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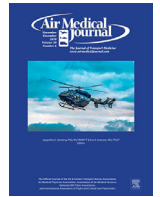
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## Case Report

## Clamshell in a Heartbeat

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## A B S T R A C T

There is a restrained attitude toward the implementation and performance of resuscitative thoracotomy as a last resort procedure in patients with cardiac arrest after penetrating thoracic trauma. We present a case with a remarkable recovery and hope to boost morality in the use of this procedure in the prehospital setting. A disoriented 25-year-old woman stabbed multiple times was found next to the highway. Her clinical situation deteriorated swiftly upon arrival of the helicopter emergency medical services. They were able to perform a clamshell thoracotomy and fly the patient out to the nearest trauma center. She awoke with good neurologic function. Her hospital admission was complicated by mediastinitis. A routine cardiac ultrasound showed mitral valve insufficiency due to combined perforation of the anterior leaflet and ventricular septum. Both lesions were in the trajectory of the primary stab wound. Successful outcome in our case was due to the following: little delay between clinical deterioration and the arrival of the helicopter emergency medical services physician (signs of life on arrival of paramedics are an independent predictor of survival), young age and penetrating injury are associated with a good neurologic outcome in case of traumatic cardiac arrest, and extensive follow-up cardiac ultrasound as part of tertiary survey after resuscitative emergency thoracotomy is advised.

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Resuscitative thoracotomy is a resuscitative (bailout) procedure in patients with cardiac arrest after penetrating thoracic trauma. The increasing experience with this procedure in emergency departments has been translated to prehospital emergency care. Rhee et al<sup>1</sup> showed survival rates with a good neurologic outcome in 20% of emergency department patients with a single stab wound in the chest. Davies and Lockey<sup>2</sup> took this procedure to the prehospital phase with the London helicopter emergency medical service (HEMS). However, traumatic arrest on scene is still associated with a poor prognosis. The literature on successful resuscitative thoracotomy in the prehospital setting is scarce. This results in a restrained attitude toward the implementation and performance of the clamshell procedure.<sup>3</sup> We present a case of resuscitative thoracotomy after penetrating thoracic trauma with a remarkable recovery and hope to boost morality in its use in the prehospital setting.

## Case Report

When investigating a fatal car crash on a cold December night, the police noticed a second victim in a field approximately 400 meters from the highway. The victim was a disoriented 25-year-old woman who was stabbed twice in the front of the chest, 3 times in the back, and 2 times in her left upper arm. Her initial Glasgow Coma Scale score of 13 deteriorated within 15 minutes to a Glasgow Coma Scale score of 4 when the physician-staffed HEMS arrived. She was intubated and transfused with 2 packed cells on scene. Shortly after, she deteriorated into a state of pulseless electrical activity. Chest compressions were initiated. Bilateral finger thoracostomies were negative for a hemothorax/pneumothorax. After a 1-mg bolus of adrenaline, her cardiac rhythm converted to ventricular fibrillation. Electrical defibrillation with 200 J resulted in return of spontaneous circulation (ROSC). An ultrasound of the heart showed fluid in the pericardial sac with kissing walls of the left ventricle. The time of transportation to the nearest trauma center was at least 30 minutes. When the patient became hypotensive and tachycardic again, a resuscitative clamshell thoracotomy was undertaken by extending and joining both finger thoracostomies. The pericardial sac was

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**Figure 1.** A clamshell thoracotomy with a right ventricular defect. \*A urinary catheter with a saline insufflated balloon.

opened, and a large clot was evacuated. A 2-cm centimeter right ventricular myocardial defect, as the source, was managed using a urinary catheter with a saline insufflated balloon (Fig. 1). Subsequently, staples were applied to further close the defect. Next, the bleeding mammary arteries were clamped. With increasing blood pressure, a rebleed occurred from the myocardial wound, which was sutured a second time. Once the patient was stabilized, she was transported by air to the nearest trauma center. At arrival, she was rushed to the operating room where the myocardial defect was resutured, and both mammary arteries were clipped; her wounds were cleaned and closed.

Postoperatively, the patient remained ventilated for 2 days. She was treated with broad-spectrum antibiotics. In the intensive care unit, a wound in the axilla region was re-explored, and an arterial bleed was treated. After 3 days on the ventilator, she awoke with good neurologic function, and on day 5, she was transferred to the surgical ward. Unfortunately, she was readmitted to the ICU two days later with respiratory failure because of pleural effusion caused by mediastinitis, which was managed with chest tube drainage and the continuation of antibiotics for a total of 13 days. The need for ventilator support was short. During this second admission, a follow-up cardiac ultrasound showed a mitral valve insufficiency caused by perforation of the anterior leaflet (A2 and A3) combined with perforation of the ventricular septum. Both lesions were in the trajectory of the primary stab wound. Because she had stable hemodynamics, surgery was not yet indicated, and the lesions were followed up by a cardiologist.

## Discussion

This case illustrates that resuscitative (clamshell) thoracotomy on scene can result in a favorable outcome despite the remote area, the cold conditions, and the poor surgical conditions. It confirms that survival with a good neurologic outcome after out-of-hospital thoracotomy is possible. To our knowledge, this is the first case of out-of-hospital resuscitative thoracotomy reported to be transported by air after a thoracotomy on scene.

A good neurologic outcome is scarce after a successful out-of-hospital resuscitative thoracotomy, which is contrary to resuscitative thoracotomy performed in the emergency department. In the case series published in 2017 from our colleagues in the Netherlands,<sup>3</sup> 9

of 23 patients with stab wounds had ROSC, with only 1 patient (4.3%) surviving until hospital discharge with a good neurologic outcome. In this case series, gunshot wounds never achieved ROSC. The London experience reported 13 of 71 (18%) patients surviving, with 11 showing a good neurologic outcome. In the most recent study performed in Texas, survival after resuscitative thoracotomy (emergency department) was 9.4% (11% for penetrating trauma and 6.8% for blunt trauma). They demonstrated that 71% of the patients who survived until ICU admission died; 67% died within the first 24 hours of admission.<sup>4</sup> The great difference in the survival rate depends on several key factors, which have led to clear indications upon which to start resuscitative thoracotomy.

Indications for a (prehospital) resuscitative thoracotomy are cardiac arrest after a penetrating injury to the chest or upper abdomen, the arrival of a medical team within 10 minutes, and the time of transportation to the nearest emergency room exceeding 10 minutes. The primary goal is to treat a possible cardiac tamponade and/or stop intrathoracic bleeding, thereby resolving the cause for cardiac arrest.<sup>3</sup> In addition, it offers access to open cardiac massage and the possibility to clamp the thoracic aorta to attenuate distal bleeding.

The details of the technique applied have been described in previous publications.<sup>3,5</sup> A cadaver study in 2013<sup>5</sup> enforced the beliefs that the clamshell technique for emergency thoracotomy is the preferred technique. The procedure can be summarized in the following steps as applied in our case:

- Skin disinfection
- Bilateral finger thoracostomies in the fifth intercostal space (a possible confounding tension pneumothorax will be relieved using this maneuver)
- Connection of both thoracostomy wounds by cutting through skin and subcutis
- Extending the incision to the posterior
- Incision of the sternum with scissors
- Opening up the chest by hands or a Finochietto retractor
- A vertical incision of the pericardium
- Resolution of any bleeding encountered

The main complications one can expect during the procedure are bleeding, especially from the mammary arteries, and injury to the phrenic nerve. A high risk for the provider due to blood-borne pathogens and increased psychological burden are other important concerns. Once admitted to the ICU, the most noted complications are acute kidney injury, ventilator-associated pneumonia, acute respiratory distress syndrome, deep surgical site infection, and deep venous thrombosis.<sup>4</sup>

In our case, the successful outcome was due to several factors. First of all, there was little delay between clinical deterioration and arrival of the HEMS physician who performed the thoracotomy. Signs of life on arrival of the paramedics are an independent predictor of survival. This seems obvious because it is a time-dependent intervention. A long duration of cardiac arrest inevitably results in a poor neurologic outcome. The easy accessibility of a well-trained HEMS team on-site helps.<sup>2</sup> Second, young age and penetrating injury are favorable factors for an improved neurologic outcome in case of traumatic cardiac arrest.<sup>6</sup>

The anatomic location and mechanism of injury are independent predictors of survival.<sup>6</sup> Damage control surgery focuses on resolving life-threatening situations and does not involve complete evaluation of all organs if not directly indicated. After damage control surgery, focus shifts to stabilization in the ICU before any other procedures are indicated. In general trauma, patient follow-up consists of secondary and tertiary surveys, exploring for any missed diagnoses. When dealing with patients after stab wounds undergoing resuscitative emergency thoracotomy, extensive cardiac ultrasound is mandatory as part of the survey.

Fortunately, the patient did not progress to severe sepsis after being exposed to many potential pathogens, even though she was treated for mediastinitis with pleural effusion. A review by Petersen and Waterman in 2011<sup>7</sup> clearly showed the lack of high evidence for 1 particular antibiotic strategy. A meta-analysis showed a potential reduction in the risk of empyema with prophylactic antibiotics. Coverage of gram-positive and gram-negative bacteria and anaerobes is advised as per expert opinion and was also applied in this case. However, Petersen and Waterman concluded that treatment should be ended after 24 hours and do not advocate a routinely extended antibiotic prophylactic course despite gross contamination.

## References

1. Rhee PM, Acosta J, Bridgeman A, Wang D, Jordan M, Rich N. Survival after emergency department thoracotomy: review of published data from the past 25 years. *J Am Coll Surg*. 2000;190:288–298.
2. Davies GE, Lockey DJ. Thirteen survivors of prehospital thoracotomy for penetrating trauma: a prehospital physician-performed resuscitation procedure that can yield good results. *J Trauma*. 2011;70:E75–E78.
3. Van Vledder MG, Van Waes OJ, Kooij FO, Peters JH, Van Lieshout EM, Verhofstad MH. Out of hospital thoracotomy for cardiac arrest after penetrating thoracic trauma. *Injury*. 2017;48:1865–1869.
4. Fitch JL, Dieffenbaugher S, McNutt M, et al. Are we out of the woods yet? The aftermath of resuscitative thoracotomy. *J Surg Res*. 2020;245:593–599.
5. Simms ER, Flaris AN, Franchino X, Thomas MS, Caillot JL, Voiglio EJ. Bilateral anterior thoracotomy (clamshell incision) is the ideal emergency thoracotomy incision: an anatomic study. *World J Surg*. 2013;37:1277–1285.
6. Joseph B, Khan M, Jehan F, Latifi R, Rhee P. Improving survival after an emergency resuscitative thoracotomy: a 5-year review of the Trauma Quality Improvement Program. *Trauma Surg Acute Care Open*. 2018;3:e000201.
7. Petersen K, Waterman P. Prophylaxis and treatment of infections associated with penetrating traumatic injury. *Expert Rev Anti Infect Ther*. 2011;9:81–96.