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Benchmarking emergency department thoracotomy: Using trauma video review to generate procedural norms

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ABSTRACT

Introduction: Emergency department thoracotomy (EDT) must be rapid and well-executed. Currently there are no defined benchmarks for EDT procedural milestones. We hypothesized that trauma video review (TVR) can be used to define the 'normative EDT' and generate procedural benchmarks. As a secondary aim, we hypothesized that data collected by TVR would have less missingness and bias than data collected by review of the Electronic Medical Record (EMR).
Methods: We used continuously recording video to review all EDTs performed at our centre during the study period. Using skin incision as start time, we defined four procedural milestones for EDT: 1. Decompression of the right chest (tube thoracostomy, finger thoracostomy, or clamshell thoracotomy with transverse sternotomy performed in conjunction with left anterolateral thoracotomy) 2. Retractor deployment 3. Pericardiotomy 4. Aortic Cross-clamp. EDTs with any milestone time $\geq 75^{th}$ percentile of time or during which a milestone was omitted were identified as outliers. We compared rates of missingness in data collected by TVR and EMR using McNemar's test.
Results: 44 EDTs were included from the study period. Patients had a median age of 30 [IQR 25–44] and were predominantly African-American (95%) males (93%) with penetrating trauma (95%). From skin incision, median times in minutes to milestones were as follows: right chest decompression: 2.11 [IQR 0.68–2.83], retractor deployment 1.35 [IQR 0.96–1.85], pericardiotomy 2.35 [IQR 1.85–3.75], aortic cross-clamp 3.71 [IQR 2.83–5.77]. In total, 28/44 (64%) of EDTs were either high outliers for one or more benchmarks or had milestones that were omitted. For all milestones, rates of missingness for TVR data were lower than EMR data (p < 0.001).
Conclusions: Video review can be used to define normative times for the procedural milestones of EDT. Steps exceeding the 75th percentile of time were common, with over half of EDTs having at least one milestone as an outlier. Data quality is higher using TVR compared to EMR collection. Future work should seek to determine if minimizing procedural technical outliers improves patient outcomes.

Introduction

Emergency department thoracotomy (EDT) is associated with mortality rates of 75–94% [1,2] but is currently the only widely accepted salvage option available for injured patients in cardiac arrest. Despite the high mortality, EDT has a favourable incremental cost-effectiveness ratio of $16,125/quality adjusted life year

secondary to the young average age of EDT patients [3]. Factors associated with mortality have been described in this patient population including mechanism [4–7] and pattern of injury [8,9], prehospital transport time [10–12], and the presence of signs of life [13] but unfortunately none of these factors are subject to modification by treating centres or providers.

According to the 'three-phase' model of cardiac arrest proposed by Becker et al time after cardiac arrest can be divided into three phases (electrical: up to 4 min; circulatory: ~4 to ~10 min; and metabolic: >~10 min) [14]. Most patients presenting in cardiac arrest after injury will be beyond the electrical phase secondary to prehospital transport time. In the circulatory phase of cardiac arrest, the most important therapy is to initiate a technique to

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provide oxygen delivery to ischemic tissue. After ~10 min without perfusion, cardiac arrest patients may progress into the metabolic phase, beyond which point survival is poor even if circulation returns secondary to global ischemia-reperfusion. Because there is only a limited amount of time until patients progress from the circulatory phase into the metabolic phase, techniques to restore perfusion that are not completed rapidly are likely to be futile. Based on this framework, speed of EDT may represent a modifiable risk factor for mortality in trauma patients arriving in cardiac arrest.

A critical barrier to the study of technique and speed as a modifiable risk factor for mortality in post-injury cardiac arrest patients undergoing EDT is data collection. Prospective data collection by research personnel is challenging because patients requiring emergency department thoracotomies arrive unexpectedly and infrequently. Prospectively collecting data on EDTs requires research personnel that are continuously present and available, a resource that is beyond most centres. Prospective real-time data collection is additionally challenged by the rapid and chaotic nature of these emergent events, which may lead to imprecise or incomplete capture of data elements [15]. Important aspects such as timing and technique of EDT are not recorded or incompletely captured in the electronic medical record, which may limit the utility of retrospective chart review as an option for reliable data collection [16].

Use of trauma video review (TVR) with continuous high-definition audiovisual recording systems may present a solution to the near absence of granular data on timing and technique of emergency department thoracotomy. As a first step towards generating procedural benchmarks for EDT, we hypothesized that we could rigorously define the distribution of times to achieve critical procedural milestones using TVR as a data collection tool. We further hypothesized that compared to TVR, data collection using retrospective chart review would have higher rates of missing data and be associated with substantial bias with respect to timing of procedural milestones.

Methods

The John Paul Pryor Shock Trauma and Resuscitation Center at the University of Pennsylvania evaluates ~2700 contacts annually, of which ~21% are victims of penetrating trauma. The state of Pennsylvania is located in the northeastern region of the United States and is the fifth most populous state in the country. The Trauma Quality Improvement Audiovisual Program has been an integral part of quality improvement and education efforts at our centre since the early 1990 s. At our institution, each of the 5 resuscitation bays is equipped with a continuously recording, high-definition audiovisual camera at the foot of the bed and another camera at the head of the bed (Fig. 1). These cameras continuously record all activity within the field of view 24-hours a day, seven days a week. Recordings are stored on a secure server for 28 days, after which time they are automatically deleted. Resuscitations with opportunities for improvement (including multiple patient scenarios, combative patients, and patients in extremis) are selected and reviewed in a monthly multidisciplinary conference with a focus on education and continuous quality improvement. As part of these efforts, we noted that there appeared to be significant variability in the times to completion of EDT which led to a quality improvement effort focused on this procedure.

For this project, we reviewed the resuscitations of every patient who underwent an emergency department thoracotomy between April 2016 and September 2017 at our institution. All resuscitations were reviewed by one of three reviewers (DH, RD, KC). 10% of videos were co-abstracted independently and reviewed together to ensure time points were similarly defined. We used TVR to carefully review every resuscitation in which a patient underwent a EDT, from the moment the patient arrived until the patient moved on to the next phase of care. Reviewers were able to play, pause, rewind and fast-forward recordings. The ability to pause and resume playback allows for very accurate data collection in a prospective fashion as-if it the resuscitation is occurring in real-time.

The first aim of this study was to describe the central tendencies and variability in times to completion of procedural milestones. Based on the cardinal steps of emergency department thoracotomy and available literature [17], we defined four procedural milestones for EDT: 1. Decompression of the right chest (tube thoracostomy, finger thoracostomy, or clamshell thoracotomy with transverse sternotomy performed in conjunction with left anterolateral thoracotomy) 2. Retractor deployment 3. Pericardiotomy 4. Aortic Cross-clamp (Table 1). Using TVR, we rigorously measured the time to completion of these procedures from a.) patient arrival in the trauma bay and b.) from the time of emergency department thoracotomy skin incision. Because right chest decompression ideally occurs by a second provider and in conjunction with left chest entry, it is possible for the right chest to be decompressed prior to completion of the left anterolateral thoracotomy. We defined times to procedural milestones as high outliers if they met or exceeded the 75th percentile of time to completion of at least one milestone or those cases which were deficient in one or more milestones (e.g. no right chest decompression). The second aim of this study was to compare the data collection using TVR compared to review of the electronic medical record (EMR). We compared the rates of missingness for TVR and EMR data abstraction. Because TVR recordings contain a running time-date clock, we also calculated the percentage bias between time measurements derived from TVR and EMR for each of the four procedural milestones defined above.
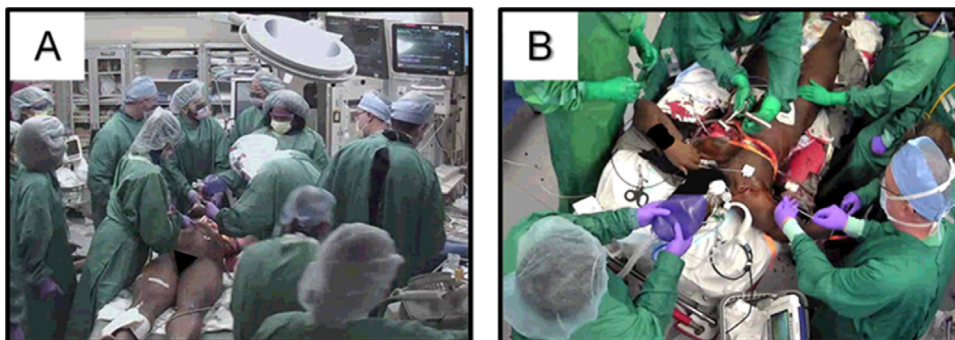

Fig. 1. Representative views from the foot-of-the-bed (A) and overhead (B) high-definition video recording cameras located in each resuscitation bay.