

Original Research Article

Surviving against the odds: outcomes of emergency resuscitative thoracotomies at an Australian level 1 trauma centre

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ABSTRACT

Background: Emergency resuscitative thoracotomy (ERT) is performed in thoracic trauma patients who present in extremis. Newer studies outside North America report higher survival rates, however literature from Australia is limited. This study reviews 12 years of ERT outcomes from an Australian level 1 trauma centre and whether trauma triage mechanisms may impact survival rates

Methods: A retrospective observational study using data from the trauma registry at St. George hospital Sydney for all who underwent an ERT between 2009 and 2021, supplemented with information from medical records. Parameters examined included demographics, injury profile, ERT details and outcomes. Data was then analysed by descriptive statistics

Results: The 29 ERTs were performed of which 25 were male (85%) and 4 were female (14%). Mean age was 40 and mean injury severity score (ISS) was 32. Overall, 13 patients survived after ERT (45%), with 10 patients surviving admission post ERT for penetrating injuries (53%), compared to 3 surviving admissions for blunt injuries (27%). The 82% of ERTs were performed in the operating theatre (OT), with survival rates the highest when ERT was performed in OT by the cardiothoracic surgical team

Conclusions: In this study, ERT conferred good outcome with survival in almost half of patients. More studies are required to establish whether triage mechanisms which facilitate early transfer to OT confer higher survival in ERT patients.

Keywords: Trauma, Resuscitative thoracotomy, Emergency thoracotomy, Survival, Major trauma, Thoracic trauma

INTRODUCTION

An emergency resuscitative thoracotomy (ERT) is a potentially lifesaving measure in the setting of trauma. It allows for relief of tension pneumothorax or cardiac tamponade, direct control of intrathoracic haemorrhage, direct open bimanual cardiac compression and defibrillation. It also allows cross-clamping of the descending aorta or the pulmonary hilum in the presence of a suspected air embolism.¹ At St. George hospital, a level 1 trauma centre in south-eastern Sydney Australia, ERT is performed as an attempt to save the life of the thoracic trauma patient who is in extremis despite other resuscitative efforts.

However there has been significant debate in literature about the acceptable indications for performing ERT and the futility of this procedure. In a 2015 meta-analysis of available trauma thoracotomy literature, the overall survival rate after performing ERT was found to be only 8%. Loss of signs of life or commencement of cardiopulmonary resuscitation (CPR) prior to thoracotomy was associated with higher rates of mortality. Survival after ERT in those with penetrating trauma was 9.8% compared to only 5.2% in blunt trauma patients.² As a result of poor outcomes, current trauma guidelines agree that ERT should be performed selectively in patients who have blunt trauma, considering this mechanism of injury a relative contraindication.^{1,3}

Interestingly, recent emergency thoracotomy studies in trauma centres outside of the United States of America (USA) have reported higher survival outcomes even in blunt trauma.^{1,2,4} This variation in survival rates may be due to factors such as pre-hospital services, demographic characteristics, injury patterns and low volume of cases. Unfortunately, there is limited data regarding ERTs in Australia. Demographics and injury profile-wise eastern Australia is similar to Scandinavian countries who have reported much higher survival rates after ERT than our North American counterparts.^{1,2,5} It is also important to note that, due to the geographical vastness of Australia, we have many enhanced retrieval and triage mechanisms which may impact survival rates after trauma.

The trauma department at St. George hospital has implemented hospital policies, in collaboration with the emergency department and pre-hospital teams, aimed at early recognition, triage and holistic management of a trauma patient. The trauma team at St. George hospital consists of trauma consultants (who are trauma surgeons or emergency medicine physicians), trauma fellows of the Royal Australasian college of surgeons, trauma registrars (including both emergency medicine and general surgical trainees), junior doctors and trauma clinical nurse consultants (CNCs). Such a multidisciplinary team allows for a coherent and coordinated approach to each patient combining both emergency medicine and surgical care.

St. George hospital also has a trauma triage system in which emergency staff examine mechanism of injury, physiologic parameters and at risk-demographics of trauma presentations then assign them a trauma response priority level.

A 'trauma standby' patient must be reviewed with 20 minutes by the trauma team upon arrival to the emergency department (ED). A 'trauma attend' patient must be reviewed within 5 minutes by not only the trauma team, but also intensive care unit staff, anaesthetics and any relevant subspecialty teams such as cardiothoracic surgery. It also alerts the blood bank, operating theatre and radiology departments to a severe trauma patient arrival.

There is a more recent category of trauma patient, the 'code crimson' which is a variation of the 'trauma attend' call. Code crimson is designed to facilitate rapid transfer of a possibly exsanguinating pre-arrest patient to OT and into care of an appropriate surgical team within 20 minutes of arrival.⁶ A Code crimson can be activated by pre-arrival, and in rare circumstances where the patient is in extremis, this can involve by-passing the emergency department and taking the patient directly to the operating theatre or interventional radiology.

At St. George hospital, surgical teams (such as general surgery and cardiothoracic surgery) and OT in-charge personnel receive the code crimson alert as well as the involved trauma and ED staff. Code crimson was first

begun at the Nepean hospital in Sydney and formally used at St. George hospital in 2019.⁶

All these trauma triage mechanisms may allow the team to recognise the deteriorating thoracic trauma patient early and perform ERT relatively sooner.

This study aims to review ERT survival rates at an Australian level 1 trauma centre and whether such local policies and triage mechanisms may have contributed to a difference in survival outcomes.

METHODS

We conducted a retrospective cohort study of all thoracotomy cases from the St. George trauma registry since conception, spanning 2009 to 2021. The St. George trauma registry is a database maintained from 2009 for all patients aged over 18 years of age for whom a trauma team response is activated on arrival or during pre-arrival to the hospital. This database has ethical approval under South Eastern local health district. Inclusion criteria for the data collected included thoracotomy cases performed as emergency resuscitative thoracotomies (ERT), defined as thoracotomy performed in a clinically deteriorating patient that could not be delayed. All elective/scheduled emergency thoracotomies (such as for rib fixations for flail chest) were excluded. The protocol for location to initiate an ERT was dependent on the team leader assessing the trauma, with liaison with surgical staff in attendance. Decision for emergency department ERT is shown in Figure 1.

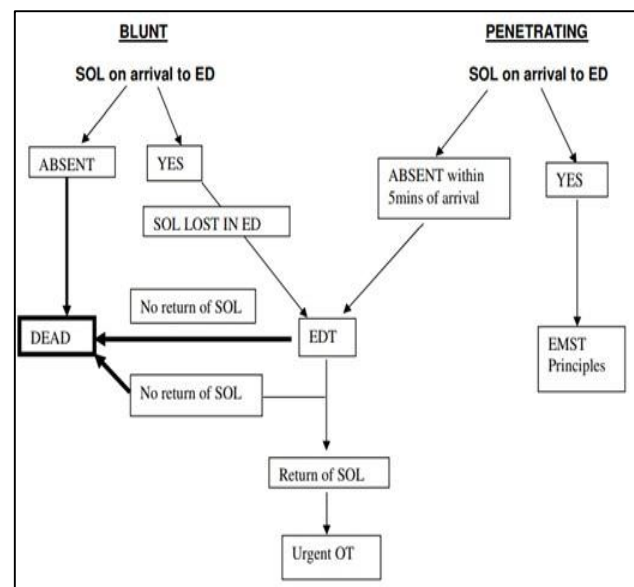


Figure 1: Algorithm for deciding when to perform emergency department thoracotomy at St. George hospital.

SOL=Signs of life, ED=Emergency department, EDT=emergency department thoracotomy, OT=operating theatre, EMST=Early management of severe trauma.

Data extracted from the trauma registry included patient demographics, mechanism of injury (MOI), injury severity score (ISS), interventions and location of intervention, time to ERT, length of stay and mortality were collected.⁷ Survival was defined as survival from their hospital admission. Operative descriptions, findings and documentation of resuscitation were sourced through the medical records system.

The primary outcome of interest was in-hospital survival, with secondary outcomes of location of thoracotomy and team that performed the ERT.

All data was evaluated using R×64 v3.5.1 (The R foundation for statistical computing, Vienna, Austria). Data was represented with descriptive statistics, with

analysis performed using the χ^2 test for categorical results and Mann-Whitney U for independent continuous results between two groups.

RESULTS

There were 88 trauma related thoracotomies identified in the database, of which 29 were classified as ERT. Of the 29, the majority were male at 86.2% (n=25). The mean age overall was 40.6 (standard deviation (SD) of 18.9) years, with females trending younger than males (34.0±SD 19.0 versus 41.4±SD 19.1, p=0.74). Mean ISS was 32.1±SD 15.6 overall, with no significant difference between sex, but females trending higher (44.8±SD 18.6 v 31.2±SD 15.0, p=0.56). The majority of injury types were penetrating trauma at 62.1% (n=18) (Table 1).

Table 1: Demographics and parameters of patients who underwent ERT.

Variables	Females, n (%)	Males, n (%)	Comparison	Total (Average)
Counts	4 (13.8)	25 (86.2)		29
Survived	1 (25)	12 (48)	χ^2 , p=0.73	13 (44.8)
Age (years) (mean, SD)	34.0 (19.0)	41.4 (19.1)	MWU, p=0.74	(40.6, 18.9)
ISS mean, (n, SD)	44.8 (18.6)	31.2 (15.0)	MWU, p=0.56	(32.1, 15.6)
Injury type				
Penetrating	1 (25)	17 (68)	χ^2 , p=0.24	18 (62.1)
Blunt	3 (75)	8 (32)		11 (37.9)

ECT=Emergency resuscitative therapy, SD=Standard deviation, ISS=Injury severity score, MWU= Mann Whitney U.

Survival was analysed in Table 2. Overall survival for patients undergoing ERT was 44.8% (n=13), with 55.6% (n=10) of patients surviving admission post ERT for penetrating injuries, compared to 27.3% (n=3) surviving admission for blunt injuries. This difference was not statistically significant (χ^2 test=2.21, p=0.137).

Table 2: Outcome by mechanism of injury.

Injury type	Survived, n (%)	Died, n (%)	Total
Blunt	3 (27.3)	8 (72.2)	11
Penetrating	10 (55.6)	8 (44.4)	18
Total	13 (44.8)	16 (51.7)	29

There was no difference in mean ISS between those who lived and those who died. The mean ISS was 34.5 in those who died, and 25 in those who lived, with no evidence (p=0.192) of a difference (95% CI mean difference -1 to 25). Time to thoracotomy and survival also did not show significant difference (MWU=55, p=0.079). In those that survived, the mean time from injury to thoracotomy was 219 minutes compared to 126 minutes in those that died. Overall mean time to ERT was 172 minutes.

Survival post ERT was analysed in Table 3 for location and team responsible for the ERT. The highest survival rate was noted when the cardiothoracic surgical team performed ERT in an operating theatre at 73% (n=8), and the lowest by the ED team and retrieval teams at 100%

mortality (n=1 and 3 respectively), both out of OT. Overall survival was 52.2% (n=12) for patients in OT and only one patient surviving an out of OT ERT.

Table 3: ERT survival by team and location.

Variables	Location of thoracotomy n (%)		
	Outcome	OT	Non-OT
Cardio-thoracic	Survived	8 (73)	0
	Died	3 (17)	0
	Total	11	0
Trauma surgery	Survived	4 (33)	1 (50)
	Died	8 (66)	1 (50)
	Total	12	2
Retrieval	Survived	0	0
	Died	0	3 (100)
	Total	0	3
ED	Survived	0	0
	Died	0	1 (100)
	Total	0	1
Overall total (all teams)	Survived	12 (52.2)	1 (16.7)
	Died	11 (47.8)	5 (83.3)
	Total	23	6

ED=Emergency department, OT=operating theatre.

DISCUSSION

This study found an overall survival rate of 45%, which is much higher than that previously reported in literature.^{2,3} Especially high are our survival rates in those with blunt

injury requiring ERT (27%), compared to literature.^{2,3} The difference between survival rates between patients with blunt and penetrating injury in ERT has thought to be because of the lower possibility of there being a surgically correctable cause of shock in blunt injury.¹

A similar 2020 Norwegian study, in terms of the demographics, case numbers (26) and mean ISS (38), reported an overall survival rate of 19% as well as in blunt trauma (19%).⁴ However, a major difference with the Norwegian study, which may account for our survival rate of 45%, is that the majority of the ERTs in the current study were performed in the OT (82%). The ERTs in the afore mentioned study were performed mainly in the emergency room.⁴

The reason that ERTs at our centre were able to be performed in the OT at St George hospital may be due to the trauma triage mechanisms and enhanced pre-hospital communication mentioned earlier in this article. Making earlier management decisions on which patient's disposition is likely for the OT, such as with the 'code crimson' and 'trauma attend' activations, may allow the receiving hospital trauma team, surgical team and OT to be prepared for the possibility for damage control surgery (such as in an ERT). The above then allows immediate transfer of the deteriorating thoracic trauma patient from helicopter directly to OT for initial assessment and management. A 2020 Australian study found that a code crimson activation reduced the median time to OT of an exsanguinating truncal trauma patient from 95 minutes to 23 minutes.⁸ In a separate 2022 study Code Crimson activation was also associated with lower mortality rates.⁹

This may also explain that why we found survival rates were highest when the cardiothoracic surgical team performed ERT in the OT (73%), with this team likely to have been alerted early and OT made available for patient arrival.

The major limitation in our study is that this is a relatively small study, with low case volumes. This reflects on the lower population at risk, the lower prevalence of penetrating trauma in Australia and the subsequent rarity of ERT when compared to trauma centres such as those in the USA.^{3,5} Also, due to the small case numbers, we were unable to analyse trends over time in outcomes related to ERT. This study did not explore impact of ERT on morbidity, such neurological outcomes, as outcomes focused on survival rates.

CONCLUSION

Although the current study is in a low-volume setting, we found much higher survival rates when compared to recent literature. Almost half of the patients survived after ERT. Even in blunt trauma, almost 30% survived. Our study found that the majority of our ERTs were performed in the OT by a surgical team, and this may be due to specific trauma triage mechanisms which allow early identification

and transfer of the deteriorating patient to the OT by a surgical team. We hope this study acts as an impetus for a review of ERT in Australia at other trauma centres, to improve our decision-making when it comes to performing ERT in blunt trauma and facilitate early surgical and OT involvement by using trauma triage levels.

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