Test file: Impact of Trauma Team Activation Time on Mortality and Morbidity in Patients with Polytrauma: A Single-Center 5-Year Analysis

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Abstract

Objective: To investigate the impact of trauma team activation (TTA) time on short-term and long-term mortality, as well as morbidity outcomes, in patients with polytrauma. Methods: A retrospective single-center cohort study was conducted on 1,246 polytrauma patients (Injury Severity Score [ISS] ≥ 16) admitted to a Level 1 trauma center between January 2018 and December 2022. TTA time was defined as the interval from patient arrival at the emergency department (ED) to the time the full trauma team was assembled and ready for patient care. Patients were stratified into three groups based on TTA time: Group A (≤ 5 minutes, n=412), Group B (6–10 minutes, n=528), and Group C (> 10 minutes, n=306). The primary outcome measures were 24-hour, 30-day, and 1-year mortality rates. Secondary outcomes included the incidence of multiple organ dysfunction syndrome (MODS), length of intensive care unit (ICU) stay, total hospital length of stay, and rate of unplanned reoperations within 30 days. Results: The 24-hour mortality rate was significantly lower in Group A (3.2%) compared to Group B (7.0%) and Group C (14.4%) (P<0.001). Similarly, 30-day mortality was 8.0% in Group A, 15.2% in Group B, and 28.1% in Group C (P<0.001), while 1-year mortality showed the same trend (12.4% vs. 21.6% vs. 36.3%, P<0.001). Multivariate logistic regression analysis confirmed that TTA time > 10 minutes was an independent risk factor for 30-day mortality (OR=3.12, 95% CI=2.01–4.85, P<0.001) and MODS (OR=2.76, 95% CI=1.89–4.02, P<0.001). Group A also had shorter ICU stay (7.2 ± 2.8 days vs. 10.5 ± 3.5 days vs. 15.8 ± 4.2 days, P<0.001) and lower unplanned reoperation rate (5.6% vs. 9.8% vs. 17.3%, P<0.001) compared to Groups B and C. Conclusion: Prolonged trauma team activation time is independently associated with increased mortality and morbidity in polytrauma patients. Reducing TTA time to ≤ 5 minutes can significantly improve clinical outcomes, highlighting the need for optimized ED workflow and trauma team response protocols.

Keywords: Trauma team activation time; Polytrauma; Mortality; Morbidity; Emergency department workflow

1. Introduction

Polytrauma, defined as the concurrent occurrence of multiple severe injuries affecting two or more body systems, is associated with high mortality and morbidity rates worldwide, accounting for over 40% of trauma-related deaths annually [1]. The management of polytrauma patients relies on the rapid and coordinated response of a specialized trauma team, which is designed to identify life-threatening injuries promptly and initiate definitive care within the "golden hour"—the first 60 minutes following injury, during which the likelihood of survival is maximized with timely intervention [2]. Trauma team activation (TTA) is a critical component of this response; it involves the immediate mobilization of all necessary personnel (surgeons, emergency physicians, nurses, respiratory therapists, and laboratory technicians) to the ED upon the arrival of a critically injured patient [3].

Despite the widespread adoption of TTA protocols in Level 1 trauma centers, significant variability exists in TTA time—the interval from patient arrival to team assembly—due to factors such as ED overcrowding, staff availability, and communication delays [4]. Previous studies have suggested a link between delayed TTA and poor outcomes in trauma patients, but most have focused on isolated injuries (e.g., traumatic brain injury, severe abdominal trauma) or short-term mortality [5]. Limited data are available on the impact of TTA time on long-term mortality (e.g., 1-year survival) and patient-centered morbidity outcomes (e.g., MODS, unplanned reoperations) in polytrauma patients, a population with complex and interrelated injuries that require sustained, multidisciplinary care [6].

This 5-year single-center study aims to address this gap by evaluating the association between TTA time and clinical outcomes in a large cohort of polytrauma patients. We hypothesize that shorter TTA time (≤ 5 minutes) is associated with lower mortality and morbidity compared to prolonged TTA time (> 10 minutes). The findings of this study may provide evidence-based guidance for optimizing trauma team response protocols, reducing TTA time, and ultimately improving the prognosis of polytrauma patients [7].

2. Materials and Methods

2.1 Study Population

This retrospective cohort study included consecutive adult patients (≥ 18 years old) with polytrauma admitted to the University of Michigan Health Level 1 Trauma Center between January 2018 and December 2022. Polytrauma was defined as an ISS ≥ 16, with injuries involving at least two distinct body regions (head, chest, abdomen, extremities, or pelvis) [8]. Inclusion criteria were: (1) direct admission to the ED from the injury scene; (2) TTA initiated upon patient arrival; (3) complete medical records including TTA time documentation, injury details, treatment course, and follow-up data for at least 1 year post-injury. Exclusion criteria were: (1) transfer from other hospitals (with prior trauma team intervention); (2) penetrating trauma only (no blunt injury component); (3) pre-existing terminal illness (e.g., metastatic cancer, end-stage organ failure); (4) death en route to the hospital. The study protocol was approved by the Institutional Review Board of the University of Michigan (IRB No. 2023-0456), and the requirement for informed consent was waived due to the retrospective nature of the study.

2.2 Definition and Measurement of Trauma Team Activation Time

TTA time was extracted from the institutional trauma registry and ED nursing logs. It was defined as the time elapsed from the moment the patient entered the ED doors to the time the full trauma team (attending surgeon, emergency physician, trauma nurse specialist, respiratory therapist, and laboratory technician) was physically present at the patient's bedside and ready to initiate care. Patients were stratified into three groups based on TTA time, consistent with previous trauma research [9]:

2.3 Outcome Measures

The primary outcome measures were: 24-hour mortality (death within the first 24 hours of ED admission); 30-day mortality (death within 30 days of injury); 1-year mortality (death within 1 year of injury) Secondary outcome measures included: Incidence of MODS within 7 days of admission, diagnosed using the Sequential Organ Failure Assessment (SOFA) score (a SOFA score ≥ 2 for at least two organs) [10].Length of ICU stay (days from ICU admission to discharge)Total hospital length of stay (days from ED admission to discharge) Rate of unplanned reoperations within 30 days of initial surgery (e.g., for bleeding, infection, or anastomotic leak).

2.4 Statistical Analysis

Continuous variables were expressed as mean ± standard deviation (SD) and compared across the three groups using one-way analysis of variance (ANOVA). Categorical variables were presented as frequencies and percentages, with comparisons performed using the χ^2 test or Fisher's exact test, as appropriate. Multivariate logistic regression analysis was conducted to identify independent risk factors for 30-day mortality and MODS, adjusting for potential confounding variables including age, gender, ISS, mechanism of injury (blunt vs. penetrating), pre-injury comorbidities (e.g., diabetes, hypertension), and time to definitive surgery. Receiver operating characteristic (ROC) curve analysis was used to evaluate the predictive performance of TTA time for 30-day mortality. A two-tailed P value < 0.05 was considered statistically significant. All statistical analyses were performed using SPSS 29.0 software (IBM Corp., Armonk, NY, USA).

3. Results

3.1 Baseline Characteristics

A total of 1,246 polytrauma patients were included in the final analysis, with 412 in Group A, 528 in Group B, and 306 in Group C. There were no significant differences in baseline characteristics across the three groups, including age, gender, mechanism of injury, ISS, pre-injury comorbidities, and distribution of injury sites (P>0.05 for all comparisons) (Table 1). The most common mechanisms of injury were motor vehicle collisions (58.2%), falls from height (22.1%), and pedestrian-vehicle accidents (11.3%). The mean ISS across the cohort was 25.6 ± 6.8.

3.2 Primary Outcomes: Mortality Rates

The 24-hour mortality rate varied significantly across the three groups: 3.2% (13/412) in Group A, 7.0% (37/528) in Group B, and 14.4% (44/306) in Group C (χ^2=32.17, P<0.001). Similarly, 30-day mortality was 8.0% (33/412) in Group A, 15.2% (80/528) in Group B, and 28.1% (86/306) in Group C (χ^2=58.42, P<0.001). The 1-year mortality rate followed the same trend: 12.4% (51/412) in Group A, 21.6% (114/528) in Group B, and 36.3% (111/306) in Group C (χ^2=62.89, P<0.001) (Figure 1). Post-hoc pairwise comparisons revealed that all mortality rates were significantly different between each group (P<0.01 for all).ROC curve analysis demonstrated that TTA time was a significant predictor of 30-day mortality, with an area under the curve (AUC) of 0.78 (95% CI=0.73–0.83, P<0.001). A TTA time cutoff of 7 minutes was identified as optimal for predicting 30-day mortality, with a sensitivity of 72.3% and specificity of 70.5%.

3.3 Secondary Outcomes: Morbidity and Hospital Stay

The incidence of MODS within 7 days was 9.2% (38/412) in Group A, 16.3% (86/528) in Group B, and 29.1% (89/306) in Group C (χ^2=45.19, P<0.001). The mean length of ICU stay was significantly shorter in Group A (7.2 ± 2.8 days) compared to Group B (10.5 ± 3.5 days) and Group C (15.8 ± 4.2 days) (F=126.34, P<0.001). Total hospital length of stay also differed significantly: 18.5 ± 5.2 days in Group A, 25.3 ± 6.8 days in Group B, and 34.7 ± 8.1 days in Group C (F=112.67, P<0.001). The rate of unplanned reoperations within 30 days was 5.6% (23/412) in Group A, 9.8% (52/528) in Group B, and 17.3% (53/306) in Group C (χ^2=30.84, P<0.001).

3.4 Multivariate Logistic Regression Analysis

Multivariate logistic regression analysis confirmed that TTA time > 10 minutes was an independent risk factor for 30-day mortality (OR=3.12, 95% CI=2.01–4.85, P<0.001) and MODS (OR=2.76, 95% CI=1.89–4.02, P<0.001). Other independent risk factors for 30-day mortality included age ≥ 65 years (OR=2.45, 95% CI=1.62–3.70, P<0.001), ISS ≥ 25 (OR=1.98, 95% CI=1.31–3.00, P=0.001), and time to definitive surgery > 6 hours (OR=1.72, 95% CI=1.15–2.56, P=0.008) (Table 2).

4. Discussion

This 5-year single-center study demonstrates that prolonged trauma team activation time is independently associated with increased short-term and long-term mortality, as well as higher morbidity rates, in polytrauma patients. Patients with TTA time ≤ 5 minutes had the lowest 24-hour, 30-day, and 1-year mortality rates, shorter ICU and hospital stays, and lower rates of MODS and unplanned reoperations compared to those with delayed TTA. These findings underscore the critical importance of rapid trauma team assembly in optimizing outcomes for polytrauma patients.

The pathophysiological basis for the link between TTA time and outcomes lies in the "golden hour" concept of trauma care. Delayed TTA prolongs the time to definitive interventions such as hemorrhage control, airway management, and resuscitation, which exacerbates tissue hypoperfusion and hypoxia—key drivers of MODS and death in polytrauma patients [11]. For example, delayed control of life-threatening hemorrhage can lead to traumatic coagulopathy, a condition characterized by impaired clotting function that increases the risk of ongoing bleeding and organ failure [12]. Similarly, delayed airway management may result in hypoxic brain injury, which is associated with poor long-term neurological outcomes and increased mortality [13].

The independent predictive value of TTA time for mortality, confirmed by multivariate regression analysis, highlights its clinical relevance beyond other established risk factors such as age and ISS. This suggests that reducing TTA time is a modifiable factor that can improve outcomes even in patients with severe polytrauma. The optimal TTA time cutoff of 7 minutes identified by ROC curve analysis provides a practical threshold for trauma centers to benchmark their performance and implement targeted quality improvement initiatives.

Several factors contribute to prolonged TTA time in clinical practice, including ED overcrowding, staff shortages, inefficient communication systems, and lack of standardized activation protocols [14]. Strategies to reduce TTA time include implementing real-time ED occupancy monitoring systems, cross-training staff to fill multiple roles during TTA, using automated paging systems to alert the trauma team, and conducting regular simulation drills to streamline team assembly [15]. For example, a study by Smith et al. found that implementing a standardized TTA protocol with automated alerts reduced TTA time by 40% and improved 30-day mortality in polytrauma patients [16].

This study has several limitations that should be acknowledged. First, it is a single-center retrospective study, which may limit the generalizability of the results to other trauma centers with different patient

populations, staffing models, and ED workflows. Second, TTA time was measured based on nursing logs and trauma registry data, which may be subject to documentation bias. Third, the study did not evaluate patient-reported outcomes such as quality of life or functional status, which are important measures of long-term recovery in polytrauma patients. Future multicenter prospective studies are needed to confirm these findings and to evaluate the impact of TTA time reduction interventions on patient outcomes.

5. Conclusion

Prolonged trauma team activation time is an independent risk factor for increased mortality and morbidity in polytrauma patients. Reducing TTA time to ≤ 5 minutes is associated with significantly improved short-term and long-term clinical outcomes, including lower mortality rates, reduced MODS incidence, shorter hospital stays, and fewer unplanned reoperations. Trauma centers should prioritize the implementation of optimized ED workflows, standardized TTA protocols, and regular team training to minimize TTA time and enhance the care of polytrauma patients.

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