Establishing Benchmarks for Resuscitation of Traumatic Circulatory Arrest: Success-to-Rescue and Survival among 1,708 Patients

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BACKGROUND: Attempts are made with emergency department thoracotomy (EDT) to salvage trauma patients who present to the hospital in extremis. The EDT allows for relief of cardiac tamponade, internal cardiac massage, and proximal hemorrhage control. Minimally invasive techniques, such as endovascular hemorrhage control (EHC) are available, but their noninferiority to EDT remains unproven. Before adopting EHC, it is important to evaluate the current outcomes of EDT. We hypothesized that EDT survival has improved during the last 4 decades, and outcomes stratified by pre-hospital CPR and injury patterns will provide benchmarks for success-to-rescue and survival outcomes for patients in extremis.

STUDY DESIGN: Consecutive trauma patients undergoing EDT from 1975 to 2014 were prospectively observed as part of quality improvement. Predicted probabilities of survival were adjusted for pre-hospital CPR, mechanism of injury, injury pattern, patient demographics, and time period of EDT using logistic regression. Success-to-rescue was defined as return of spontaneous circulation with blood pressure permissive for transfer to the operating room.

RESULTS: There were 1,708 EDTs included, with an overall 419 (24%) success-to-rescue patients and 106 survivors (6%), and 1,394 (79%) of these patients had pre-hospital CPR and 900 (54%) had penetrating wounds. The most common injury patterns were chest (29%), multisystem with head (27%), and multisystem without head (21%). Penetrating injury was associated with higher survival than blunt trauma (9% vs 3% $p < 0.001$). Success-to-rescue increased from 22% in 1975 to 1979 to 35% over the final 5 years ($p < 0.001$); survival increased from 5% to 14% ($p < 0.001$).

CONCLUSIONS: Outcomes of EDT have improved over the past 40 years. In the last 5 years, STR was 35% and overall survival was 14%. These prospective observational data provide benchmarks to define the role of EHC as an alternative approach for patients arriving in extremis. (J Am Coll Surg 2016;223:42–50. © 2016 by the American College of Surgeons. Published by Elsevier Inc. All rights reserved.)

Emergency department thoracotomy (EDT) has been used for half a century to salvage trauma patients arriving in circulatory arrest. Early pioneers of this procedure from Ben Taub Hospital appreciated the therapeutic role of a thoracotomy for patients who develop circulatory arrest from penetrating chest trauma, irrespective of location

Disclosure Information: Dr Ernest Moore received grants to his institution for supplies and some salaries from Haemonetics and TEM research. All other authors have nothing to disclose.

Disclosures outside of the scope of this work: Dr Hunter Moore's institution receives royalties from UpToDate, and Dr Fox is an unpaid clinical advisory board member of Prytime Medical Devices, Inc.

Support: This study was supported in part by National Institute of General Medical Sciences grants T32-GM008315 and P50-GM49222.

Disclaimer: The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIGMS, or National Institutes of Health.

Presented at the Western Surgical Association 123rd Scientific Session, Napa Valley, CA, November 2015.

Received January 8, 2016; Revised March 23, 2016; Accepted April 11, 2016.

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http://dx.doi.org/10.1016/j.jamcollsurg.2016.04.013
ISSN 1072-7515/16

Abbreviations and Acronyms

AUROC = area under the receiver operating characteristics curve
EDT = emergency department thoracotomy
EHC = endovascular hemorrhage control
IQR = interquartile range
REBOA = resuscitative endovascular balloon occlusion of the aorta

in the hospital.[1] This concept was expanded to blunt trauma patients with reportedly high salvage rates in the late 1970s.[2] However, widespread adoption of this procedure in all trauma patients presenting to the emergency department in circulatory arrest was regarded as an "indiscriminate fire drill"; it was proposed that there should be specific indications.[3] In 2000, a literature review of 4,000 trauma patients undergoing EDT reported a survival rate of 7.4%.[4] A decade later, however, Passos and colleagues[5] reported a dismal survival rate of 2.4% in their 17-year experience and concluded that this procedure was risky, expensive, and offered no survival benefit. Other investigators previously expressed concerns that the EDT risk and cost did not outweigh its potential benefits.[6,7] This negative opinion of EDT is reflective of the current status of this procedure at a national level. In an evaluation of 5 major level I trauma centers between 2006 and 2010, EDT was performed in only 13% of patients when indicated.[8] Our analysis of the collective experience in the US indicates that EDT survival rates vary from 35% for cardiac wounds and 14% for penetrating wounds, to 2% for blunt trauma.[9]

There is a clear need for improving early hemorrhage control in trauma because this represents 40% of preventable deaths,[10] and the median time to death in hypotensive patients is 2 hours from injury.[11] The reported under-use of EDT at level I trauma centers is concerning because pre-hospital care, resuscitation, and operative interventions have improved. Hospitals that specialize in high-risk elective surgery, such as cardiothoracic[12] and pancreatic,[13] have better outcomes when contrasted with low volume centers. An important component attributed to improved outcomes in these patients at high volume centers is that low volume centers have a higher rate of "failure to rescue" patients from postoperative complications.[14] Trauma surgery has the reverse sequence; patients must be rescued from circulatory arrest with an EDT before they can proceed to the operating room. This can be considered "success-to-rescue." It has been argued that trauma level designation, based on hospital resources and not volume, determines outcomes in trauma surgery.[15,16] However, these studies do not account for success-to-rescue from circulatory arrest because most of these centers consider a trauma patient in circulatory arrest dead on arrival.

Clinical implementation of minimally invasive hemorrhage control through resuscitative endovascular balloon occlusion of the aorta (REBOA)[17] has introduced an alternative strategy to augment resuscitation in patients with circulatory arrest after trauma. In theory, REBOA could improve resuscitation efforts in trauma centers that fear the risks of EDT or lack experience in the technique. However, before global adoption of this technique, it is essential to benchmark the outcomes of EDT at high volume level I trauma centers to identify the contemporary expected success-to-rescue patterns of trauma patients in circulatory arrest. We hypothesized that anatomic injury location and pre-hospital circulatory status are associated with markedly different success-to-rescue and survival rates in trauma patients undergoing EDT, and that overall survival rates have improved over time.

METHODS

Patient population

This prospective observational study includes continuously collected variables on all trauma patients presenting to our urban adult level I trauma center who underwent EDT from January 1975 to December 2014. Data acquisition was under the approval of the Colorado Multiple Institution Review Board. The purpose of this data collection was for quality improvement in refining the indication for this procedure to improve outcomes. The senior author (EEM) reviewed in real-time all patient pre-hospital characteristics and patient outcomes.

Patient characteristics and outcomes

Recorded patient demographics included age and sex. Pre-hospital variables included injury mechanism and anatomic location, in addition to detection of pre-hospital cardiac activity, and pre-hospital CPR. For this study, success-to-rescue was defined as return of spontaneous circulation and transfer of the patient to the operating room; by institutional protocol, a systolic blood pressure greater than 70 mmHg was necessary. Outcomes reviewed included success-to-rescue and survival to hospital discharge. Neurologic outcome was scored using the Glasgow Outcome Scale (GOS)[18] and was determined based on the most recent outpatient follow-up visit with rehabilitation if the patient left the hospital with neurologic impairment.