TO STUDY EFFICACY OF 2D ECHOCARDIOGRAPHY IN MANAGEMENT OF SHOCK IN PAEDIATRIC INTENSIVE CARE UNIT

Dr. Aditi Bansal[1], Dr. Prashant Agrawal[2], Dr. Gunjan Kela[3]

[1]MD Paediatrics, Department of Paediatrics, Sri Aurobindo Medical College and P.G. Institute, Indore, Madhya Pradesh, India

[2]MD, FNB Cardiology, Department of Paediatrics, Sri Aurobindo Medical College and P.G. Institute, Indore, Madhya Pradesh, India

[3]DCH DNB Paediatrics, Department of Paediatrics, Sri Aurobindo Medical College and P.G. Institute, Indore, Madhya Pradesh, India

Corresponding Author

Dr. Aditi Bansal

Department of Paediatrics, Sri Aurobindo Medical College and P.G. Institute, Indore, Madhya Pradesh, India

Email: aditi21bansal@gmail.com

ABSTRACT

Background & objectives: Echocardiography is pivotal in diagnosing and managing patients with shock. An important application in a shock setting is that it is non-invasive and can be rapidly applied. Therefore, to study echocardiographic parameters in shock in PICU and to find out the correlation between echocardiographic parameters and shock status in children to assess the role of 2D echo in decision-making in shock in PICU.

Methods: This cross-sectional study evaluated 60 children admitted to a PICU with shock. Routine tests, including 2D echocardiogram and laboratory parameters, assessed cardiac function to determine the type of shock and guide appropriate intervention.

Results: In 60% of the critically ill shock patients, echocardiography results were crucial in directing management choices and inotrope selection, allowing for early intervention.

Conclusions: In 60% of critically ill patients, echocardiography guided management decisions, and inotrope selection led to a successful early intervention. This study emphasizes the importance of 2D echo in managing paediatric patients with shock.

Keywords: Critical care echocardiography, PICU, Shock management.

INTRODUCTION

Shock is a clinical condition of acute circulatory insufficiency brought on by any one of four mechanisms, alone or in combination.[1,2]

The first involves a reduction in venous return driven by a reduction in circulation volume (i.e., due to internal or external loss of fluids). The second is a failure of the heart's capacity to pump blood due to a major arrhythmia, such as ventricular tachycardia or a severe A-V block, or a loss of contractility (caused by ischemia, infarction, myopathy, or myocarditis). The third is a blockage brought on by cardiac tamponade, tension pneumothorax, or pulmonary embolism. The fourth is vascular tone loss, which causes blood flow to be improperly distributed (due to sepsis, anaphylaxis, or spinal injury). These four types of shock frequently exhibit similarities, and patients admitted with one type can acquire another.

Septic shock can occasionally develop in cardiogenic or hemorrhagic shock patients due to trauma.[3,4]

Inadequate tissue perfusion, which results in decreased organ function, characterizes shock, a potentially fatal medical condition. Although decreased oxygen delivery is the environment where the shock state most frequently occurs, it is plausible that high metabolic demands could result in a similar pathogenic state. However, the body's compensatory mechanisms can adapt to meet even high metabolic demand; therefore, a condition of shock will typically only happen during inadequate oxygen and substrate delivery.

Early detection and management are essential for improving patient outcomes because shock is a frequent reason for paediatric intensive care unit (PICU) admissions. The prevalence of shock in children is rising, brought on by many conditions, including sepsis, hypovolemic shock, cardiogenic shock, and others.[5]

Rapid and precise evaluation of the underlying aetiology and level of organ dysfunction is necessary to manage shock in children. Using echocardiography to assess children who have experienced shock, real-time information on heart function can be obtained. It takes careful prioritisation and intelligent time management to manage paediatric patients who are critically ill. Multi-system illnesses frequently complicate clinical pictures with an overlap of symptoms. Recent advances in managing critically ill patients have elevated hemodynamic evaluation to the top. In the paediatric intensive care unit, echocardiography is essential to the clinical practice (PICU). It is considered an efficient bedside imaging modality and a precise diagnostic tool investigating a vital physiological system. The clinical symptoms and echocardiography results illustrate the critically ill patient's hemodynamic condition.[6]

Shock frequently involves multiple factors. The prime example of circulatory compromise caused by peripheral vasodilatation, sepsis-related cardiac dysfunction, and hypovolemia (due to poor oral intake/vomiting, etc.) is septic shock. To determine the optimal management strategy in such cases, precisely determining the hemodynamic mechanism underlying shock is essential. To further modify the dose and to direct the ongoing therapy, periodic hemodynamic monitoring at regular intervals is also necessary. Due to its capacity to provide comprehensive and precise hemodynamic data, invasive hemodynamic monitoring has generally been favoured under this circumstance; nonetheless, it is costly and associated with a significant risk of complications. On the contrary, echocardiography provides a reliable and considerably safer alternative. The type of shock can be identified, and the appropriate course of treatment can be determined by several different hemodynamic measures obtained using echocardiography.[7–9]

The information obtained from echocardiography can ultimately improve patient outcomes by assisting in selecting inotropes and other therapeutic measures. However, a significant overlap between the clinical findings is present among the different types of shock, and laboratory investigations take time. In critically ill patients, it is significantly more challenging.[10]

An estimated 10 million deaths of young children are recorded globally. Diarrhea, pneumonia, malaria, measles, and neonatal causes (birth asphyxia, low birth weight) are principal diagnoses that contribute to this mortality.[11,12] In almost all of these situations, shock brought on by hypovolemia, hypoxia, ischemia, infection, and anaemia is the primary cause of death. Adenosine triphosphate generation declines, and the organism cannot meet its

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

metabolic needs, resulting in anaerobic metabolism and the buildup of cytotoxic metabolites, according to the conventional definition of shock. On the other hand, the clinical definition of shock is based on symptoms such as tachycardia, poor capillary perfusion, decreased urine output, and altered mental status. Hypovolemic, cardiogenic, and distributive shock are three categories that can be used to categorise shock since circulatory function depends on blood volume, heart function, and vascular tone.[13]

Bedside echocardiography has been increasingly used as a method to assess volume status. Respiratory fluctuation in inferior vena cava (IVC) diameter or Velocity Time Integral (VTI) in the aorta or left ventricular outflow tract, as well as qualitative assessments of left ventricle size and motion, is used by the intensivist to help identify preload-dependent patients.[14]

However, several variables, such as the patient's position, aberrations, and the sonographer's expertise, might influence the quality of echocardiographic images in children. The use of other imaging techniques, such as magnetic resonance imaging (MRI) or computed tomography (CT), to further assess the patient may be required in some circumstances where echocardiography is unable to make a conclusive diagnosis.[15]

Despite these limitations, the evidence suggests that echocardiography is valuable for evaluating children with shock. The choice of inotropes and other therapeutic interventions can be directed by the real-time information regarding cardiac function provided by echocardiography, which ultimately improves patient outcomes.

MATERIALS AND METHODS

This cross-sectional analytical study was conducted in a tertiary care setting from April 2021 to May 2022. Sixty children diagnosed with shock and admitted to the PICU were included in the study. Each patient had a comprehensive medical history recorded. Routine tests such as a 2D echocardiogram, an Arterial Blood Gas (ABG) analysis, a sepsis marker analysis, and a hemogram were conducted to assess cardiac functioning and aid in early intervention and management. This study also employed clinical information, lab findings, and 2D echocardiography results.

RESULTS

In the study population, most children admitted to the PICU were between 1-5 years of age (Figure 1). While most of the cases had a diagnosis of chest infection (Pneumonia) 25% (15) on admission, after a 2D echo was performed, most of them were diagnosed with Congenital Heart Defects (CHD) 26.70% (16) (Table 1). LVEDD (23.06 ± 3.21mm) 18% (42) followed by PAP (normal < 36 mmHg) 17.20% (40) were the most common echocardiographic findings observed (Table 2). The hypovolemic shock was observed to be the most common type of shock observed in 40 cases, followed by cardiogenic shock in 20 (Figure 2). Survival rates were found to be 60% (36), while 30% (24) deaths were noted during the hospital stay.

DISCUSSION

An ultrasound or an echocardiographic machine can be typically found in most facilities. Bedside echocardiography, an essential, non-invasive, portable, and rapid diagnostic tool in the PICU can image the great veins, ventricular size, contractility, etc., aiding in the early diagnosis of reversible and time-dependent conditions.[16–18] Only a small fraction of adult

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

patients were observed to have a distinguished impact on disease management, according to a study.[19] In contrast, other studies demonstrate a notable shift in patient management.[17,20,21]

Myocardium's contractility refers to its capacity to contract in response to a particular load under any preload. The degree of myocardial fibre shortening during systole is assessed by 2D echo to determine the contraction. Clinically insufficient volume is frequently evident but might be challenging to assess only through physical examination. The physician uses only 2D and M-mode echocardiography at the primary level of competency. When hypovolemia is severe, images depict the collapse of the left ventricular walls at end-systole. On the other hand, if the atrial septum is fixedly bowing into the right atrium throughout the cardiac cycle, it indicates elevated left atrial pressures, and additional fluid is not required. It should be noted that none of these signs are limited to intravascular fluid status.[22] Although far from ideal, inferior vena cava (IVC) variation has been acknowledged as a helpful metric for some decades now. Multiple investigations have explored further enhancing the technique by measuring right atrial pressure (RAP) using vessel diameter fluctuation in response to the respiratory cycle, maximal diameter, and percentage of diameter alteration.[23]

According to guideline recommendations, a spontaneously breathing patient's IVC diameter (D) <21 mm that collapses with a sniff (termed the caval or collapsibility index [CI = (Dmax Dmin)/Dmax 100%]) indicates a normal RAP of 3 mmHg, while an IVC diameter >21 mm that collapse <50% with a sniff indicates a RAP of >15 mmHg.[24]

It is recommended to measure ventricular preload using 2D echo to optimize a fluid management plan. Peripheral vasoplegia has a significant pathogenic contribution to shock in sepsis, and although it cannot be measured with 2D echo, the cardiac findings can be used for estimation. For instance, a hyperdynamic, completely filled left ventricle is usually an indicator of significant peripheral vasodilatation in shock. 2D echo helps assess the structural and functional integrity of the valves in septic shock.[25]

The 2D Echo improves the capacity to show the spatial relationship of structures. This ability enables more precise anatomic identification of heart and significant vessel abnormalities. Calculating cardiac output and the magnitude of cardiac shunts can be achieved through 2D echo examination.[26,27]

The utility of echocardiography in evaluating LV function in critically ill patients has been documented in different studies. For instance, a study by Bansal et al.[9] revealed that the management of patients with cardiogenic shock improved with echocardiography guidance. In a similar study, Picard et al.[28] conclusively stated that echocardiography could be utilized early in the course of cardiogenic shock for risk stratification and its importance for determining shock aetiology.

According to a study by McLean[25], managing shock patients under echocardiography guidance can increase the precision of inotrope selection, leading to better patient outcomes. In our study, 60% of patients survived; early intervention, appropriate use of inotropes, and fluid therapy might have helped improve patient outcomes.

According to Han et al.[29], the mortality risk increased by more than twice per hour as persistent shock continued. Therefore, improved patient outcomes can result from early detection of decreased LV systolic function and guidance in selecting inotropes with the help of echocardiography. The findings of this study support the utility of echocardiography in treating shock patients. Additional research with large sample size and long-term follow-up is needed for additional information.

In diagnosing and treating shock, echocardiography is probably the single most effective tool, especially when the aetiology is undifferentiated or complex.[25] It can be used at the bedside day or night, is non-invasive, and is quick to initiate. A more sophisticated investigation that follows can provide incremental and crucially additional information that can then lead to the initiation of treatment. Further research is required to assess the effectiveness of echocardiography in managing different types of paediatric shock and evaluate how it affects patient outcomes.

CONCLUSION

Echocardiography dramatically helps treat pediatric shock patients and improves their quality of care. The successful early interventions achieved in 60% of critically ill individuals, guided by echocardiography for treatment decisions and inotrope selection, underscore the importance of incorporating 2D echo into clinical practice. A 2D echo is an invaluable and non-invasive tool for optimizing patient outcomes in this vulnerable population by enabling precise assessment.

Conflict of Interest: None

REFERENCES

1. Vieillard-Baron A, Mayo PH, Vignon P, Cholley B, Slama M, Pinsky MR, et al. International consensus statement on training standards for advanced critical care echocardiography. Intensive Care Med 2014;40:654–66.
2. Stern SA, Dronen SC, Birrer P, Wang X. Effect of blood pressure on hemorrhage volume and survival in a near-fatal hemorrhage model incorporating a vascular injury. Ann Emerg Med 1993;22:155–63.
3. Follath B Yilmaz J F Delgado J T Parissis R Porcher E Gayat Nigel Burrows A Mclean F Vilas-Boas A Mebazaa FM, Yilmaz MB, Delgado JF, Parissis JT, Porcher Á Gayat RE, Burrows IMS Health SpA N, et al. Clinical presentation, management and outcomes in the Acute Heart Failure Global Survey of Standard Treatment (ALARM-HF). Intensive Care Med 2011;37:619–26.
4. Mcmurray JJV, Adamopoulos S, Anker SD, Auricchio A, Böhm M, Dickstein K, et al. ESC Guidelines for the diagnosis and treatment of acute and chronic heart failure 2012. Eur J Heart Fail 2012;14:803–69.
5. Wheeler DS, Basu RK. Send Orders of Reprints at reprints@benthamscience.net Pediatric Shock: An Overview. Open Pediatr Med Journal 2013:2–2.
6. Tibby SM. Hemodynamic Monitoring. Cardiovascular Pediatric Critical Illness and Injury 2009:1–20.
7. Shah MR, Hasselblad V, Stevenson LW, Binanay C, O'Connor CM, Sopko G, et al. Impact of the Pulmonary Artery Catheter in Critically Ill Patients: Meta-analysis of Randomized Clinical Trials. JAMA 2005;294:1664–70.

8. Wheeler AP, Bernard GR, Thompson ; B Taylor, Schoenfeld D, Wiede-Mann HP. Pulmonary-Artery versus Central Venous Catheter to Guide Treatment of Acute Lung Injury. New England Journal of Medicine 2006;354:2213–24.
9. Bansal M, Ranjan S. Echocardiography in the Management of Cardiogenic Shock. Https://DoiOrg/101177/2632463619897849 2020;1:20–30.
10. Tavares J, Ivo R, Gonzalez F, Lamas T, Mendes JJ. <p>Global Ultrasound Check for the Critically lll (GUCCI)—a new systematized protocol unifying point-of-care ultrasound in critically ill patients based on clinical presentation</p>. Open Access Emergency Medicine 2019;11:133–45.
11. Ahmad OB, Lopez AD, Inoue M. The decline in child mortality: a reappraisal. Bull World Health Organ 2000;78:1175.
12. Black RE, Morris SS, Bryce J. Where and why are 10 million children dying every year? Lancet 2003;361:2226–34.
13. Mtaweh H, Trakas E V., Su E, Carcillo JA, Aneja RK. Advances in Monitoring and Management of Shock. Pediatr Clin North Am 2013;60:641.
14. Levitov A, Marik PE. Echocardiographic Assessment of Preload Responsiveness in Critically Ill Patients. Cardiol Res Pract 2012;2012.
15. Cheitlin MD, Alpert JS, Armstrong WF, Aurigemma GP, Beller GA, Bierman FZ, et al. ACC/AHA guidelines for the clinical application of echocardiography. A report of the American College of Cardiology/American Heart Association task force on practice guidelines (Committee on Clinical Application of Echocardiography). Circulation 1997;95:1686–744.
16. Beaulieu Y. Specific skill set and goals of focused echocardiography for critical care clinicians. Crit Care Med 2007;35.
17. Vignon P, Chastagner C, François B, Martaillé JF, Normand S, Bonnivard M, et al. Diagnostic ability of hand-held echocardiography in ventilated critically ill patients. Crit Care 2003;7:R84.
18. Pershad J, Myers S, Plouman C, Rosson C, Elam K, Wan J, et al. Bedside limited echocardiography by the emergency physician is accurate during evaluation of the critically ill patient. Pediatrics 2004;114.
19. Chandrasekhar J, Ammash NM, Aksamit TR. Echo in the Medical Intensive Care Unit: Does It Really Impact Patient Management? A Retrospective Observational Stud. No 4_MeetingAbstracts Chest 2003;124:174.
20. Orme E, Oram MP, Mckinstry CE. CRITICAL CARE Impact of echocardiography on patient management in the intensive care unit: an audit of district general hospital practice n.d.
21. Rabah F, Al-Senaidi K, Beshlawi I, Alnair A, Abdelmogheth A-AA. Echocardiography in PICU: when the heart sees what is invisible to the eye. J Pediatr (Rio J) 2016;92:96–100.
22. Feissel M, Michard F, Mangin I, Ruyer O, Faller JP, Teboul JL. Respiratory changes in aortic blood velocity as an indicator of fluid responsiveness in ventilated patients with septic shock. Chest 2001;119:867–73.

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

23. Kircher BJ, Himelman RB, Schiller NB. Noninvasive estimation of right atrial pressure from the inspiratory collapse of the inferior vena cava. Am J Cardiol 1990;66:493–6.
24. Rudski LG, Lai WW, Afilalo J, Hua L, Handschumacher MD, Chandrasekaran K, et al. Guidelines for the Echocardiographic Assessment of the Right Heart in Adults: A Report from the American Society of Echocardiography Endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. Journal of the American Society of Echocardiography 2010;23:685–713.
25. Mclean AS. Echocardiography in shock management 2016.
26. El-Nawawy AA, Abdelmohsen AM, Hassouna HM. Role of echocardiography in reducing shock reversal time in pediatric septic shock: a randomized controlled trial PALAVRAS-CHAVE. J Pediatr (Rio J) 2018;94:31–9.
27. Ghorbani A, Ouyang D, Abid A, He B, Chen JH, Harrington RA, et al. Deep learning interpretation of echocardiograms. Npj Digital Medicine 2020 3:1 2020;3:1–10.
28. Picard MH, Davidoff R, Sleeper LA, Mendes LA, Thompson CR, Dzavik V, et al. Echocardiographic Predictors of Survival and Response to Early Revascularization in Cardiogenic Shock. Circulation 2003;107:279–84.
29. Han YY, Carcillo JA, Dragotta MA, Bills DM, Watson RS, Westerman ME, et al. Early Reversal of Pediatric-Neonatal Septic Shock by Community Physicians Is Associated With Improved Outcome. Pediatrics 2003;112:793–9.

TABLES

Diagnosis	No. of cases (At admission)	No. of cases (After 2D echo)
Moderate - severe bronchiolitis	10 (16.70%)	8 (13.30%)
Chest infection (Pneumonia)	15 (25.00%)	12 (20.00%)
Severe sepsis	12 (20.00%)	11 (18.30%)
CHD	12 (20.00%)	16 (26.70%)
Unknown poisoning	4 (6.70%)	4 (6.70%)
Cardiomyopathy	2 (3.30%)	4 (6.70%)
Acute haemolysis	5 (8.30%)	5 (8.30%)

*CHD: Congenital Heart Defects

Table 1: Diagnosis of study cases (at admission) (n=60)

2-D Echo findings	No. of cases
Ejection fraction (abnormal < 30%)	20
CVP (abnormal < 6mmHg)	35
PAP (normal < 36 mmHg)	40
LVEDD (23.06 ± 3.21mm)	42
LVESD (23.06 ± 4.23mm)	36
IVC collapse with respiration (>50%)	32
IVC collapse with respiration (fully)	5
IVC collapse with respiration (<50%)	23

ISSN: 0975-3583, 0976-2833 VOL14, ISSUE 08, 2023

*EF: Ejection Fraction, CVP: Central Venous Pressure, PAP: Pulmonary Artery Pressure, LVEDD: Left Ventricular End-Diastolic Dimension, LVESD: Left Ventricular End-Systolic Dimension, IVC: Inferior vena cava

Table 2: Echocardiographic findings (n=60)

FIGURES

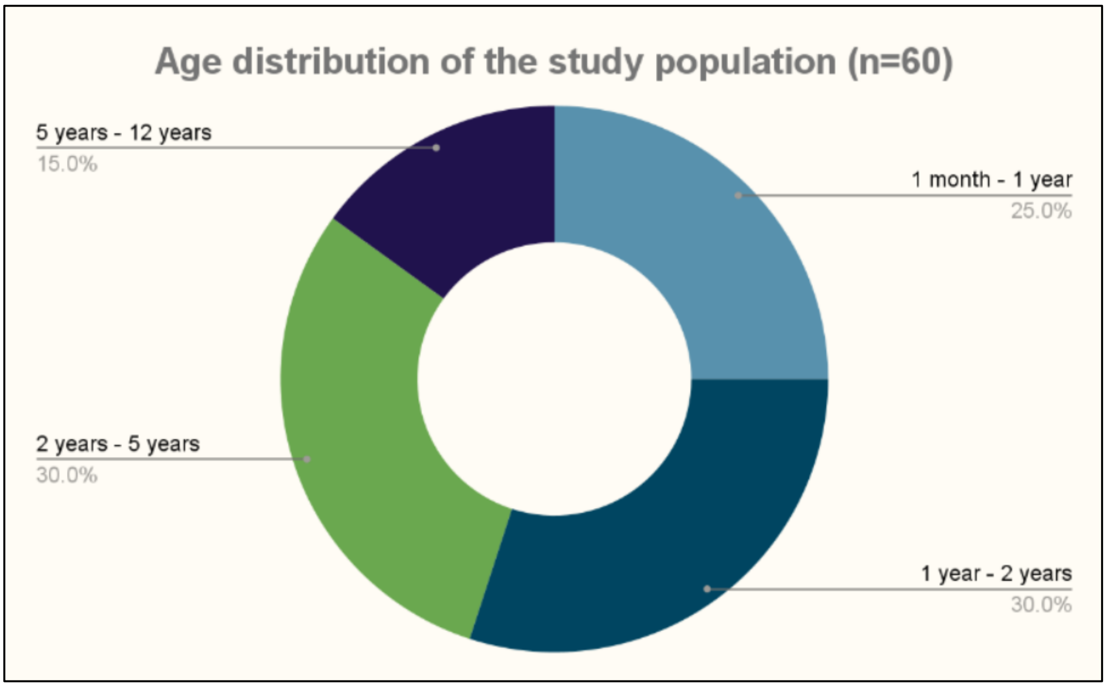

Figure 1: Age distribution of the study population (n=60)

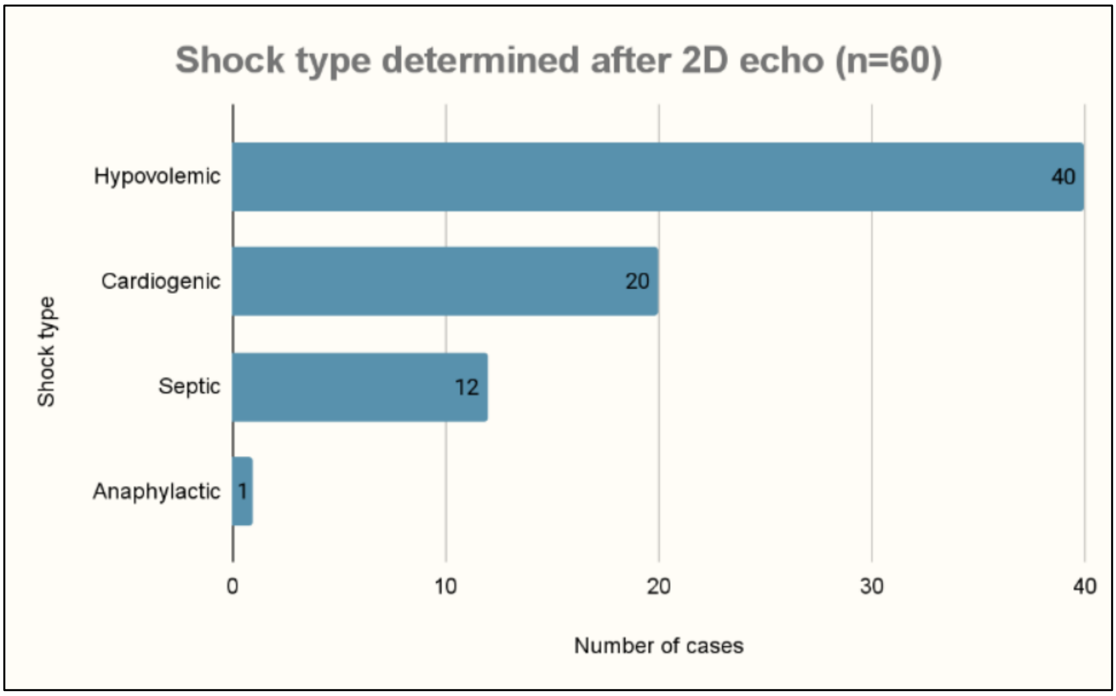

Figure 2: Shock type determine after 2D echo (n=60)