



## Evidence-Based EMS

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# Prehospital Resuscitative Thoracotomy: The Next Step in Improving Trauma Outcomes?

With victims of penetrating trauma, there could be value in bringing the practice to the field

**Y**ou are an EMS physician on patrol during an unseasonably warm spring night when you get an echo call about a gunshot wound patient. Fortunately you are located near the call and arrive just as the police secure the scene.

The patient is quickly brought to you and your EMS crew. You jump into ED trauma mode as your crew takes vitals and prepares for treatment. The airway is clear as the patient moans when you shake him; breath sounds are decreased at the right lung base, and you notice a small hole on the right midaxillary area of the man's chest. His pulses are weak and thready.

You assess a GCS of 11 due to eye opening to pain, confusion and localization of pain. The EMS supervisor calls out the vitals as heart rate 122, blood pressure 76/42, respiratory rate 25 and pulse ox 88%.

There is a rush of air as you needle-decompress the right side of the man's chest. He is loaded into the ambulance, and you begin to leave the scene with the paramedic crew. Hoping you improved his frightening vitals, you quickly recycle them: HR 125, BP 70/38, RR 20, SpO<sub>2</sub> 98%. As his mental status and vital signs continue to decline, you and your paramedic colleagues know he has a high probability of needing an urgent thoracotomy if decompensation continues.

As the patient's carotid pulse becomes weaker and threadier, you hope he arrives at the hospital in time for definitive intervention. And you think, *As an EMS*

*physician on scene, could I help save this patient's life by performing a prehospital thoracotomy?*

## Background

In the United States, trauma is the leading cause of death between the ages of 1–46 and the third-leading cause of death overall.<sup>1</sup> It accounts for 30% of all life-years lost in the U.S.<sup>2</sup> Traumatic injuries can be further subdivided into blunt and penetrating trauma. Urban and rural settings differ significantly in their mechanisms of trauma, with rural locations having almost exclusively blunt trauma and urban centers seeing a much higher incidence of penetrating trauma compared to rural settings.<sup>3,4</sup>

Penetrating thoracic trauma, primarily from knives and firearms, is a common mechanism for cardiac injury. Overall 10% of firearm deaths may be attributed to cardiac injury. As can be expected, cardiac injury is frequently fatal, and most patients do not survive long enough to reach a hospital.<sup>5</sup> For patients with traumatic cardiac arrest who reach the emergency department, resuscitative thoracotomy is a maneuver that can save some who otherwise would not be successfully resuscitated. But is there more we could be doing to increase survival in these patients?

Emergency resuscitative thoracotomy can relieve cardiac tamponade, repair or temporize defects in the heart, temporize pulmonary hemorrhage and cross-clamp the aorta to improve blood flow to the brain



## OBJECTIVES

- » Describe the evidence for the utility of thoracotomies
- » Discuss the pre-hospital logistics of performing a thoracotomy
- » Identify how emergency resuscitative thoracotomy could be implemented into EMS trauma protocols

## EMSWORLD® CE

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*Ed's Note: This month's CE activity focuses on research in cardiac care. Assessment will be based on this article and the article on page 32.*

and heart while decreasing abdominal and lower-extremity hemorrhage.<sup>6,7</sup>

## Evidence for the Utility of Thoracotomies

The first successful thoracotomy reported in medical literature was performed in 1902 on the kitchen table of a physician in Alabama.<sup>8</sup> It wasn't until 1966 that the first paper was published advocating for thoracotomies to be performed in the emergency department.<sup>9</sup> Since this time emergency thoracotomies have become an accepted part of the traumatic arrest or periarrest algorithm in certain patients. In fact, there are many different published algorithms and recommendations for ED thoracotomy.

The 2013 ATLS guidelines include the following indications and contraindications for resuscitative thoracotomy: Indications include evacuation of blood causing pericardial tamponade, direct control of exsanguinating intrathoracic hemorrhage, open cardiac massage and cross-clamping of the descending aorta to slow blood loss below the diaphragm and improve blood flow to the brain and heart. Contraindications include no signs of life (SOL) on arrival, severe traumatic brain injury or a most likely extrathoracic cause of circulatory collapse.<sup>6</sup>

The Eastern Association for the Surgery of Trauma published recommendations for ED thoracotomy in 2015. It strongly recommends thoracotomy for patients who present pulseless but with SOL after penetrating thoracic injury. It conditionally recommends thoracotomy for patients who present pulseless with absent SOL after penetrating thoracic trauma, pulseless with and without SOL after penetrating extrathoracic trauma, and pulseless with SOL after blunt injury. It conditionally recommends against thoracotomy for pulseless patients without SOL after blunt injury.<sup>10</sup>

The Western Trauma Association published an decision algorithm for ED thoracotomy in 2012 that recommends it for trauma patients who meet the following criteria:

» Profound refractory shock including SBP less than 60 or undergoing CPR with SOL;

» Penetrating trauma patients with no SOL and CPR time less than 15 minutes;

» Blunt trauma patients with no SOL and CPR time less than 10 minutes.<sup>11</sup>

Additionally, a trauma and vascular surgeon in the U.K. named Karim Brohi, who also worked with helicopter EMS in London, set up a website called Trauma.org to make trauma education resources publicly available worldwide.<sup>12</sup> He published a set of indications for ED thoracotomy in 2001 that recommended the following:

*Accepted indications include penetrating thoracic injury with unresponsive hypotension (BP less than 70) or arrest with previously witnessed cardiac activity; blunt thoracic injury with unresponsive hypotension or rapid exsanguination from chest tube (greater than 1,500 mL). Relative indications include penetrating thoracic injury and arrest without previously witnessed*

*cardiac activity, and penetrating nonthoracic or blunt thoracic injury and arrest with previously witnessed cardiac activity. Contraindications include blunt thoracic injury with no witnessed cardiac activity, multiple blunt trauma and severe head injury.<sup>7</sup>*

The above indications are summarized in *Table 1*.

Literature on emergency thoracotomies performed in trauma patients quotes an overall survival rate between 7% and 27%.<sup>1,13-20</sup> The wide variability of reported survival rates in these studies can partially be attributed to the varied locations of "emergency" thoracotomies (ED vs. OR) and the varied definitions of survival. Further, locations with physicians integrated into EMS systems (U.K. and Europe)

**TABLE 1: INDICATIONS AND CONTRAINDICATIONS FOR THORACOTOMY**

Indications
Pericardial tamponade <sup>a</sup>
Exsanguinating intrathoracic hemorrhage <sup>a</sup>
Open cardiac massage <sup>a</sup>
Aortic cross-clamping for exsanguination below the diaphragm <sup>a</sup>
Pulseless with SOL after penetrating thoracic trauma <sup>b</sup>
Traumatic injury and profound refractory shock/unresponsive hypotension <sup>c,d</sup>
Pulseless with SOL after traumatic injury <sup>c</sup>
Penetrating trauma and no SOL with CPR < 15 mins. <sup>c</sup>
Blunt trauma and no SOL with CPR < 10 mins. <sup>c</sup>
Penetrating traumatic arrest with previously witnessed cardiac activity <sup>d</sup>
Blunt trauma with rapid exsanguination from chest tube <sup>d</sup>
Relative Indications
Pulseless with no SOL after penetrating thoracic trauma <sup>b</sup>
Pulseless with penetrating extrathoracic trauma (with or without SOL) <sup>b</sup>
Pulseless with SOL after blunt trauma <sup>b</sup>
Penetrating thoracic trauma and no previously witnessed cardiac activity <sup>d</sup>
Penetrating nonthoracic trauma and previously witnessed cardiac activity <sup>d</sup>
Blunt thoracic trauma and previously witnessed cardiac activity <sup>d</sup>
Relative Contraindications
Pulseless without SOL after blunt trauma <sup>b</sup>
Contraindications
No SOL <sup>a</sup>
Severe head injury/TBI <sup>a,d</sup>
Extrathoracic cause of circulatory collapse <sup>a</sup>
Blunt thoracic trauma and no previously witnessed cardiac activity <sup>d</sup>
Multiple blunt trauma <sup>d</sup>

a—ATLS, b—Eastern Association for the Surgery of Trauma, c—Western Trauma Association, d—Trauma.org

report higher survival rates. Some studies reported survival to hospital discharge of 2.6%–4.5%<sup>19,21</sup> and neurologically intact survival of 2.2%–12.8%.<sup>1,14,17,19</sup> Penetrating trauma almost universally had better survival rates. Blunt trauma had reported survival rates between 0%–12.5%,<sup>1,15,18,22,23</sup> and penetrating trauma had a reported survival between 8.8%–22%.<sup>1,15,18,22,23</sup> Some studies even went further to divide penetrating trauma into stab and gunshot wounds, with survival rates of 15.2%–70.9%, and 0%–29.2% respectively.<sup>1,15,16,20,22</sup>

With relatively low survival and widely variable rates of traumatic arrest patients undergoing emergency thoracotomy, many studies have focused on which patients benefit from resuscitation after traumatic arrests. As discussed above, blunt trauma is more uniformly fatal compared to penetrating trauma. When looking at penetrating trauma, stabbing victims are much more likely to be successfully resuscitated compared to gunshot victims. But with patients in all of the above categories surviving traumatic arrests after emergency thoracotomy, what other factors influence survival in these patients?

As can be expected, isolated head injuries suffering traumatic arrests do not survive resuscitation efforts.<sup>24</sup> Location of injury is also a major factor, with thoracic injuries (and specifically cardiac injuries) having the highest survival, followed by abdominal injuries, with multiple injury locations having the lowest survival.<sup>1</sup> Studies also frequently quoted signs of life at the scene or ED as independent predictors of survival.<sup>22,23</sup> Throughout the literature, the general trend was for increasing survival the closer the arrest was to the hospital.<sup>1,15,16,18,19,25,26</sup>

Although the above studies cannot answer this question, is the reason for increased survival for those patients who lose vital signs closer to the hospital due to the time-sensitive nature of more definitive intervention, specifically emergency resuscitative thoracotomy? We already know that CPR is not definitive care for these patients, as hypovolemia or tamponade physiology (typically the cause of arrest) prevents significant blood circulation with chest compressions.<sup>27</sup> And for those patients with cardiac tamponade, pericardiocentesis does not typically work due to clotted blood in

the pericardial sac.<sup>28</sup> So how do we get these patients to definitive care more rapidly?

## Prehospital Evidence

As emergency thoracotomy is a time-critical intervention for traumatic arrest and periarrest patients, is bringing this intervention to the field the next step in trauma care in the United States? In places like the United Kingdom, Germany, Japan, Spain and Australia, this intervention is already a part of the prehospital algorithm for trauma victims. The 2003 guidelines for withholding or terminating resuscitation in prehospital traumatic cardiopulmonary arrest by NAEMSP and ACS said, “Thoracotomy is not a procedure that falls under the purview of prehospital care.”<sup>29</sup> This may be true in a paramedic-run EMS system, as thoracotomy should not be a procedure expected to be performed by paramedics. But in certain other countries across the globe, and increasingly in the United States, physicians have become an integral part of EMS systems.

## Is it time to put emergency resuscitative thoracotomy into our EMS trauma protocols as the next step in trauma care when physicians are available at the scene?

The first case report of prehospital thoracotomy was actually performed in the United States and is the only published account of a prehospital thoracotomy being performed in the U.S. This procedure was performed in 1988 by a senior surgical resident riding with the Houston EMS system. The patient was a left-thorax stabbing victim and lost pulses prior to EMS departure from the scene, with an estimated transport time of 15–20 minutes. The resident performed a left-sided thoracotomy using a scalpel from an OB kit, evacuated a large amount of blood and clot from the chest, and applied manual compression of the descending aorta. The patient regained pulses prior to arrival at the hospital and survived neurologically intact.<sup>30</sup>

Since this time case reports of successful prehospital thoracotomies have been pub-

lished in the U.K., Finland and Austria.<sup>31–35</sup> Additionally, several EMS systems across the globe have adopted protocols that include prehospital thoracotomy for traumatic arrests.<sup>27,36,37</sup>

Although thoracotomy as a prehospital intervention is gaining acceptance outside the United States, the data on who benefits most from this procedure is still somewhat limited. A handful of retrospective studies have been published by EMS systems that now include prehospital thoracotomy as part of their trauma algorithms.

A retrospective review from 1993–1999 in London included penetrating trauma patients with cardiac arrest. This time frame saw 39 prehospital thoracotomies performed. Providers obtained ROSC in 59% of patients, 10% survived to hospital discharge, and 75% of those survived neurologically intact. All of the long-term survivors in this study were from stab wounds. Of all the stabbing victims, 16% survived. None of the GSW victims survived. All survivors had cardiac tamponade.<sup>38</sup> This study led to the policy of prehospital thoracotomies being performed on all trauma arrest patients with more than 10 minutes’ hospital transport time in the London HEMS system.

After the inclusion of prehospital thoracotomy in the London HEMS system, a 15-year retrospective database review was published using data from 1993–2008. This included all thoracotomies performed for penetrating chest injury with cardiac arrest times less than 10 minutes prior to EMS arrival. This review excluded GSW victims. In this review 18% of patients survived to hospital discharge, 77% of them neurologically intact. Additionally, all survivors with arrest times less than five minutes prior to EMS arrival had good neurologic outcomes.<sup>39</sup>

A London HEMS study published in 2004 showed a 9.7% survival for prehospital thoracotomies. This retrospective review included both blunt and penetrating trauma victims, although it did not separate them for analysis. This study showed that thoracotomy was not an independent predictor of death and concluded that this may be a lifesaving procedure for a select group of patients (although it did not define this subset).<sup>40</sup>

Another study published about the London HEMS system in 2006 showed that prehospital thoracotomy was an independent predictor of survival. Of patients who received thoracotomy for penetrating trauma, 8.6% survived, and 62.5% of those were neurologically normal. In contrast, there was only a 4.7% survival in penetrating trauma if no prehospital thoracotomy was performed.<sup>41</sup>

A review published out of Madrid in 2007 included six patients undergoing prehospital thoracotomy. This study showed a 33% survival, 50% neurologically intact. It is, of course, limited by its small sample size, but its authors noted that their neurologically intact survivors—though located in a city with quoted transport times of less than 10 minutes—would not likely have arrived to the hospital and undergone a thoracotomy in less than 10 minutes from EMS arrival.<sup>42</sup> This paper addresses the question of whether it's still beneficial to perform prehospital thoracotomies in cities where transport times are usually within 10 minutes.

Finally a retrospective review published in 2009 out of the Japanese helicopter EMS system looked at 81 patients undergoing thoracotomy for blunt trauma. While 59% achieved ROSC and 34% made it to the ICU, no patients survived to hospital discharge. This study was limited by the long times between EMS arrival and physician arrival at the scene to perform the thoracotomy prior to transport (greater than 19 minutes on average).<sup>43</sup>

## Prehospital Logistics

A prominent factor in patient outcomes is paramedic involvement in the prehospital setting. The “scoop and run” and “stay and play” methods have been studied in the past, leading to the conclusion that “scoop and run” is the preferred technique for penetrating or unstable trauma victims. Studies in the U.S. have shown that patients have a significantly higher chance of survival with immediate transport to the hospital.<sup>44,45</sup> A study from South Carolina also noted that in the “scoop and run” group, 20% of patients lost vital signs between EMS arrival and hospital arrival, versus 40% in the “stay and play” group. This difference may have been a major factor in the groups’ mortality rates, as no patients who lost vitals

prior to arrival at the hospital survived in this study.<sup>45</sup> These studies may reflect the time-sensitive nature of thoracotomy in traumatic arrest victims.

Even though patient survival is increased with rapid transport to the hospital, we know EMS plays a vital role in improving survival for these patients. A 1992 study showed that field intubation in patients with loss of vitals due to penetrating trauma increased the tolerance of CPR time from 4.2 minutes to 9.4 minutes in survivors.<sup>20</sup> Additionally, a German study looking at patients with traumatic arrest requiring thoracotomy showed that the only factor that improved survival was aggressive field care, including chest tube insertion.<sup>13</sup>

The NAEMSP currently has a position paper, *Guidelines for Withholding or Termination of Resuscitation in Prehospital Traumatic Cardiopulmonary Arrest*. These guidelines, written in 2001 in conjunction with the American College of Surgeons Committee on Trauma, define when prehospital resuscitation efforts should be withheld or discontinued in traumatic arrest patients.<sup>46</sup> A retrospective cohort study published in 2005 collected data between 1994–2001 on 184 prehospital traumatic arrest patients. This study showed a 7.6% survival to hospital discharge. When comparing the documented EMS assessments of the survivors to the NAEMSP/ACS guidelines, this study found that if the guidelines had been strictly applied, 13 of the 14 survivors would not have been transported to the hospital, and several patients met multiple criteria for withholding resuscitation. Notably, 93% of survivors had CPR times greater than 15 minutes due to the combined on-scene and transport times, although no survivors had transport times greater than 15 minutes. On the converse side of the argument, 111 nonsurvivors would not have been transported to the hospital, which could have freed these EMS teams to transport other patients. This study also noted frequent discrepancies between initial EMS assessment and initial ED assessment, concluding that field assessments are often not reliable.<sup>24</sup>

## The Next Step in the U.S.?

While there has been limited success in prehospital thoracotomy for blunt trauma, it

is clear there is a role for prehospital thoracotomy in penetrating trauma, especially stabbing victims. And the data shows that thoracotomy is a time-sensitive intervention. Based on this evidence, a number of EMS systems across the globe have already adopted prehospital thoracotomy into their current EMS trauma algorithms. But is this something we should be adopting in the United States?

In our current EMS system, physicians do not play an integral role in day-to-day patient care and transport. But with the growing popularity of active EMS medical directors and EMS now being a certified medical subspecialty, there are a fair number of EMS systems with emergency medicine-trained physicians available on scenes. Additionally, there are emergency medicine residents and EMS fellows across the country who participate in EMS calls during their training.

Is it time to put emergency resuscitative thoracotomy into our EMS trauma protocols as the next step in trauma care when physicians are available at the scene? Possibly. It must be recognized that a thoracotomy is an inherently dangerous procedure. Sharp fractured ribs, bullet fragments, scalpels and the austere prehospital environment put the provider at high risk for iatrogenic injury and possible infection with bloodborne pathogens. It is clear that more data is needed to better define which patients, and at what time intervals, can most benefit from emergency resuscitative thoracotomy. ☼

Article references available online at  
[EMSWorld.com/12284767](http://EMSWorld.com/12284767).

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