Factors associated with delay in trauma team activation and impact on patient outcomes

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ABSTRACT

Objective: Trauma code activation is initiated by emergency physicians using physiological and anatomical criteria, mechanism of injury, and patient demographic factors. Our objective was to identify factors associated with delayed trauma team activation.

Methods: We assessed consecutive cases from a regional trauma database from January 2008 to March 2014. We defined a delay in trauma code activation as a time greater than 30 minutes from the time of arrival. We conducted univariate analysis for factors potentially influencing trauma team activation, and we subsequently used multiple logistic regression analysis models for delayed activation in relation to mortality, length of stay, and time to operative management.

Results: Patients totalling 846 were included for our analysis; 4.1% (35/846) of trauma codes were activated after 30 minutes. Mean age was 40.8 years in the early group versus 49.2 in the delayed group ($p = 0.01$). Patients were over age 70 years in 7.6% in the early activation group versus 17.1% in the delayed group ($p = 0.04$). There was no significant difference in sex, type of injury, injury severity, or time from injury between the two groups. There was no significant difference in mortality, median length of stay, or median time to operative management.

Conclusions: Delayed activation is linked with increasing age with no clear link to increased mortality. Given the severe injuries in the delayed cohort that required activation of the trauma team, further emphasis on the older trauma patient and interventions to recognize this vulnerable population should be made.

RÉSUMÉ

Introduction: Les codes d'appel des équipes de soins en traumatologie (EST) sont déclenchés par les médecins d'urgence selon des critères physiologiques et anatomiques, le type de blessure et des facteurs démographiques. L'étude visait à cerner des facteurs associés au retard d'appel des EST.

Méthode: L'étude consistait en l'évaluation de cas consécutifs de traumas inscrits dans une base de données régionale, pendant la période de janvier 2008 à mars 2014. Les retards d'appel ont été définis comme un délai supérieur à 30 minutes à partir de l'arrivée. Nous avons d'abord procédé à une analyse univariée de différents facteurs susceptibles d'influer sur l'appel des EST, puis nous avons eu recours à des modèles d'analyse de régression logistique multiple pour établir des relations entre les retards d'appel des EST et la mortalité, la durée de séjour ainsi que le temps écoulé avant la prise en charge chirurgicale.

Résultats: L'analyse a porté sur 846 patients, et 4,1 % (35/846) des codes d'appel des EST ont été déclenchés après une période de 30 minutes. L'âge moyen était de 40,8 ans dans le groupe de soins spécialisés précoces et de 49,2 ans dans le groupe de soins spécialisés tardifs ($p = 0,01$). Les patients âgés de plus de 70 ans composaient 7,6 % de la population dans le groupe de mise en branle précoce contre 17,1 % dans le groupe de mise en branle retardée ($p = 0,04$). Il n'y avait pas de différence importante entre les deux groupes quant au sexe, au type de blessure, à la gravité des lésions et au temps écoulé depuis la survenue de l'accident. Aucun écart important n'a été relevé entre les deux groupes en ce qui concerne la mortalité, la durée médiane du séjour ainsi que le temps médian écoulé avant la prise en charge chirurgicale.

Conclusion: Les retards d'appel des EST sont liés à un âge avancé, mais aucun lien n'a été clairement établi entre les retards et une augmentation de la mortalité. Compte tenu de la gravité des blessures observées dans la cohorte de mise en branle retardée, qui a pourtant nécessité l'appel de ces équipes, il faudrait mettre davantage l'accent sur les patients âgés traumatisés et les interventions pour discerner cette population vulnérable.

Keywords: trauma, triage, trauma team activation, emergency medicine

INTRODUCTION

Injury is a major source of morbidity and accounts for 9% of global mortality.[1] It is the leading cause of death for young people in Canada ages 1 to 34[2] years and also an important cause of hospitalization, impairment, and disability throughout all age groups, including seniors.[3]

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Patient care at dedicated trauma centres has been shown to both lower mortality and improve functional outcomes in trauma patients.[4,5] Trauma teams are multidisciplinary and made up of emergency medicine physicians, anesthetists, general surgeons, nurses, and other support staff led by a team leader. The aim of this team is to rapidly assess and stabilize the trauma patient and arrange definitive treatment. Trauma code activation is most frequently initiated by emergency physicians using physiological and anatomical criteria, mechanism of injury, and patient demographic factors, in conjunction with data obtained from emergency medical service personnel. Specific criteria for activation at our institution can be seen in Figure 1.

Having a dedicated trauma team composed of emergency physicians and trauma surgeons has been shown to improve mortality among severely injured trauma patients.[6] Delayed activation of the trauma team has been shown previously to be a common provider-related complication in evaluating trauma service performance.[7] Delayed trauma team activations at a Level II trauma centre in the United States were significantly linked to patients over age 55, non-white ethnicity, blunt force assault, Glasgow Coma Scale (GCS) of 15, Injury Severity Score (ISS) of 16 or higher, and head injury with maximum Abbreviated Injury Scale (AIS) of 3 or higher. In this study, they found no link with increased mortality for delayed trauma team activation but did find that hospital length of stay was longer, and discharge to a rehabilitation facility was more common.[8] There has been no study looking at delayed trauma team activation in the Canadian setting. Our goal was to identify factors that may be associated with delayed activation in our setting to inform our trauma team activation policy.

Our study assessed delays in trauma code activation in the setting of a Canadian Level I trauma centre. Our objectives were to 1) analyse factors associated with delayed activation of the trauma team to help characterize the patient populations who are at risk for potential poor outcomes in trauma and 2) determine patient outcomes between those who had no delay versus those who had a delay in trauma code activation.

METHODS

We conducted an ethics review board-approved health records review to augment data already collected as part of a regional trauma data repository. Our tertiary care regional trauma centre serves a population of 1.23 million people over a 17,000 square-kilometer area with an annual patient census of more than 70,000.[9] Our centre is a regional adult referral centre that receives referrals from 13 hospitals within a regional trauma network as well as occasionally from hospitals outside of our trauma network. A trauma bypass procedure exists for paramedics to divert directly to our trauma centre instead of the nearest hospital in our network when appropriate. Trauma patients at our centre, if requiring admission, would be admitted under the care of a trauma surgeon to a dedicated trauma unit or to an intensive care unit, if they had more immediate life-threatening injuries. When a trauma patient is seen in the emergency department (ED), he or she is assessed by the emergency physician who makes a decision to activate the trauma team, which activates a multidisciplinary team, including a trauma team leader as well as early X-ray and computed tomography (CT) imaging.

Consecutive trauma cases from January 2008 to March 2014 were selected for review. As seen in Figure 2, we included any trauma code activation by an emergency physician. Trauma code activations that were accepted directly to the trauma service prior to arrival to the ED were excluded. These patients would have had the trauma team activated automatically upon patient arrival prior to emergency physician assessment and were managed differently with the emergency physician not involved in the decision to activate the trauma team. These two patient populations would differ in acuity and time from injury, and, for this study, we were looking specifically at the decision-making of the emergency physician to activate the team or not. Based upon a prior study looking at delay in trauma team activation, we defined delay in trauma code activation as a time greater than 30 minutes from the time of arrival in the ED to the activation of the trauma team.[8]

A single reviewer identified cases meeting the inclusion criteria from data already available in a trauma database maintained by a data analyst. A standardized data extraction form was completed, including age, sex, mechanism of injury, ISS, history of ethanol use, time from injury, and time of presentation. We looked at whether patients were transferred via ground or air ambulance. The ground ambulance crews consisted of both primary care paramedics and advanced care paramedics who have additional training and scope of practice above primary care paramedics. For example,

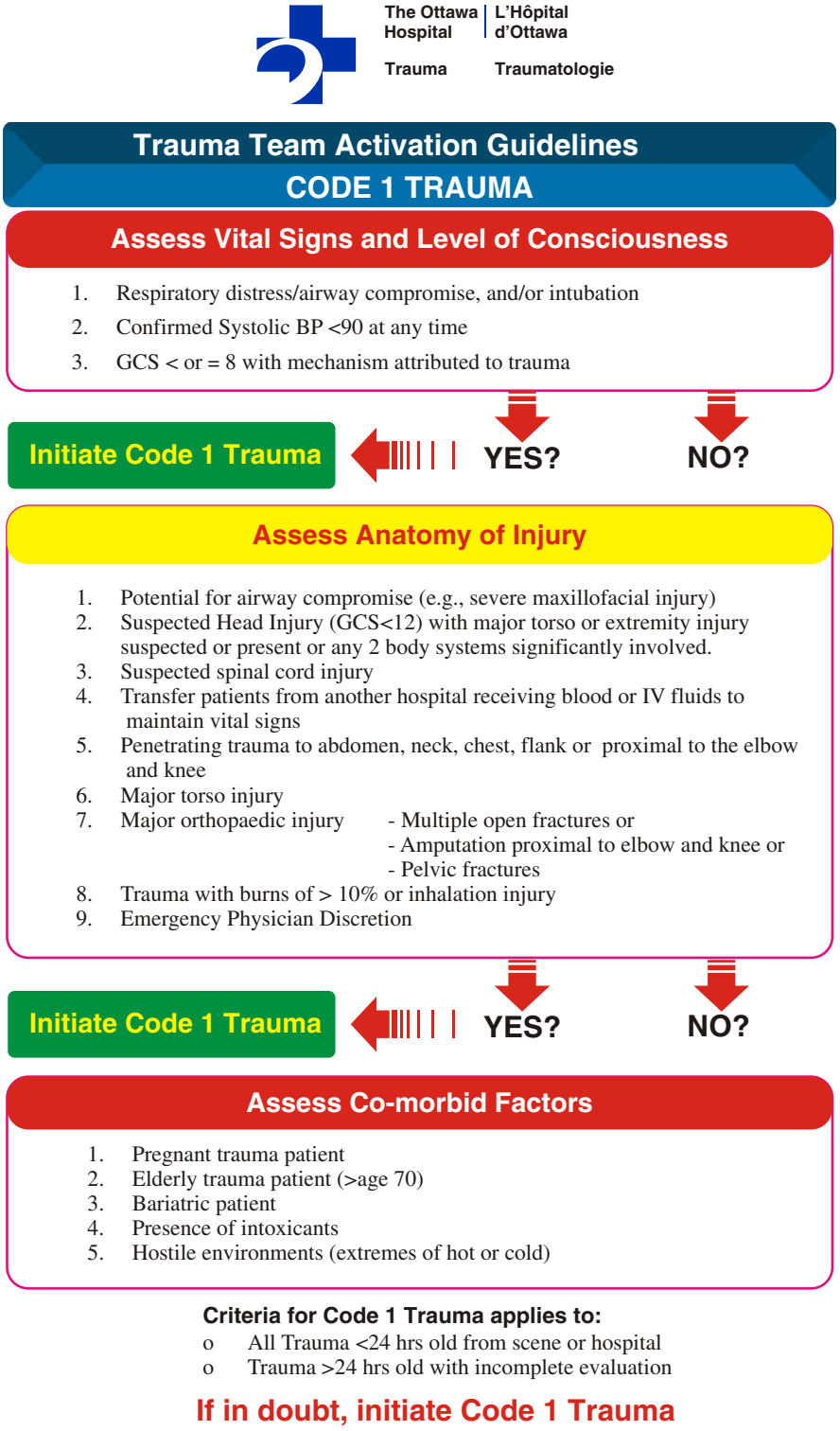

Figure 1. The Ottawa Hospital Trauma Team Activation Guidelines.

advanced care paramedics would be trained in endotracheal intubation, compared to primary care paramedics, who would be limited to supraglottic airways. Air ambulance crews included critical care paramedics who have a greatly expanded scope of practice above advanced care paramedics, such as rapid sequence

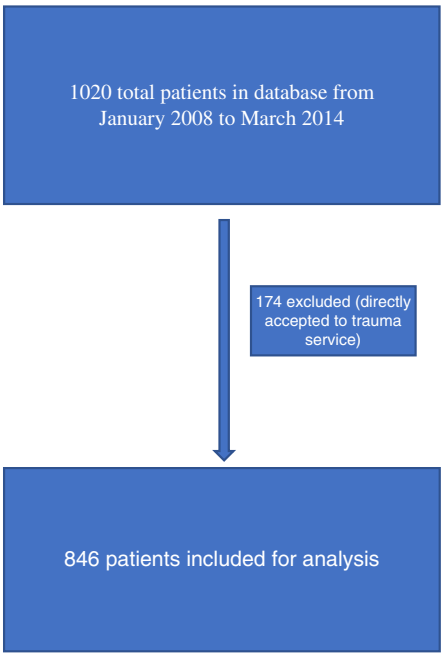

Figure 2. Summary of patients included for analysis.

induction intubation. Some of the emergency physicians also work as trauma team leaders at our centre, although not while they are staffing the ED. We looked at this variable and the emergency physicians' experience, whether they had been involved in more than 10 codes over the study period. We also looked at patient arrival by time of day. Comparison of severity of injury between the two groups was done using the AIS (1-6) and ISS. AIS 1-6 are based on the following regions: head and neck, face, chest, abdomen, extremities, and external injuries. From the AIS scores, a total ISS is calculated, which is a standardized measure of injury severity.[10] All data from codes, which were identified as delayed, were checked manually via chart review, and any missing data from the trauma repository were extracted via chart review for those cases. In cases of discrepancy between data from the chart and the database, the chart data were used. For two datapoints in the database, there were substantial missing data, including 32.3% did not have any data on blood alcohol level, and 23.6% of patients did not have a time of injury.

Data were collected on a Microsoft Excel sheet and exported into the Statistical Analysis System (SAS). A univariate analysis was performed to look at factors that may influence trauma team activations. We subsequently used multiple regression analysis models for delayed activation in relation to discharge destination, mortality, length of stay, and time to operative management.

RESULTS

From 1,020 patients identified by the trauma database, 174 patients were excluded because they were seen directly by the trauma team, leaving 846 patients for analysis. Table 1 summarizes the baseline patient characteristics. The mean age was 41.2 years old with 77.4% being male. The mean ISS score was 21.8. The mechanism of injury in the majority of patients was from blunt trauma (74.0%) followed by penetrating injuries (25.5%). Most patients were transferred to the hospital by ground ambulance (88.7%), with 9.5% via air ambulance; 1.9% of patients were walk-in arrivals and not via ambulance, and 14.7% were transferred from another hospital for assessment by an emergency physician. These patients were not accepted directly to the trauma team; 23.5% of all patients had an ethanol level measured above the Canadian legal limit for operating a motor vehicle, although a large proportion (32.3%) was not tested.

Table 2 shows the outcome data for all patients in the study; 5.8% of these patients died in the ED, and 85.0% survived to discharge; 41.5% of all patients were discharged home, 16.3% were sent to a specialized rehabilitation facility, and 2.2% percent were sent to other discharge destinations, which consisted mainly of local homeless shelters and group homes.

A comparison between early and delayed activation of the trauma team can be seen in Table 3. In trauma codes, 4.1% (35/846) were activated after 30 minutes. The median length of time from arrival to activation of the trauma team was 5 minutes in the early group versus 41 minutes in the delayed group ($p < 0.01$). Mean ISS scores were very similar between the two groups as well as component AIS scores and physiological data. Delayed trauma activation was more frequent in older patients. Mean age was significantly different between the two groups at 40.8 years in the early group versus 49.2 in the delayed group ($p = 0.01$). Age over 55 years was also statistically significant (22.4% in the early group v. 37.1% in the delayed group; $p = 0.04$). Age over 70 years was statistically significant (7.6% in the early group v. 17.1% in the delayed group; $p = 0.04$). There was no statistical difference in terms of what time of day that the patient arrived in the ED. There was a higher percentage of blunt trauma in the delayed group

Table 1. Baseline characteristics of trauma patients (N = 846)

Male (%)	655 (77.4)
Age > 55 years (%)	195 (23.1)
Age > 70 years (%)	70 (8.3)
Mean age (years)	41.2
Median time from injury to arrival at ED (minutes)	44.0
Mean Injury Severity Score (ISS)	21.8
Mechanism of injury	
Blunt (%)	626 (74.0)
Penetrating (%)	216 (25.5)
Burns (%)	3 (0.4)
Drowning (%)	1 (0.1)
Transportation from scene	
Land EMS (%)	750 (88.7)
Air EMS (%)	80 (9.5)
Private (%)	16 (1.9)
Transfer from outside hospital (%)	124 (14.7)
EP also works as a TTL (%)	85 (10.1)
EP experience in > 10 codes (%)	754 (89.1)
*Ethanol level**	
> 17 mmol/L (%)	199 (23.5)
< 17 mmol/L (%)	374 (44.2)
No data (%)	273 (32.3)
Transfusion in ED (%)	164 (19.4)

ED = emergency department; EMS = emergency medical services; EP = emergency physician; TTL = trauma team leader.
*Blood alcohol legal limit in Canada = 17 mmol/L.

Table 2. Outcome characteristics of trauma patients (N = 846)

Disposition from ED	
Intensive care unit (%)	242 (28.6)
Operation room (%)	233 (27.5)
Trauma unit (%)	204 (24.1)
Died in ED (%)	49 (5.8)
Ward (%)	49 (5.8)
Discharged (%)	47 (5.6)
Interventional radiology (%)	7 (0.8)
Transfer to acute care hospital (%)	6 (0.7)
Left against medical advice (%)	4 (0.5)
Neurological observation unit (%)	3 (0.4)
Cardiac surgery unit (%)	1 (0.1)
Obstetrics unit (%)	1 (0.1)
Operative management during admission (%)	415 (49.1)
Discharge destination (%)	
Home (%)	351 (41.5)
Special rehab facility (%)	138 (16.3)
Died (%)	127 (15.0)
Transfer to acute care hospital (%)	77 (9.1)
Home with support services (%)	63 (7.5)
Convalescence care (%)	26 (3.1)
Left against medical advice (%)	13 (1.5)
Retirement home (%)	12 (1.4)
Chronic care facility (%)	10 (1.2)
Police custody (%)	10 (1.2)
Other* (%)	22 (2.2)
Median length of stay (days)	10
Median time from arrival to operative management (minutes)	329.5

ED = emergency department.
*Other destinations included local homeless shelters, nursing homes, and unknown.

(85.7% v. 73.5%), but this did not approach statistical significance ($p = 0.3$). Emergency physician level of experience was similar between the early and delayed groups.

As seen in Table 4, there was no significant difference in mortality. Survival to discharge was 84.8% in the early group versus 88.6% in the delayed group ($p = 0.54$). Median length of stay was identical at 10 days in both groups. Median time from arrival in the ED to operative management was similar (331.0 minutes in the early group v. 277.5 minutes in the delayed group; $p = 0.52$). There was no significant difference in terms of hospital discharge destination or destination from the ED.

DISCUSSION

Our data, in the setting of a Canadian Level I trauma centre, showed that approximately 4% of trauma team activation occurs after 30 minutes. The only clear association was age, in terms of risk factors for delayed activation. There was no difference in terms of outcome data such as mortality, hospital length of stay, or time to operative management. The two groups were similar in terms of their severity of injuries. Elderly trauma patients are recognized by trauma guidelines to be at risk for more adverse outcomes post-injury,[11] and age over 70 years is included in the trauma activation guidelines at our institution (see Figure 1). Age over 70 years has also been postulated to be a cut-off for increased mortality in elderly trauma patients.[12] Elderly patients may not mount the same physiological response to trauma as younger patients do to both age and medications, such as beta blockers, and therefore their vital signs may be falsely reassuring. In general, the small percentage of delayed activation and the lack of any differences in outcome likely mean that the activation system is working efficiently. However, it appears that, despite data and guidelines stating that elderly patients are at high risk of poor outcomes, they are still at risk for under-triage, and further emphasis on

Table 3. Comparison of early versus delayed activation of trauma team

	Early activation ≤30 min (N = 811)	Delayed activation >30 min (N = 35)	*p*
Mean age (years)	40.8	49.2	0.01
Age > 55 years (%)	182 (22.4)	13 (37.1)	0.04
Age > 70 years (%)	62 (7.6)	6 (17.1)	0.04
Male (%)	630 (77.7)	25 (71.4)	0.39
Blood ethanol > 17 mmol/L (%)	190 (23.4)	9 (25.7)	0.26
Transfusion in emergency room (%)	158 (19.5)	6 (17.1)	0.73
Mean ISS	21.8	21.6	0.94
AIS1 (mean)	1.8	1.9	0.81
AIS2 (mean)	0.4	0.3	0.47
AIS3 (mean)	1.9	1.7	0.35
AIS4 (mean)	1.0	0.7	0.34
AIS5 (mean)	1.4	1.8	0.08
AIS6 (mean)	0.5	0.4	0.15
Type of injury			0.30
Blunt (%)	596 (73.5)	30 (85.7)	
Penetrating (%)	211 (26.0)	5 (14.3)	
Burn (%)	3 (0.4)	0 (0.0)	
Drowning (%)	1 (0.1)	0 (0.0)	
Arrival			0.15
Air (%)	76 (9.4)	4 (11.4)	
Land (%)	721 (88.9)	29 (82.9)	
Private (%)	14 (1.7)	2 (5.7)	
Arrival time			0.33
Day shift (%)	248 (30.6)	11 (31.4)	
Evening shift (%)	337 (41.6)	18 (51.4)	
Night shift (%)	226 (27.7)	6 (17.1)	
Median time from injury to arrival (minutes)	44.0	52.0	0.09
Median time from arrival to activation (minutes)	5.0	41.0	<0.01
Patient vitals on arrival			
Temperature in degrees (mean)	35.5	35.6	0.70
Heart rate bpm (mean)	93.2	84.1	0.08
Respiratory rate (mean)	20.4	20.8	0.81
Systolic BP (mean)	128.5	134.8	0.29

AIS = Abbreviated Injury Scale; BP = blood pressure; bpm = beats per minute.

having a low threshold for trauma activation in the elderly would be appropriate.

To our knowledge, this is the only Canadian study looking at delayed trauma team activation. Ryb et al. undertook a similar study looking at trauma team activation at their Level II trauma centre in Maryland (United States).[8] Similar to the Ryb et al. study, we found mean age to be statistically significant. Unlike their study, we did not find blunt trauma, a higher ISS, or head injury as significant causes of delayed activation of the trauma team. As seen in their study, there were no differences in patient outcomes. Our population of trauma patients was substantially sicker, and it would seem that we have a much higher threshold to activate the trauma team. Our mean ISS was 21.8, which was substantially higher than seen in the Ryb et al. study, which had a median ISS in their delayed activation group of 9 and 5 in their early activation group. Our median length of stay was also much higher (10 v. 1-2 days). This likely represents a difference in practice between the two centres of when to activate the trauma team.

Another study in Maryland (United States)[13] has shown that patients over the age of 70 years were less likely to be transported to trauma centres, despite meeting criteria, and attributed this to an unconscious

Table 4. Outcome data comparing early versus late activation of trauma team

	Early activation ≤30 min (N = 811)	Delayed activation >30 min (N = 35)	*p*
Destination from ED (%)			0.48
Intensive care unit (%)	236 (29.1)	6 (17.1)	
Operative management (%)	224 (27.6)	9 (15.7)	
Trauma unit (%)	193 (23.8)	11 (31.4)	
Died in ED (%)	48 (5.9)	1 (2.9)	
Ward (%)	45 (5.6)	4 (11.4)	
Discharged (%)	43 (5.3)	4 (11.4)	
Interventional radiology (%)	7 (0.9)	0 (0.0)	
Transfer to acute care hospital (%)	6 (0.7)	0 (0.0)	
Left against medical advice (%)	4 (0.5)	0 (0.0)	
Neurological observation unit (%)	3 (0.4)	0 (0.0)	
Cardiac surgery (%)	1 (0.1)	0 (0.0)	
Obstetrics unit (%)	1 (0.1)	0 (0.0)	
Operative management during admission (%)	397 (48.9)	18 (51.4)	0.77
Survival to discharge (%)	688 (84.8)	31 (88.6)	0.81
Discharge from hospital (%)			0.10
Home (%)	340 (41.9)	11 (31.4)	
Special rehab facility (%)	135 (16.7)	3 (8.6)	
Died (%)	123 (15.2)	4 (11.4)	
Transfer to acute care hospital (%)	72 (8.9)	5 (14.3)	
Home with support services (%)	57 (7.0)	6 (17.1)	
Convalescence care (%)	24 (3.0)	2 (5.7)	
Left against medical advice (%)	13 (1.6)	0 (0.0)	
Retirement home (%)	11 (1.4)	1 (2.9)	
Chronic care facility (%)	10 (1.2)	0 (0.0)	
Police custody (%)	9 (1.1)	1 (2.9)	
Other (%)	17 (2.1)	2 (5.7)	
Median length of stay (days)	10	10	0.94
Time from arrival to operative management in minutes (median)	331.0	277.5	0.52

age bias. It is possible that this unconscious bias is what contributed to the increase in age in the delayed population in our study.

Some of the limitations of this study include that it is retrospective and, as such, prone to all of the limitations of retrospective studies. Given that this was a local study of one trauma system, it may not be generalizable to other trauma systems. It was not practical to go through each case in the early activation group to see whether the cases met trauma code activation criteria, mainly due to lack of clear charting around decisions to activate the team. The exact criteria for activation for each case in the delayed group were not clear; therefore, the reason for delays remain unclear. This is likely multifactorial and, given the increased age in the delayed group, represents an unconscious bias to either undertriage or delay activation of the trauma team in elderly patients. There were also data that were incompletely captured, and it is possible there were cases that were missed entirely in the trauma database, because each case was put in manually by a research assistant, which could bias our results. We tried to mitigate this by using a large sample size over several years and looking at the delayed codes in further detail. It was not possible to assess cases that were never called as trauma codes but met activation guidelines. Importantly, given the relatively small number of delayed activation, this study may be underpowered to see differences in outcome data, including morbidity and mortality.

CONCLUSION

Our trauma activation guidelines appear to result in very few delayed activations of the trauma team.

Trauma team activation delays were not associated with worse outcomes in our population. Delayed activation is linked with increasing age. Considering there were severe injuries in this delayed cohort that required activation of the trauma team, this suggests that further emphasis and intervention on the aging trauma patient should be made to recognize this vulnerable population. This is especially important given an increasingly aging population that will likely result in a larger percentage of geriatric trauma in the future.

Competing interests: None declared.

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