

Emergency Department Resuscitative Thoracotomy: A comprehensive literature review on the current methods of instruction for this complex, life-saving procedure.

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ABSTRACT:

The emergency department resuscitative thoracotomy (EDRT) is an emergent, invasive, and life-saving procedure that is performed in rare instances on patients who have suffered major thoracic trauma and have lost a pulse. The inclusion and exclusion criteria for this emergent procedure have long been contested as medical professionals seek to improve the historically low rates of survival associated with this procedure. Given the narrow scope in which this procedure is indicated, many emergency medicine physicians will perform few, if any, throughout their careers. This promotes concern that emergency medicine residents, who will learn this procedure through traditional teaching methods alone, may not be provided with adequate hands-on opportunities to master the skills necessary to successfully perform this procedure, thus necessitating a standardized training method. This review aims to analyze this procedure and the methods in which it is taught to investigate whether current teaching modalities adequately prepare physicians to perform this procedure.

Keywords: Emergency department resuscitative thoracotomy, penetrating thoracic trauma, blunt trauma, cardiac tamponade, cardiac arrest, residency procedural curriculum, simulation training, emergency medicine

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Introduction:

The thoracotomy is a surgical procedure in which an incision is made in the lateral chest wall to gain access to the heart, lungs, esophagus, aorta, and vasculature (Minervini, 2022). The thoracotomy technique may be used in elective thoracic surgeries such as lobectomies or when a laparoscopic approach is not possible. Additionally, this procedure may be indicated outside of the operating room in cases of traumatic resuscitation (Weare & Gnugnoli, 2023). The most common indication for this procedure is cardiac arrest in the setting of penetrating trauma to the chest. However, it can also be considered appropriate in select blunt trauma cases (Groombridge et al., 2021). This procedure allows the attending physician access to the chest to relieve cardiac tamponade, repair damage to the great vessels or ventricles, perform open cardiac massage, and other life-saving measures. This dramatic and highly invasive procedure is only performed in select cases with the intention of rapid intervention to save a patient's life.

While the emergency department resuscitative thoracotomy (EDRT) is an infrequent procedure, when immediate intervention is needed, a well-trained physician is paramount. Unfortunately, despite the current training standards, this procedure has historically yielded low patient survival rates, prompting many to ask why and what can be done to improve patient outcomes. A narrative review performed by Aseni et al. in 2020 reviewed 7236 patient cases between 1975 and 2020 in which an EDRT was performed. Of those cases, the study reported that only 7.8% of patients survived post-procedure. While there is some variation in the reported survival rate across studies with different inclusion criteria, survival rates for this procedure are still relatively low. Panossian et al.'s 2020 study reported a survival rate of 19.9% of 2012

patients who underwent an EDRT and noted that those patients who suffered penetrating trauma were more likely to survive than those who suffered blunt trauma. It should be noted that the patients typically receiving a resuscitative thoracotomy are already poised to have a poor outcome, given that they have no pulse in the setting of significant trauma.

These low survival rates prompt whether the current teaching modalities for EDRT are sufficient and if more effective training solutions are available (Ricard et al., 2023). Therefore, the objective of this study is to examine the current literature regarding the methods used to teach emergency medicine residents the EDRT, how these methods may or may not have changed in recent years, and what the impact of EDRT education methods has been on patient survival rates. Additionally, this review seeks to compare the traditional teaching methods with teaching emergency medicine physicians mastery-level curriculums that include simulation training as it impacts procedural competency and patient survival. The discussed findings may necessitate further development of an alternate, low-cost simulation model and competency assessment following training with a model compared to the industry standard.

Indications for EDRT:

Before performing an EDRT, physicians must assess the patient's condition quickly but thoroughly to determine whether the procedure is indicated. Weare and Gnugnoli's 2023 publication on the Emergency Room Thoracotomy identified the following as indications for this procedure: penetrating cardiac trauma, cardiac tamponade demonstrated on a FAST exam or in the setting of penetrating cardiac trauma, the absence of a pulse but undergoing CPR for less than 15 minutes following the traumatic thoracic injury, or a case of blunt thoracic trauma without other mortal injuries present and present signs of life (SOL). Additionally, this publication identified that the risk for unfavorable outcomes is notably increased when the

patient is less than 14 or over 57 years old, so an ideal candidate should fall within that age range. However, this set of inclusion criteria is not universally accepted. Given the historically low success rates of the EDRT, inclusion criteria for this procedure have long been debated, as multiple factors contribute to the outcome of this procedure, consequently leading to differences in policy and opinion among medical professionals.

The variable that has perhaps caused the most significant source of contention regarding the indication of the EDRT is the primary mechanism of injury experienced by the patient. In the case of penetrating trauma to the thoracic cavity, the EDRT has been noted to yield the highest success rate with stab wounds (16.8%), gunshot wounds (4.3%), compared to blunt trauma (1.4%) (Rhee et al., 2000). Consequently, blunt trauma is often listed as a contraindication for the procedure and is contested in many reviews, such as in the 2015 study performed by Seamon et al. This study further explored the conditions that should be met for a successful emergency department thoracotomy (EDT) outcome. It concluded that EDT is strongly indicated in the cases of penetrating trauma with the absence of a pulse but present signs of life (SOL). However, this study conditionally recommended against EDT when a pulse and lack were absent of SOL in the case of blunt trauma (Seamon et al., 2015). Panossian et al.'s (2020) study agreed with this stance, noting that of the 2012 patients included in their study, none who presented with blunt trauma and absent SOL survived. This is different from other studies which did conditionally recommend the emergency resuscitative thoracotomy in the setting of cardiac arrest following blunt thoracic injury (Sengalini et al., 2018; Groombridge et al., 2021; Slessor & Hunter, 2015). While this is not the focus of this review, it is essential to understand the statistical evidence of outcomes related to different inclusion criteria.

Contraindications for EDRT:

Compared to the inclusion criteria, the exclusion criteria for this procedure are broad, with several conditions yielding contraindications to performing the EDRT. However, this, too, is contested for the same reasons listed in the above section. Generally, however, most research seems to agree that the EDRT is not indicated in the case of a patient who lacks SOL (as in asystole without pericardial tamponade), has not had a pulse for greater than 15 minutes, or has other catastrophic injuries present that are incompatible with life (Weare & Gnugnoli, 2023; Panossian et al., 2020; Elhadj et al., 2020). In addition, the National Trauma Data Bank states that there is nearly 100% mortality when performed on patients >57, regardless of the mechanism (Gil et al., 2018). Several relative contraindications are widely discussed across the literature, including (but not limited to) the presence of any vital signs, severe head trauma, or a setting where an operating room and surgeon are not immediately available (Weare & Gnugnoli, 2023; Groombridge et al., 2021; Segalini et al., 2019).

METHODS

A systematic search was conducted through various electronic journals and databases to collect relevant literature on the above objective. Given how medicine changes and adapts, we elected to include articles published within the last ten years (2013 - 2023). The following electronic databases were utilized: PubMed, Google Scholar, Science Direct, Wiley Online Library, and SCOPUS. Search terms used for this literature review include the following: “Emergency Department Resuscitative Thoracotomy” OR “Emergency Thoracotomy” OR “Thoracotomy” AND “training,” OR “curriculum,” OR “education,” OR “residency,” OR “success,” OR “survival,” OR “indications,” OR “contraindications,” OR “simulation training,” OR “curriculum,” OR “penetrating trauma,” OR “blunt trauma” OR “tamponade.”

REVIEW OF THE LITERATURE

Traditional Teaching Methods:

Despite the disagreements in the medical community about the inclusion criteria for this procedure, it can be noted that the indications for this procedure are incredibly narrow. Thus, the procedure is considered to have a high acuity low occurrence (HALO) (Ricard et al., 2023). Given the infrequency of this procedure in the clinical setting and the extremely high stakes associated with it, there has been a push to identify the best way to prepare emergency medicine residents to perform this procedure effectively and efficiently in the rare instance that it is indicated (Bilello et al., 2021). Currently, most residents learn the EDRT through verbal presentation, PowerPoints, computer models, cadavers, and animal models— but without a standardized, competency-based curriculum where procedural competency is not assessed. Thus, there is concern that emergency medicine residents are not currently provided with enough training and experience to effectively perform this rare, high-stakes procedure, which may be a contributing factor to success rates (Miller et al., 2020; Clifford et al., 2023; O’Connell et al., 2020; Ricard et al., 2023).

A study by Fitzgerald et al. 2020 evaluated the impact of a formal institutional resuscitative thoracotomy program on patient survival rates and whether such a program would improve patient outcomes. The retrospective cohort study evaluated 12,399 primary trauma patients between 2009 and 2017, of which 7,657 suffered significant thoracic trauma. The formal training program instituted the credentialing required to perform the resuscitative thoracotomy procedure. To become credentialed physicians, they underwent a training program involving pre-reading a 17-page teaching manual, a 40-minute didactic lecture, and a two-hour surgical skills

station using anesthetized pigs. (Fitzgerald et al., 2010) It was concluded that the formal training program achieved a survival rate of 25%, which is markedly higher than the 7.8% survival rate reported by Aseni et al. (2020). These results pose the question: Do current training protocols properly prepare emergency department physicians to perform this life-saving procedure? If not, could the current method of teaching negatively impact patient outcomes?

Simulation:

The idea of clinical simulation for mimicking “real world” clinical settings has become a popular way to immerse learners in an environment where they can obtain the technical skills needed to perform complex procedures. Simulation-based medical education (SBME) is defined as any educational activity that utilizes simulation techniques like computerized mannequins, cadavers, virtual reality, and many other modalities to replicate a clinical scenario (Bohnen et al., 2018; Petrosoniak et al., 2017; Aebersold, 2018; Villanueva et al., 2019). Simulation training in conjunction with high-complexity, routine procedural training for HALO procedures has been associated with increased efficiency and efficacy (Park et al., 2019). This leads to the opinion that simulation training should be a central aspect of medical student education. It better prepares students for complex or high-stakes procedures without creating unnecessary risk for actual patients (Ji Hye et al., 2021). Various studies have demonstrated the benefits of simulation training across various procedures, including a few recent studies that specifically focused on the EDRT. Yates et al. (2018) utilized 3D-printed materials to simulate the emergency department thoracotomy. They found that repeated use of simulation materials can increase physician comfort in performing the EDRT and other invasive procedures. A similar study by Benjamin et al. (2019) used a modified department store mannequin to create a cost-effective simulation

model for residents to practice EDRT. Using this simulation model improved physician confidence and provided an effective method to practice the procedure. Beyond the rudimentary models, high-fidelity simulation models commercially available for the EDRT include features such as a synthetic beating heart. Studies on these models, too, demonstrated an improvement in confidence when performing this procedure (Bohnen et al., 2018). Despite the benefits demonstrated using simulation models for the EDRT, there is still paucity in much of the literature as to whether or not exposure to procedures via simulation models translates into success in real clinical scenarios, given the lack of a standardized curriculum (Binstadt et al., 2019).

A 2020 study by Miller et al., published in the *Western Journal of Emergency Medicine*, sought to evaluate whether a mastery learning curriculum using simulation models would positively impact procedural competency with the EDRT. The researchers created a curriculum using the Mastery Angoff approach, which included baseline testing, educational videos, hands-on instruction, and deliberate practice using a simulation trainer to test whether procedural competency could be met and improved with a mastery learning framework. Baseline testing prior to instruction from the researcher's proposed curriculum revealed a 0% pass rate, demonstrating that the traditional methods of teaching this life-saving procedure are, in fact, insufficient in producing procedural competency when evaluated against a standardized mastery level curriculum. This was a significant finding, given the historically low reported survival rates of this procedure, and suggested that procedural competency and preparation may be a contributing factor to poor EDRT outcomes, among many other variables (Miller et al., 2020; O'Connell et al., 2020; Ricard et al., 2023). The residents who participated in the Miller et al. study were scored before and after instruction with the proposed curriculum based on a 22-item

checklist of the required steps to complete the procedure successfully. The study concluded that residents could successfully perform the procedure with greater efficiency using the simulation-based mastery learning curriculum, thus demonstrating the need to improve the current teaching methods for this procedure (Miller et al., 2020).

Drawbacks:

While simulation-based learning has been recognized as a beneficial form of instruction, especially for HALO procedures such as the EDRT, regular implementation into residency programs is only sometimes feasible regarding budgetary decisions. Many programs are not prepared to front the exorbitant cost of the high-fidelity models that are commercially available despite the benefits that they have in procedural training (O’Connell et al., 2020). Furthermore, these high-fidelity models often come with additional price tags, as they have replaceable parts that require frequent changing. A few low-fidelity models have been created and studied as cost-effective alternatives, but these are not widely available. With regards to animal models, “Cadaveric or porcine models have been explored for establishing proficiency; however, the expense of the models and the need for repetitive deliberate practice to ensure competency have made these modalities cost-prohibitive for education on a widespread basis” (Miller et al., 2020, p. 1259). In summary, there is demonstrated benefit to simulation and model-based training, but many programs cannot financially afford routine use of the commercially available models.

CONCLUSION:

Review of the literature shows that there is not currently a standardized and consensus curriculum to teach the high-fidelity, low-occurrence emergency department resuscitative thoracotomy which leads to the concern that physicians are inadequately prepared to perform this rare, live-saving procedure. Several studies have been performed that demonstrate the benefits of using models and simulation in addition to standard classroom modalities. Consequently, several specialties utilize simulation in their curriculum to teach complex surgical procedures and trauma resuscitation (McLaughlin et al., 2019; Klein et al., 2023; Park et al., 2019; Meshkinfamfard et al., 2021). Currently, there are a few select models available on the market to teach the resuscitative thoracotomy, however these models often accrue exorbitant costs and are difficult to reuse (O'Connell et al., 2020). Given these findings, procedural competency could likely be improved with the use of a mastery-level curriculum in conjunction with a cost-effective, commercially available simulation model.

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