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REVIEW **Open Access**

Transesophageal echocardiography in cardiac arrest: why, how, when, and where in clinical practice

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Abstract

Transesophageal echocardiography (TEE) has emerged as a transformative tool in the management of cardiac arrest, offering significant advantages over traditional transthoracic echocardiography (TTE) by enabling continuous, high-resolution cardiac imaging during resuscitation. Initially used in operating rooms before 2000, TEE expanded into emergency departments (EDs), intensive care units (ICUs), and even prehospital settings. Its superior imaging capability during cardiopulmonary resuscitation (CPR) supports rapid diagnosis, optimization of compression quality, and more accurate rhythm assessment, including the differentiation between asystole and fine ventricular fibrillation. TEE has been shown to influence intra-arrest clinical decision-making in up to 78% of cases, often revealing pathologies—such as aortic dissection or cardiac rupture—not detected by TTE. Importantly, TEE aids in identifying reversible causes of cardiac arrest, guiding high-quality CPR by assessing left ventricular outflow tract (LVOT) obstruction, and shortening the duration of pulse checks. It also may play a role in extracorporeal CPR (ECPR) and organ donation procedures, particularly in cannulation and monitoring during extracorporeal membrane oxygenation (ECMO) and normothermic regional perfusion (NRP). TEE use is feasible and safe during cardiac arrest, with high insertion success rates and minimal complications when performed by trained personnel. While cardiologists, anesthesiologists, and intensivists traditionally perform TEE, simplified training protocols now enable emergency physicians to safely and effectively deploy TEE in critical settings. Protocols such as "POCUS-TEE" may promote rapid acquisition of essential views, facilitating broader implementation. Despite the potential benefits, several barriers to widespread adoption remain. These include the availability of equipment, limitations in training, and concerns regarding the safety of the probe during defibrillation. Resuscitation guidelines recommend removing the transesophageal echocardiogram (TEE) probe, or at least insulating it, as a precaution during defibrillation. TEE is particularly valuable when TTE proves inadequate, such as in obese or mechanically ventilated patients. In conclusion, TEE might enhance the quality and precision of resuscitation in cardiac arrest and has the potential to improve survival and neurological outcomes in selected cases. Its broader adoption hinges on institutional support, streamlined protocols, operator training, and further research to validate its impact on patient-centered outcomes. As technology advances and clinical integration improves, TEE may become a cornerstone of advanced life support in both in-hospital and out-of-hospital settings.

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Introduction

Transesophageal echocardiography (TEE) was initially introduced in operating rooms and cardiology units during cardiac arrest scenarios prior to 2000 [1, 2]. In the early 2000 s, its application expanded into critical care environments, including intensive care units (ICUs) and emergency departments (EDs) [3, 4]. A pivotal 2008 report by Blaivas et al. described the use of TEE in six ED patients during cardiac arrest, highlighting its growing utility [5].

Later studies confirmed that emergency physicians (EPs), with brief, simulation-based training, could acquire focused TEE views within 7–12 min of patient arrival [6].

Clinically, TEE use was first documented by Frazin et al. in 1976 using a rigid endoscopic probe with a single M-mode crystal [7–10]. The introduction of phased-array transducers in 1980 led to biplane probes and the integration of color Doppler technology [11]. By 1990, probes capable of 180° mechanical or electronic rotation were developed [12]. More recently, real-time 3D imaging has enhanced the anatomical assessment of cardiac structures, especially valvular disease [9–13]. These technological advances have strengthened TEE's role in cardiac arrest management across settings like the operating room, ICU, and ED.

TEE has been shown to influence intra-arrest clinical decisions in up to 78% of cases [14]. Notably, 55.6% of TEE examinations revealed clinically significant findings not visible on transthoracic echocardiography [15]. These may include life-threatening aortic pathologies (e.g., dissection with tamponade, rupture), which often indicate poor prognosis and could lead to the de-escalation of resuscitative efforts [16–18].

Additionally, TEE optimizes cardiopulmonary resuscitation (CPR) quality—for instance, by assessing aortic valve motion—and supports the implementation of extracorporeal CPR (ECPR) [19]. Specifically, TEE can guide wire and cannula placement, potentially streamlining the procedure and improving outcomes (Fig. 1) [20]. In selected centers, this may increase opportunities for organ donation when intensive resuscitative efforts fail.

This review aims to address four key questions:

1. Why should TEE be used?
2. How to use TEE and who should perform it?
3. Where can transesophageal echocardiography be applied in the perioperative and critical care settings?
4. When is TEE Appropriate in the Perioperative and Critical Care Settings?

Methods

This review was conducted as a narrative synthesis aimed at summarizing and contextualizing the available evidence on the role of transesophageal echocardiography (TEE) in cardiac arrest across perioperative, intensive care, and emergency settings. To improve transparency and minimize selection bias, we followed general recommendations for narrative reviews, including explicit reporting of search sources, time frames, and selection criteria [21].

A comprehensive literature search was performed in PubMed/MEDLINE, Scopus, and EMBASE for studies published between January 1990 and January 2025, using the following Boolean search terms: ("transesophageal echocardiography" OR "TEE" OR "transesophageal probe") AND ("cardiac arrest" OR "cardiopulmonary resuscitation" OR "CPR") AND ("feasibility" OR "safety" OR "complication" OR "clinical impact").

Inclusion criteria comprised:

- Original studies (randomized, observational, or feasibility) and systematic reviews evaluating the use, safety, or diagnostic/therapeutic impact of TEE during cardiac arrest or CPR.
- Studies involving adult or pediatric patients in perioperative, ICU, ED, or prehospital settings.
- Articles written in English and available in full text.

Exclusion criteria were:

- Abstracts, editorials, or conference proceedings without original data.
- Studies focusing exclusively on intraoperative monitoring outside cardiac arrest contexts.
- Animal or purely technical studies unless directly addressing safety or feasibility during CPR.

The initial search retrieved a substantial number of citations, which were screened by title and abstract to identify studies directly relevant to the objectives of this narrative review. Studies not addressing the use of TEE during cardiac arrest, or focusing solely on intraoperative monitoring outside resuscitation contexts, were excluded.

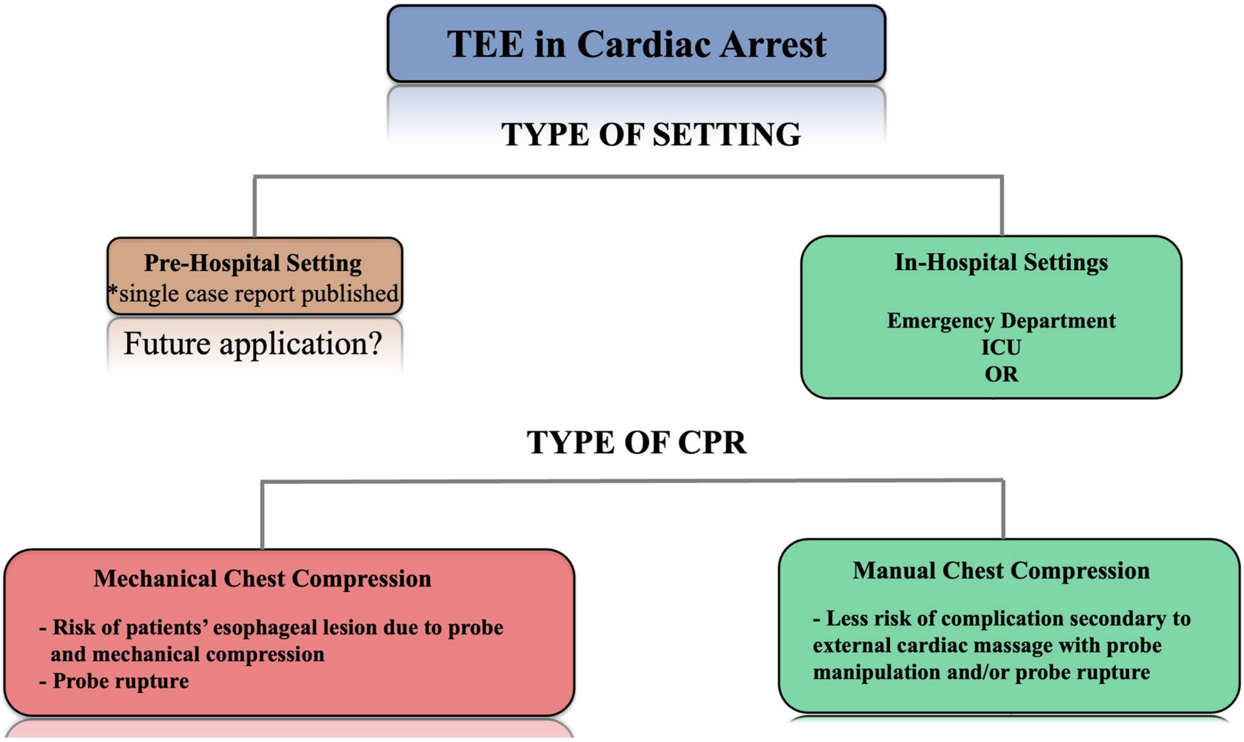

Fig. 1 Use of transesophageal echocardiography according to the setting and type of cardiopulmonary resuscitation. Some tips and tricks for TEE use during cardiac arrest rely on the recognition of its advantages and limitations (or risks). For example, in ED, it is less useful and less available during CPR, but most of the time it becomes useful after ROSC. In ICU setting, TEE is useful, and, if available, most of the time it is better than TTE. Finally, in OR, it could be very useful because it is immediately available, while TTE is often not applicable. Legend: ED, emergency department; ICU, intensive care unit; OR, operating room; TEE, transoesophageal echocardiography; CPR, cardiopulmonary resuscitation; ROSC, return of spontaneous circulation

We did not perform quantitative pooling or formal risk-of-bias assessment, given the heterogeneity of study designs and objectives, in line with recommendations for narrative reviews. However, we explicitly report the literature sources, time frame, and study selection process to enhance transparency and reproducibility.

In addition, recent systematic reviews and guidelines were critically appraised to contextualize the evidence and identify gaps for future investigation.

Why should TEE be used?

Effective cardiac compression remains the cornerstone of generating blood flow during CPR [22]. Historically, efforts to improve the efficacy of external chest compressions have focused predominantly on optimizing compression depth and rate [23]. Even under ideal conditions, however, external chest compressions produce only approximately one-third of normal cardiac output [24, 25].

According to the 2025 European Resuscitation Council (ERC) guidelines on adult advanced life support, this should be kept at 5 to 6 cm [26]. Additionally, TEE can also support monitoring of adequate chest recoil during CPR.

Similarly, ERC still recommends targeting the midpoint of the lower half of the sternum [26].

Early defibrillation of shockable rhythms represents another key pillar of successful resuscitation. Importantly, most modifications to compression techniques have aimed to minimize iatrogenic trauma, rather than to maximize generated cardiac output. Transthoracic echocardiography (TTE) during cardiac arrest generally offers limited insight into compression quality, as it provides only intermittent imaging—typically during procedural pauses—and is most often constrained to a subxiphoid single view, which can compromise image quality. Conversely, TEE permits continuous visualization throughout the CPR cycle. Below, we discuss the impact of TEE on rhythm recognition and algorithm adherence, optimization of external chest compressions, and pulse check management during resuscitation. TEE enhances the accuracy of determining when compressions should be delivered and is superior in differentiating true myocardial standstill from residual cardiac activity [27]. This improved rhythm recognition may increase the chances of successful resuscitation. In a study by Teran et al., of 33 out-of-hospital cardiac arrest (OHCA) patients, TEE identified fine ventricular fibrillation in four patients (12%) initially presumed to be in asystole, leading to earlier defibrillation, and also revealed two cases of pseudo-pulseless electrical activity (PEA) [28–30]. TEE is also valuable in evaluating the effectiveness of chest compressions and guiding optimal hand or device positioning. In a cohort of 34 non-traumatic cardiac arrest patients, Hwang et al. utilized TEE to examine the maximal compression area and calculate left ventricular stroke volume. They found that compressions caused narrowing of the left ventricular outflow tract (LVOT) or aortic root in 19%–83% of cases, with stroke volume correlating to compression position [23]. Teran et al. similarly reported LVOT compression in 53% of cases [30]. Romito et al. described a case of refractory OHCA in which TEE guidance identified ineffective compressions delivered by a mechanical CPR “piston-driven devices” (LUCAS®), prompting device repositioning [31]. Furthermore, a retrospective study from Milan demonstrated that no patients exhibiting LVOT obstruction during compressions were successfully resuscitated, underscoring the value of TEE in directing high-quality compressions and potentially improving survival rates [32]. Regarding pulse checks, TEE enables real-time assessment of native cardiac activity while minimizing interruptions in compressions. Fair et al. evaluated 139 pulse-check pauses in 25 cardiac arrest patients and demonstrated that TEE-guided pulse checks were significantly shorter averaging 9 s (95% CI 5–12 s)—compared with TTE (19 s; 95% CI 16–22 s) and manual palpation (11 s; 95% CI 8–14 s) [29].

Several recent systematic reviews and guideline statements have reinforced the role of TEE as a complementary tool during cardiac arrest. Teran et al. [33] summarized feasibility and diagnostic accuracy data across emergency and ICU settings, while Prager et al. performed a scoping review emphasizing TEE’s impact on clinical decision-making but highlighting the lack of randomized trials demonstrating outcome benefit [14]. The 2025 European Resuscitation Council Advanced Life Support Guidelines now acknowledge intra-arrest TEE as a potential adjunct for rhythm interpretation and identification of reversible causes, though they stop short of issuing strong recommendations due to limited evidence quality [34]. Our synthesis integrates these critical perspectives, underscoring the need for prospective multicenter data on survival and neurological outcomes.

Case Vignette 1

A 72-year-old patient presented to the emergency department with suspected urosepsis and evolving septic shock. On admission, blood pressure was 90/50 mmHg despite administration of 1 L of crystalloid, and the cardiac rhythm was sinus tachycardia at 125 beats per minute. Shortly after evaluation by the medical emergency team, the patient developed worsening dyspnea and fever (38.6 °C). Arterial blood gas analysis showed a P_aO_2/F_IO_2 ratio of 130 and serum lactate of 2.4 mmol/L. Non-invasive ventilation was initiated via full-face mask in pressure support mode (Pressure Support 10 cmH_2O, PEEP 5 cmH_2O). Within minutes, the patient became progressively hypotensive with deterioration of blood pressure to 70/30 mmHg and subsequently suffered cardiac arrest. Advanced life support (ALS) was immediately initiated, including chest compressions and administration of 1 mg intravenous epinephrine every 3 min. Initial TTE in the subcostal view was technically inadequate, prompting cardiology consultation and deployment of a TEE probe.

A mid-esophageal four-chamber view demonstrated a left ventricle that remained distended without effective emptying during chest compressions, while the right ventricle exhibited complete systolic collapse (clip 1-A). Based on this observation, the team adjusted the compression point to optimize left ventricular outflow. Following this modification and a subsequent cycle of CPR, return of spontaneous circulation (ROSC) was achieved (clip 1-B). Post-ROSC assessment revealed severe aortic stenosis (clip 1-C), likely contributing to the cardiac arrest in the context of septic shock. Notably, no systolic murmur had been detected before the patient’s admission.

How to use TEE and who should perform it?

The TEE probe should be sheathed in an endocavitary cover, adequately lubricated, and gently introduced through the oral cavity while elevating the mandible. If resistance is encountered after a few centimeters, it is possible the probe tip may be impacted in a pyriform sinus; in such cases, it should be withdrawn slightly and re-advanced under careful alignment with the esophageal axis [35].

Neglecting correct technique increases the risk of trauma to the pharynx, larynx, esophagus, or stomach. In experienced hands, probe insertion typically takes under 2 min [36]. For safety reasons, insertion should occur after endotracheal intubation. Most resuscitation teams have predefined roles, which may include a designated operator for TEE—often a cardiologist [37]. Nevertheless, trained emergency physicians and intensivists are increasingly performing the procedure. Data regarding feasibility during cardiac arrest are encouraging: in a series of 183 out-of-hospital cardiac arrests, Hwang et al. reported failure to insert the probe in only three patients (1.6%) and observed a vallecular injury in one case (0.5%) [19]. To obtain the standard mid-esophageal window, the probe is advanced 35–40 cm at a 0° multiplane angle, yielding a four-chamber view that allows assessment of ventricular morphology during CPR and exclusion of pericardial tamponade or intracardiac thrombus [38]. Rotating the multiplane angle to 120–140° provides a long-axis view, useful for visualizing the LVOT and aortic valve excursion during compressions. These views aid in identifying reversible causes of arrest, monitoring compression quality, and detecting return of spontaneous circulation—often earlier than electrocardiographic indications [38]. Aortic root and ascending aortic pathology, including Type A dissection or critical aortic stenosis, can also be detected. In suspected type B dissection, posterior rotation of the probe allows visualization of the descending aorta and identification of an intimal flap, with experienced operators often able to differentiate true vs. false lumen. In the absence of invasive arterial pressure monitoring, CPR efficacy can be further evaluated using transgastric Doppler measurements. Advancing the probe into the stomach allows assessment of LVOT velocity time integral (VTI) from the transgastric long-axis (120–140°) or deep transgastric (0°) views. The transgastric short-axis view at the mid-papillary level (0–20°) can also be used to assess ventricular filling and ejection [38]. Cavayas et al. recently proposed a systematic TEE-based approach to lung ultrasound for identifying post-ROSC hypoxia; this, however, falls outside the scope of the present review [39]. Competent use of TEE during cardiac arrest requires appropriate training, typically obtained by cardiologists, anesthesiologists, or intensivists through routine clinical practice [40].

Some argue that only board-certified providers should carry out TEE-guided resuscitation; however, such limitations may be impractical in the setting of time-sensitive cardiac arrest [41, 42]. This has prompted the emergence of focused “POCUS-TEE” protocols to enable broader adoption by emergency physicians [43]. Encouragingly, Field et al. demonstrated that simplified TEE training can enable emergency physicians to competently deploy the technique in clinical practice, with meaningful impact on diagnosis and management [44]. Simplified protocols using a limited set of views have been proposed to shorten the learning curve. Arntfield et al. retrospectively evaluated 54 cardiac arrest cases in which TEE was performed by 14 emergency physicians following a 4-h workshop. Using a focused four-view protocol—mid-esophageal four-chamber, transgastric short-axis, mid-esophageal long-axis, and bicaval—the authors reported 98% feasibility and clinical usefulness [6]. More recently, simulation-based curricula have shown similar success among emergency medicine residents [28]. Reflecting these developments, the American College of Emergency Physicians issued a policy statement in 2017 endorsing TEE use during cardiac arrest [45]. Nevertheless, real-world uptake remains limited outside of early adopters.

The growing utilization of extracorporeal cardiopulmonary resuscitation (ECPR) further increases the relevance of TEE [46]. Beyond guiding CPR, TEE is instrumental in visualizing guidewire advancement and cannula placement during femoral cannulation—procedures associated with risks of vascular injury and hemorrhage [47]. Similarly, during controlled donation after circulatory death (cDCD) with normothermic regional perfusion, TEE assists in the correct placement of intra-aortic balloon occlusion catheters [48].

Upon the initiation of extracorporeal membrane oxygenation (ECMO), TEE becomes an invaluable tool in the clinical setting [49]. It allows healthcare providers to meticulously assess the position of the cannula, ensuring it is optimally placed, while also confirming the adequacy of blood flow. TEE is critical for identifying potential complications, such as left ventricular (LV) distention, which can arise from improper cannulation or other factors.

Furthermore, TEE plays a vital role in evaluating ventricular contractility after ECMO implantation. This assessment is essential for understanding how well the heart is functioning under the stress of support devices, including unloading technologies like the Impella and intra-aortic balloon pumps (IABP) [50]. These devices can significantly aid in alleviating the workload on the heart, and TEE can guide clinicians in making informed weaning decisions by monitoring key parameters such as left ventricular outflow tract (LVOT) flow, tricuspid annular plane systolic excursion (TAPSE), and overall biventricular function [50].

It is also crucial to be aware of the common occurrence of right heart failure associated with high-flow Impella support, as this can further complicate a patient’s condition. Given that the time interval from diagnosis to the initiation of ECMO is one of the most influential predictors of survival, any intervention that accelerates the cannulation process—such as the strategic use of TEE—carries the possibility of significantly improving patient chances of recovery.

Case Vignette 2

A 58-year-old previously healthy woman was brought to the emergency department following a high-impact motor vehicle collision. On arrival, she was hypotensive (systolic blood pressure 60 mmHg), tachycardic, and unresponsive. Focused assessment with sonography for trauma (FAST) was positive for free intraperitoneal fluid, and physical examination demonstrated an open-book pelvic fracture, consistent with multi-system trauma. While preparations were being made for massive transfusion and damage-control surgery, the patient developed pulseless electrical activity (PEA) cardiac arrest. Cardiopulmonary resuscitation was initiated immediately. Following 18 min of resuscitation—including crystalloid and blood product administration, as well as pelvic stabilization—return of spontaneous circulation (ROSC) was achieved. In the operating theatre, external pelvic fixation was performed and a splenectomy was undertaken. Due to absent neurological recovery, parenchymal intracranial pressure monitoring was established. Intracranial pressure (ICP) values were markedly elevated from insertion and continued to rise despite escalation to tier-3 therapies in the intensive care unit. After a protracted ICU course and in light of a very poor neurological prognosis, treatment withdrawal was determined to be in the patient's best interest, in accordance with her previously expressed wishes, family expectations, and clinical judgement. A controlled donation after circulatory death (cDCD) protocol was therefore initiated. Transesophageal echocardiography was utilized to confirm the correct placement of guidewire and aortic balloon occlusion (clip 2-A and 2-B), to ensure appropriate positioning of the drainage cannula tip in the inferior vena cava, and to verify effective regional perfusion during normothermic regional perfusion (NRP).

Where can transesophageal echocardiography be applied in the perioperative and critical care settings?

Operating room

Transesophageal echocardiography (TEE) was initially introduced in the operating room to facilitate immediate assessment of outcomes following cardiac surgery [51]. By the early 1990 s, its role evolved to include intraoperative monitoring of hemodynamic status in patients experiencing post-cardiotomy shock, primarily to guide fluid management and inotropic support [52]. The establishment of perioperative TEE practice guidelines in 1996 prompted several cardiovascular societies to implement structured international training programs—with the first program incorporating TEE assessment launched in 1998—rapidly becoming the global standard of care [53]. In 1997, the first study evaluating TEE's diagnostic accuracy during cardiac arrest was conducted in the Netherlands [54]. TEE was performed in 48 patients with prolonged circulatory arrest, with findings compared to diagnoses confirmed via autopsy, surgical exploration, or clinical follow-up. The study demonstrated a sensitivity of 93%, a specificity of 50%, and a positive predictive value of 87%. Importantly, TEE provided clinically significant therapeutic insights in 15 patients (31%), facilitating identification of the underlying etiology of cardiac arrest during cardiopulmonary resuscitation. Subsequent studies further underscored TEE's utility in non-cardiac surgery. Lin et al. [55] reviewed 125,965 procedures over 6 years, identifying ten cases of unexpected intraoperative cardiac arrest [55]. Causes included myocardial infarction (five cases), pulmonary embolism (two), severe hypovolemia (two), and one indeterminate case; seven patients survived. The authors concluded that TEE is valuable in non-cardiac surgery for promptly identifying or excluding pulmonary embolism and guiding interventions in intraoperative myocardial infarction. Similarly, Memtsoudis et al. [56] reported 22 patients experiencing sudden hemodynamic collapse during non-cardiac surgery, all of whom underwent intraoperative TEE [56]. A presumptive diagnosis was established in 19 cases, with eight patients requiring emergent interventions for thromboembolic events, acute myocardial ischemia, or pericardial tamponade. Garvin et al. [57] further documented TEE's use in orthopedic procedures, demonstrating its role in diagnosing intraoperative pulmonary embolism and managing hemodynamic instability in patients with severe aortic stenosis [57]. Based on this evidence, the American Society of Anesthesiologists and the Society of Cardiovascular Anesthesiologists classified "acute, life-threatening intraoperative hemodynamic collapse" as a class I indication for TEE [53, 58]. Although recent guidelines from the European Society of Anaesthesiology and Intensive Care and the European Society for Trauma and Emergency Surgery do not specifically address TEE use during intraoperative cardiac arrest [59], they recognize its potential to identify the cause of arrest and guide resuscitation and subsequent management. Despite the absence of studies directly evaluating survival outcomes, clinical judgment supports TEE use in all cases of intraoperative cardiac arrest, barring contraindications [60, 61].

Intensive care unit and emergency department

Since the early 2000 s, transesophageal echocardiography (TEE) has been primarily used in intensive care units for patients with suspected endocarditis [62]. Its application has gradually expanded to include critically unstable patients, such as those who require differentiation between cardiogenic and septic shock in intubated individuals. In this context, one notable advantage of TEE is its ability to provide hemodynamic calculations of cardiac output, such as through the measurement of left ventricular outflow tract velocity time integral (LVOT VTI).

According to the 2009 consensus statement of the American College of Chest Physicians and La Société de Réanimation de Langue Française, ultrasound applications in critical care are categorized, and the required competencies are defined. The panel distinguished between general critical care ultrasound and critical care echocardiography (CCE). General critical care ultrasound focuses on thoracic, abdominal, and vascular assessments, whereas CCE is stratified into basic and advanced levels. Advanced CCE involves a comprehensive hemodynamic evaluation, including quantitative assessment of cardiovascular function, which may incorporate TEE. In the context of cardiac arrest as reported in Table 1, the retrocardiac positioning of TEE provides an optimal acoustic window, overcoming many limitations of TTE and enabling continuous, high-quality imaging [63].

Prehospital emergency medical services

With advancements in technology and wider availability of scientific tools, commercially available single-use miniaturized TEE probes are emerging as valuable resources in ICUs, EDs, and prehospital emergency medical services (EMS). A single-use TEE probe, designed for indwelling use up to 72 h with a diameter of 5.5 mm, may be particularly advantageous for monitoring the hemodynamics of ventilated patients during cardiac arrest, especially in out-of-hospital settings [64]. This device offers single-plane, two-dimensional imaging with color-Doppler capability (IMACOR™, New York, NY, USA) and allows both anteflexion and retroflexion of the tip.

A multicenter pilot study demonstrated that this single-use miniaturized TEE probe was easy to insert, well tolerated over several days, and effective in guiding therapeutic management of ventilated patients experiencing cardiopulmonary compromise [64]. Regarding out-of-hospital cardiac arrest, the first documented case demonstrating successful TEE deployment and clinical utility in this setting has recently been published [65]. The only established indication for out-of-hospital TEE is ongoing CPR with intubation during cardiac arrest, whether or not extracorporeal CPR (ECPR) is intended.

Although technological limitations remain, such as the need for a compact display, it is the training and proficiency of physicians which constitute the primary challenge. In institutions utilizing TEE for out-of-hospital cardiac arrest, physicians underwent 5 h of training comprising didactic lectures and simulator practice [66]. Notably, all physicians were already credentialed in TTE [38, 67, 68]. Based on these developments, it is reasonable to anticipate an increased adoption of TEE in the coming years.

The availability of a TEE probe at the site of cardiac arrest can be challenging. In practice, two scenarios are likely: (1) TEE is readily accessible, such as in the operating room, ICU, or a well-equipped ED; (2) TEE is not immediately available, such as prehospital setting. To address the latter, implementing a local protocol with a systematic approach for TEE use during cardiac arrest and emergency resuscitation could significantly enhance patient care, whereas failure to do so may be considered suboptimal practice.

Case Vignette 3

A 56-year-old male was admitted to the emergency department (ED) following a motorcycle collision. On arrival, he was alert with a Glasgow coma scale (GCS) score of 15 and reported severe pain in his left leg, rated 8/10 on the numeric rating scale (NRS), which was initially managed with 0.1 mg of intravenous fentanyl. He exhibited no signs of respiratory distress, and his vital parameters were stable, with a blood pressure of

Table 1 Phenotypization of cardiac arrest in the emergency room

	Cardiac arrest presentation according to the first rhythm assessment classification				
Means of evaluation	**Asystole**	**PEA**		**pVT**	**VF**
Digital evaluation of carotid pulse	Absent	Absent		Absent	Absent
EKG rhythm	Asystole	Any other rhythm		VT	VF
Wall motion on cardiac US	Rarely	Absent (i.e., true PEA, true EMD, PRES)	Present (i.e., pseudo PEA, pseudo EMD, PREM)	Present	Possible (muscle fibrillation)
Pulsatility detection by A-line[a]	Absent	Absent	Likely	Possible	Absent
Indirect blood flow detection by E_TCO_2 [a]	Absent	Absent	Likely	Possible	Absent
Pulsatility detection by carotid US[a]	Absent	Absent	Likely	Possible	Absent
Amenable to DC shock treatment	No	No		Yes	Yes

PEA pulseless electrical activity, *pVT* pulseless ventricular tachycardia, *VT* ventricular tachycardia, *VF* ventricular fibrillation, *EMD* electromechanical dissociation, *PREM* pulseless with a Rhythm with Echocardiographic Motion, *PRES* pulseless with a Rhythm with Echocardiographic Standstill

[a] Assessed during pauses for rhythm check

120/80 mmHg and a heart rate of 100 bpm. Laboratory investigations demonstrated a normal hemoglobin level of 14 g/dL. A total-body CT scan was performed revealing a left lung contusion and a type I splenic lesion. The patient was subsequently taken to the operating room for surgical stabilization of a femoral fracture. Following induction of general anesthesia, he experienced a sudden cardiac arrest. Continuous electrocardiographic monitoring demonstrated organized electrical activity, while the invasive arterial line revealed absent blood pressure, indicating pulseless electrical activity (PEA). Immediate resuscitative measures were initiated with intravenous fluids. Simultaneously, a second anesthesiology consultant prepared the echocardiography equipment and requested insertion of a TEE probe. Initial four-chamber views at 0° demonstrated a small, inwardly collapsed left ventricle, yet with preserved rhythmic contraction (clip 3-A). Subsequent trans-gastric imaging at approximately 89° revealed complete collapse of the inferior vena cava and a new accumulation of free intraperitoneal fluid (clip 3-B). The surgical team was promptly alerted, and the patient underwent emergency laparotomy, which confirmed active splenic bleeding. A splenectomy was performed during the same procedure, effectively addressing the source of hemorrhage.

When is TEE appropriate in the perioperative and critical care settings?

Transthoracic echocardiography (TTE) remains the first-line imaging modality for patients experiencing cardiac arrest, primarily because the majority of cardiologists, emergency physicians, intensivists, and anesthesiologists are trained in its use [69]. Nevertheless, TTE is not the sole useful ultrasound tool in this context; lung ultrasound (LUS), abdominal ultrasound, and venous compressive ultrasound may also provide critical diagnostic information [70]. Consistent with recommendations from multiple expert groups, we suggest performing a LUS examination to exclude pneumothorax as a cause of cardiac arrest prior to TEE probe insertion. There are specific clinical scenarios in which TTE may be preferable, thereby limiting TEE application. For instance, TTE is particularly advantageous for the diagnosis of pericardial tamponade during cardiac arrest, as it enables detection of pericardial effusions and guides timely therapeutic interventions [71]. The clinical impact of TTE in conditions such as pericardial tamponade and tension pneumothorax is well documented. In a cohort of 793 patients, 34 were found to have pericardial effusions; of these, 13 underwent ultrasound-guided pericardiocentesis, achieving a hospital discharge survival rate of 15.4%, compared to 1.3% among those who did not receive the intervention [72]. During percutaneous drainage, TTE facilitates direct visualization of the needle entering the pericardial space using a standard Seldinger technique, allowing precise guidewire placement. The subcostal and apical four-chamber views are most commonly employed for this purpose [73, 74].

The safety of TEE during CPR is a critical consideration. Blaivas' seminal article in 2008 highlighted this issue [5]. Notably, the three major manufacturers—Philips™, GE Healthcare™, and Sonosite™—have not formally evaluated the electrical safety of their TEE systems during defibrillation [75]. Consequently, current recommendations advise against performing defibrillation while the probe is in situ, due to potential risk to both patient and operator. Despite this, evidence from human studies is limited, and no recent publications specifically address this concern. Krulewitz et al. conducted an experimental study using an animal model (eight pigs) to evaluate TEE safety during CPR and defibrillation [76]. Multiple 200-J defibrillation attempts were performed with the probe positioned in the mid-esophageal region, followed by post-mortem examination of the esophagi. No hematomas, thermal injuries, or perforations were observed. Concerns regarding thermal injury from probe heating or mechanical damage from chest compressions—whether manual or mechanical—have not been documented. Although the hypothetical risk of probe breakage exists, no data on actual device failures are publicly available.

To mitigate potential risks during defibrillation, we recommend retracting the probe approximately 20 cm before each shock and reinserting it immediately afterward. These findings underscore the need for further investigation into the safe integration of TEE into CPR protocols.

Finally, the introduction of TEE into resuscitation practices may encounter barriers related to familiarity and team culture. Advanced life support (ALS) guidelines emphasize minimizing interruptions in chest compressions, and decades of training in basic and advanced life support have established standardized approaches to CPR. Innovations such as TEE, however, offer the potential for "personalized CPR," aiming to optimize hemodynamic support and improve both survival and neurological outcomes. Successful integration of TEE requires adequate team training, protocol development, and institutional support to ensure that its use enhances, rather than disrupts, patient care.

Case Vignette 4

An 88-year-old man was transferred from the catheterization laboratory to the cardiac sub-intensive care unit following pacemaker implantation for atrial fibrillation with pathological pauses. Approximately 20 min after transfer, he developed sudden bradycardia and hypotension, resulting in loss of consciousness. The medical emergency team (MET) was promptly activated. Cardiac monitoring showed a paced rhythm at 68 beats per minute; however, both carotid and femoral pulses were absent, prompting immediate initiation of CPR. A transthoracic echocardiogram (TTE) performed via the subcostal view revealed the presence of pericardial effusion (clip 4-A). Under dynamic TTE guidance (4-B and 4-C), pericardiocentesis was successfully performed using a standard pericardiocentesis kit, leading to hemodynamic stabilization.

Discussion

The present review highlights both the considerable potential and the current limitations of transesophageal echocardiography (TEE) during cardiac arrest. Evidence to date largely stems from feasibility studies, small observational cohorts, and expert consensus statements rather than randomized controlled trials. While these studies consistently demonstrate that TEE provides superior image quality during chest compressions, enhances rhythm interpretation, and frequently alters clinical management, the strength of the supporting evidence remains low to moderate. To date, no study has shown a direct improvement in survival or neurological outcomes attributable to TEE-guided resuscitation.

Safety concerns, particularly regarding defibrillation with the probe in situ, may persist despite reassuring preclinical data. Operator training and equipment availability remain the main barriers to widespread implementation. Structured simulation-based curricula and simplified "POCUS-TEE" protocols may facilitate broader adoption among emergency physicians and intensivists, while incorporation of TEE into extracorporeal CPR (ECPR) and organ-donation workflows could enhance procedural efficiency and patient selection.

Future research should move beyond feasibility toward outcome-based and comparative studies, ideally using multicenter designs to assess whether TEE-guided resuscitation improves clinically meaningful endpoints such as ROSC, survival to discharge, and neurological recovery. Additionally, cost-effectiveness analyses and integration with other point-of-care ultrasound modalities (cardiac, lung, and vascular) should be explored to define TEE's role in advanced life support algorithms.

Limitations

We acknowledge that implementing transesophageal echocardiography (TEE) during resuscitation poses several practical challenges. Not all hospitals or emergency medical services (EMS) have immediate access to TEE equipment. Additionally, inserting a probe into a patient while active CPR is being performed can be logistically challenging.

It is important to recognize the real-world constraints that may arise, such as the limited availability of equipment, the requirement for the patient to be intubated for probe insertion, and the complications associated with inserting the probe during active chest compressions. Furthermore, it is crucial to emphasize that TEE in cases of cardiac arrest should only be performed by adequately trained personnel.

Conclusions

Transesophageal echocardiography (TEE) represents a significant advancement in the management of patients experiencing cardiac arrest across all intensive care settings. Its effectiveness is closely linked to local programs aimed at improving the quality of cardiopulmonary resuscitation and to the progressive proficiency of operators in resuscitative techniques. In the near future, the use of TEE is expected to expand in specialized centers, particularly those focusing on ECMO, ECPR, and DCD, as these areas share a foundational set of skills and knowledge that align with both patient resuscitation and organ donation. This anticipated growth, however, introduces several challenges. These include ensuring the safety of TEE during defibrillation, establishing local protocols for TEE initiation when the probe is not immediately available, and fostering awareness and training among healthcare personnel for this novel approach.

Furthermore, the development of smaller and more portable TEE probes could prove beneficial for out-of-hospital cardiac arrests, potentially mitigating logistical challenges and improving the currently low survival rates.

In summary, transesophageal echocardiography represents an emerging but still underutilized tool in cardiac arrest management. Its capacity for continuous high-quality imaging, procedural guidance, and rapid etiologic diagnosis is well established. However, its impact on patient-centered outcomes remains to be proven. Wider implementation will depend on validated training pathways, institutional support, and further prospective studies addressing safety, logistics, and cost-effectiveness.

Abbreviations

TEE	Transesophageal echocardiography
TTE	Transthoracic echocardiography
ED	Emergency departments
ICU	Intensive care unit
CPR	Cardiopulmonary resuscitation
LVOT	Left ventricular outflow tract
ECPR	Extracorporeal CPR
ECMO	Extracorporeal membrane oxygenation
NRP	Normothermic regional perfusion
EPS	Emergency physicians
OHCA	Out-of-hospital cardiac arrest

PEA	Pulseless electrical activity
PEEP	Positive end expiratory pressure
ALS	Advanced life support
ROSC	Return of spontaneous circulation
ICP	Intracranial pressure
cDCD	Controlled donation after circulatory death
LUS	Lung ultrasound

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Looking back to the 2000s, I (LV) recall a conversation with my first boss about the use of a TEE during a cardiac arrest. His advice, "If you don't understand what is happening, use a TEE probe to gain a clearer insight into what the patient is telling you," underscored the importance of understanding the patient's condition. This advice, in memory of Francesco Giordano, has since been a cornerstone in my practice, reinforcing the value of TEE in providing crucial information.

Authors' contributions
LV conceived the study, performed literature research, drafted the manuscript. CD gave important intellectual content, performed literature research, drafted the manuscript. EB performed literature research, drafted the manuscript. DGB performed literature research, drafted the manuscript. SS performed literature research, drafted the manuscript. FB performed literature research, drafted the manuscript. CF performed literature research, drafted the manuscript. YM performed literature research, drafted the manuscript. SC performed literature research, drafted the manuscript. MZ gave important intellectual content, performed literature research, drafted the manuscript. EGB gave important intellectual content, performed literature research, drafted the manuscript. SR gave important intellectual content, performed literature research, drafted the manuscript. All authors reviewed the manuscript.

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