soc Echocardiogr*. 2016;29(4):277-314. doi: <https://doi.org/10.1016/j.echo.2016.01.011>.
- Lanspa MJ, Cirulis MM, Wiley BM, Olsen TD, Wilson EL, Beesley SJ, et al. Right ventricular dysfunction in early sepsis and septic shock. *Chest*. 2021;159(3):1055-1063. doi: <https://doi.org/10.1016/j.chest.2020.09.274>.
- Kim JS, Kim YJ, Kim M, Ryoo SM, Kim WY. Association between right ventricle dysfunction and poor outcome in patients with septic shock. *Heart*. 2020;106(21):1665-1671. doi: <https://doi.org/10.1136/heart-jnl-2020-316889>.
- Vallabhajosyula S, Kumar M, Pandompam G, Sakhuja A, Kashyap R, Kashani K, et al. Prognostic impact of isolated right ventricular dysfunction in sepsis and septic shock: an 8-year historical cohort study. *Ann Intensive Care*. 2017;7:94. doi: <https://doi.org/10.1186/s13613-017-0319-9>.
- Repešé X, Charron C, Vieillard-Baron A. Acute cor pulmonale in ARDS: rationale for protecting the right ventricle. *Chest*. 2015;147(1):259-265. doi: <https://doi.org/10.1378/chest.14-0877>.
- Mukherjee M, Rudski LG, Addetia K, Afalilo J, D'Alto M, Freed BH, et al. Guidelines for the echocardiographic assessment of the right heart in adults and special considerations in pulmonary hypertension: recommendations from the American Society of Echocardiography. *J Am Soc Echocardiogr*. 2025;38(3):141-186. doi: <https://doi.org/10.1016/j.echo.2025.01.006>.
- Harjola VP, Mebazaa A, Čelutkienė J, Bettex D, Bueno H, Chioncel O, et al. Contemporary management of acute right ventricular failure: a statement from the Heart Failure Association and the Working Group on Pulmonary Circulation and Right Ventricular Function of the European Society of Cardiology. *Eur J Heart Fail*. 2016;18(3):226-241. doi: <https://doi.org/10.1002/ehj.478>.
- Vallabhajosyula S, Shankar A, Vojjini R, Cheungpasitporn W, Sundaragiri PR, DuBrock HM, et al. Impact of right ventricular dysfunction on short-term and long-term mortality in sepsis: a meta-analysis of 1,373 patients. *Chest*. 2021;159(6):2254-2263. doi: <https://doi.org/10.1016/j.chest.2020.12.016>.
- Beaubien-Souligny W, Rola P, Haycock K, Bouchard J, Lamarche Y, Spiegel R, et al. Quantifying systemic congestion with point-of-care ultrasound: development of the venous excess ultrasound grading system. *Ultrasound J*. 2020;12:16. doi: <https://doi.org/10.1186/s13089-020-00163-w>.
- Muñoz F, Born P, Bruna M, Ulloa R, González C, Philp V, et al. Coexistence of a fluid responsive state and venous congestion signals in critically ill patients: a multicenter observational proof-of-concept study. *Crit Care*. 2024;28(1):52. doi: <https://doi.org/10.1186/s13054-024-04834-1>.
- Prager R, Arntfield R, Wong MYS, Ball I, Lewis K, Rochweg B, et al. Venous congestion in septic shock quantified with point-of-care ultrasound: a pilot prospective multicentre cohort study. *Can J Anaesth*. 2024;71(5):640-649. doi: <https://doi.org/10.1007/s12630-024-02717-1>.
- Malbrain MLNG, 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. *Anaesthesiol Intensive Ther*. 2014;46(5):361-380. doi: <https://doi.org/10.5603/AIT.2014.0060>.
- de Freitas Chaves RC, Barbas CSV, Queiroz VNF, Serpa Neto A, Deliberato RO, Pereira AJ, et al. Assessment of fluid responsiveness using pulse pressure variation, stroke volume variation, plethysmographic variability index, central venous pressure, and inferior vena cava variation in patients undergoing mechanical ventilation: a systematic review and meta-analysis. *Crit Care*. 2024;28(1):289. doi: <https://doi.org/10.1186/s13054-024-05078-9>.
- Monnet X, Marik PE, Teboul JL. Passive leg raising for predicting fluid responsiveness: a systematic review and meta-analysis. *Intensive Care Med*. 2016;42(12):1935-1947. doi: <https://doi.org/10.1007/s00134-015-4134-1>.
- Monnet X, Teboul JL. Assessment of fluid responsiveness: recent advances. *Curr Opin Crit Care*. 2018;24(3):190-195. doi: <https://doi.org/10.1097/MCC.0000000000000501>.
- Si X, Song X, Lin Q, Nie Y, Zhang G, Xu H, et al. Does end-expiratory occlusion test predict fluid responsiveness in mechanically ventilated patients? A systematic review and meta-analysis. *Shock*. 2020;54(6):751-760. doi: <https://doi.org/10.1097/SHK.0000000000001545>.
- Evans L, Rhodes A, Alhazzani W, Antonelli M, Coopersmith CM, French C, et al. Surviving Sepsis Campaign: international guidelines for management of sepsis and septic shock 2021. *Intensive Care Med*. 2021;47(11):1181-1247. doi: <https://doi.org/10.1007/s00134-021-06506-y>.
- Cecconi M, De Backer D, Antonelli M, Beale R, Bakker J, Hofer C, et al. Consensus on circulatory shock and hemodynamic monitoring. *Intensive Care Med*. 2014;40(12):1795-1815. doi: <https://doi.org/10.1007/s00134-014-3525-z>.
- Aboumarie HS, Tavazzi G, Via G, Guarracino F, Stankovic I, Hagedorff A, et al. Cardiac ultrasound in cardiovascular emergency and critical care: a clinical consensus statement of the European Association of Cardiovascular Imaging, the Acute Cardiovascular Care Association of the European Society of Cardiology, and the European Association of Cardiothoracic Anaesthesia and Intensive Care. *Eur Heart J Cardiovasc Imaging*. 2025;26(11):1699-1724. doi: <https://doi.org/10.1093/ehjci/jeaf246>.

To submit the next your paper with us at:

<https://he02.tci-thaijo.org/index.php/cc/about/submissions>

