


Original Article

The efficacy of a trauma call system: challenges in managing severe trauma at a rural emergency center without full-time emergency physicians

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Aims: There have been some reports about the efficacy of trauma team activation. In November 2015, we implemented a trauma call system, wherein a general surgeon, neurosurgeon, and orthopedic surgeon are called to the emergency department when severe trauma patients are transferred to our emergency department. In this study, we evaluated the efficacy of this trauma call system.

Methods: The purpose of the present study was to evaluate the efficacy of a trauma call system for trauma cases with an Injury Severity Score ≥ 16 . We compared the mortality of trauma cases and the time from arrival to the start of the examination and intervention before and after implementing this trauma call system.

Results: There was no significant difference in the mortality rates before and after the implementation of the trauma call system. The median time from arrival to the start of contrast-enhanced computed tomography or transcatheter arterial embolization improved from 54 to 19 min ($P = 0.015$) and 171 to 84 min ($P = 0.030$), respectively, after the implementation of the trauma call system.

Conclusion: Our trauma call system did not significantly improve the mortality of trauma patients with an Injury Severity Score ≥ 16 . However, it was effective for reducing the time from the arrival to the start of contrast-enhanced computed tomography or transcatheter arterial embolization.

Key words: Contrast-enhanced CT, transcatheter arterial embolization (TAE), trauma, trauma call, trauma team activation

INTRODUCTION

TRAUMA CASES REQUIRE great care and are a battle against time, especially as some patients have damage to multiple organs. Emergency physicians and general surgeons are needed on trauma resuscitation teams, the size and composition of which can vary according to hospital size, the severity of injury, and the corresponding level of trauma team activation (TTA).¹ In addition, neurosurgeons and orthopedic surgeons are also required for the appropriate

management of trauma cases.¹ Some studies have reported that TTA is effective for reducing the time from arrival to examination and intervention.^{2,3} Khetarpal *et al.* reported that the presence of an attending trauma surgeon on a trauma team reduced the time to incision for a stab wound or gunshot wound.² The trauma team consisted of a board-certified general surgeon, a board-certified emergency medicine physician, a chief surgical resident, and two junior general surgery residents. The faculty surgeon was present with the patient in the emergency department (ED) and was actively involved in the resuscitation and all subsequent care. An attending surgeon was in the hospital 24 h a day.² Rados *et al.* reported that TTA helped to reduce the time to head computed tomography (CT).³ The trauma team included an attending trauma surgeon, residents from the critical care medicine department, a respiratory therapist, and an anesthesiologist, in addition to emergency physicians and nurses.³

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We found that some trauma patients with hemorrhagic shock who were treated at our hospital had not received appropriate resuscitation or hemostasis. We therefore discussed the management of severe trauma cases, mainly among general surgeons. We concluded that TTA might be effective for facilitating prompt resuscitation and hemostasis, and diagnosis severe trauma cases. In November 2015, we implemented a trauma call system, wherein a general surgeon, neurosurgeon, and orthopedic surgeon are called to the ED when severe trauma patients are transferred to our hospital. Our TTA staff is considered to be too small in comparison to previous reports,^{2,3} but it did include surgeons from various fields.¹ We hypothesized that our trauma call system might help reduce the time from arrival to the start of the examination and intervention, thereby improving the mortality. In this study, we evaluated the efficacy of this trauma call system.

Emergency system in our hospital

Our hospital in western Kagawa Prefecture, Japan, has 478 beds and a rural emergency center. The hospital has two computed tomography (CT) rooms located next to the ED with 320- and 256-slice systems. There are 10 general surgeons, three neurosurgeons, and five orthopedic surgeons at our facility; however, the emergency center does not employ a full-time doctor. Furthermore, because there is no doctor helicopter or trauma center in this prefecture, all severe trauma patients in the area, which has a population of approximately 130,000, are transferred to our hospital. The emergency service at our institution uses a rotation system whereby the staff (general surgeon, neurosurgeon, orthopedic surgeon, urologist, and plastic surgeon) changes depending on the day of the week. It is therefore not uncommon for physicians with little experience in treating severe trauma cases to sometimes have to treat severe trauma patients.

Trauma call system

General surgeons, neurosurgeons, and orthopedic surgeons are included on trauma calls because trauma cases often involve injury to the head, chest, abdomen, pelvis, and/or extremities. Interventional radiologists are also needed to implement hemostasis in severe trauma cases. In our hospital, as a general rule, transcatheter arterial embolization (TAE) is carried out by an interventional radiologist. However, our hospital only employs one interventional radiologist. To avoid overburdening this individual, the interventional radiologist is not involved in the trauma call system and is only summoned when a trauma patient is diagnosed with hemorrhage requiring TAE.

The trauma call system was established using examples from the doctor helicopter keyword system. We input keywords related to the mechanism of injury, mainly with reference to past severe trauma cases experienced at our hospital, including massive hemorrhage, shock, falls, pedestrians or cyclists hit by motor vehicles, explosions, and rescue cases. When the information from the medical service fits any of these keywords, a trauma call is activated before the patient arrives. The trauma call system is also activated when patients with suspected severe trauma that is not associated with the abovementioned keywords are transferred to our department.

METHODS

THE PURPOSE OF the present study was to evaluate the efficacy of a trauma call system for trauma cases with an Injury Severity Score (ISS) ≥ 16 . This study was a single-center, observational, retrospective trial. The data of patients who were treated from April 2014 to March 2018 were collected from medical records and evaluated. Patients treated from April 2014 to October 2015, from before the implementation of the

Table 1. Characteristics of trauma patients (Injury Severity Score [ISS] ≥ 16)

	BITC (n = 90)	AITC (n = 157)	P-value [†]
Median age, years	72.5	73	0.500
Male sex	58 (64.4)	108 (68.8)	0.485
Median ISS	16	18	0.137
Head AIS >3	31 (34.4)	53 (33.8)	1.000
Chest AIS >3	19 (21.1)	28 (17.8)	0.614
Abdomen AIS >3	8 (8.9)	8 (5.1)	0.286
Extremities including pelvis >3	4 (4.4)	6 (3.8)	1.000
Mortality number	12 (13.3)	33 (21.0)	0.170
Severe head injury	6 (6.7)	17 (10.8)	0.365
CPAOA	3 (3.3)	9 (5.7)	0.544
CPAAA	0 (0.0)	2 (1.3)	0.535
Complication	0 (0.0)	1 (0.6)	1.000
Hemorrhagic shock	3 (3.3)	4 (2.5)	0.708
Hemostasis (+)	1 (1.1)	4 (2.5)	0.655
Hemostasis (–)	2 (2.2)	0 (0.0)	0.132

Data are shown as median values or n (%).

[†]Mann–Whitney U-test or Fisher's exact test.

AITC, after implemented trauma call system; AIS, Abbreviated Injury Score; BITC, before implemented trauma call system; CPAAA, cardiopulmonary arrest immediately after arrival; CPAOA, cardiopulmonary arrest on arrival.

Table 2. Comparison of time from arrival to start of examination (Injury Severity Score [ISS] ≥ 16)

	BITC	AITC	<i>P</i> -value [†]
From arrival to start of plain CT			
Cases	79	117	
Male sex, <i>n</i> (%)	52 (65.8)	81 (69.2)	0.642
Median ISS	16	17	0.245
Mortality, <i>n</i> (%)	10 (12.7)	18 (15.4)	0.680
Time (min)			
Median	13	14	0.757
Minimum	4	4	
First interquartile	10	12	
Third interquartile	21	20	
Maximum	225	57	
From arrival to start of contrast-enhanced CT			
Cases	24	46	
Median age	61.5	71.5	0.146
Male sex, <i>n</i> (%)	19 (79.2)	34 (73.9)	0.772
Media ISS	18	25	0.198
Mortality, <i>n</i> (%)	3 (12.5)	9 (19.6)	0.526
Time (min)			
Median	54	19	0.015
Minimum	10	7	
First interquartile	20.75	14	
Third interquartile	109.5	45.75	
Maximum	279	236	

[†]Fisher's exact test or Mann–Whitney *U*-test.

AITC, after implemented trauma call system; BITC, before implemented trauma call system; CT, computed tomography.

trauma call system, were classified into the BITC group; those treated from November 2015 to March 2018, after the implementation of the trauma call system were classified into the AITC group. Cases in which the trauma call system was not activated were also included. The primary outcome of this study was mortality. The secondary outcome was the time from arrival at the ED to the start of the CT scan (plain and contrast-enhanced), transfusion, and emergency hemostasis (TAE and laparotomy). This study was approved by the ethics committee

of Mitoyo General Hospital (Kanonji-shi, Japan; 17CR-01-043), and the study protocol was published on the website of Mitoyo General Hospital. The Mann–Whitney *U*-test, multiple regression analysis, or Fisher's exact test was used for comparisons between two groups (EZRV version 1.33, Saitama Medical Center, Jichi Medical University, Saitama, Japan). *P*-values < 0.05 were considered to indicate statistical significance.

Effect of the trauma call system on mortality

A total of 250 trauma cases with an ISS ≥ 16 were identified. Three cases were excluded because of death due to blunt cervical spine injury (spine Abbreviated Injury Score 9), as the ISS could not be determined. As a result, 247 cases in the BITC ($n = 90$) and AITC ($n = 157$) groups were compared (Table 1).

Time from arrival to start of plain CT

One hundred ninety-six trauma cases with an ISS ≥ 16 underwent plain CT. We compared the time from arrival to the start of plain CT between the BITC ($n = 79$) and AITC ($n = 117$) groups.

Time from arrival to start of contrast-enhanced CT

Seventy trauma cases with an ISS ≥ 16 underwent enhanced CT. We compared the time from arrival to the start of contrast-enhanced CT between the BITC ($n = 24$) and AITC ($n = 46$) groups. We also undertook a multiple regression analysis. The time from arrival to the start of contrast-enhanced CT was established as an objective variable. The period and prognosis were established as explanatory variables.

Time from arrival to start of transfusion

Fifty-six trauma patients with an ISS ≥ 16 underwent emergency transfusion. We compared the time from arrival to the

Table 3. Multiple regression analysis (predictive factor of reduction of time from arrival to start of contrast-enhanced computed tomography)

Explanatory variable	Coefficient	Standard error	95% Confidence interval	<i>t</i>	<i>P</i> -value
AITC	−35.599	13.399	−62.343 –8.856	−2.657	0.010
Prognosis	−1.772	16.875	−35.454 16.875	−0.105	0.917

AITC, after implemented trauma call system.

start of transfusion between the BITC ($n = 24$) and AITC ($n = 32$) groups.

Time from arrival to start of TAE

Twenty-seven trauma cases with an ISS ≥ 16 underwent emergency TAE. Four cases were excluded due to being transferred from other hospitals for hemostasis ($n = 2$) and TAE not being able to be carried out immediately post-diagnosis because the angiography room was being used ($n = 2$). As a result, 23 trauma cases ultimately underwent emergency TAE. We compared the time from arrival to the start of TAE between the BITC ($n = 9$) and AITC ($n = 14$) groups.

Time from arrival to start of laparotomy

Eight trauma cases with an ISS ≥ 16 underwent emergency laparotomy for hemostasis. We compared the time from arrival to the start of laparotomy between the BITC ($n = 3$) and AITC ($n = 4$) groups.

RESULTS

Effect of the trauma call system on mortality

THE MORTALITY RATE was 13.3% in the BITC group and 21.0% in the AITC group, and did not differ to a statistically significant extent ($P = 0.17$) (Table 1).

Time from arrival to start of plain CT

The median time from arrival to the start of plain CT was 13 min in the BITC group and 14 min in the AITC group, and did not differ to a statistically significant extent ($P = 0.757$) (Table 2).

Time from arrival to start of contrast-enhanced CT

The median time from arrival to the start of contrast-enhanced CT in the BITC group (54 min) was significantly longer than that in the AITC group (19 min; $P = 0.015$) (Table 2). The multiple regression analysis revealed that the implementation of a trauma call was a predictor of a reduced time from arrival to the start of contrast-enhanced CT (Table 3).

Time from arrival to start of transfusion

The median time from arrival to the start of transfusion was 155 min in the BITC group and 137.5 min in the AITC group, and did not differ to a statistically significant extent ($P = 0.240$) (Table 4).

Table 4. Comparison of time from arrival to start of intervention (Injury Severity Score [ISS] ≥ 16)

	BITC	AITC	<i>P</i> -value [†]
From arrival to start of transfusion			
Cases	24	32	
Median age, years	69.5	74	0.121
Male sex, <i>n</i> (%)	16 (66.7)	23 (71.9)	0.772
Median ISS	20	25	0.639
Mortality, <i>n</i> (%)	7 (29.2)	9 (28.1)	1.000
Time (min)			
Median	155	137.5	0.240
Minimum	66	16	
First interquartile	98	64.5	
Third interquartile	209	198.75	
Maximum	566	547	
From arrival to start of TAE			
Cases	9	14	
Median age, years	46	74.5	0.095
Male sex, <i>n</i> (%)	6 (66.7)	8 (57.1)	1.000
Median ISS	16	27.5	0.150
Mortality, <i>n</i> (%)	1 (11.1)	4 (28.6)	0.611
Time (min)			
Median	171	84	0.030
Minimum	75	46	
First interquartile	97	63	
Third interquartile	301	112.25	
Maximum	491	326	
From arrival to start of laparotomy			
Cases	3	4	
Median age, years	75.5	39	0.359
Male sex, <i>n</i> (%)	3 (100.0)	3 (75.0)	1.000
Median ISS	18	22	0.476
Mortality, <i>n</i> (%)	0 (0.0)	0 (0.0)	1.000
Time (min)			
Median	176	217	1.000
Minimum	134	121	
First interquartile	155	129.25	
Third interquartile	189	303.75	
Maximum	202	309	

[†]Fisher's exact test or Mann–Whitney *U*-test.

AITC, after implemented trauma call system; BITC, before implemented trauma call system; TAE, transcatheter arterial embolization.

Time from arrival to start of TAE

The median time from the arrival to the start of TAE in the BITC group (171 min) was significantly longer than that in the AITC group (84 min; $P = 0.030$) (Table 4).

Time from arrival to start of laparotomy for hemostasis

The median time from arrival to the start of laparotomy for hemostasis was 176 min in the BITC group and 132 min in the AITC group, and did not differ to a statistically significant extent ($P = 1.000$) (Table 4).

DISCUSSION

THERE HAVE BEEN some reports on TTA.^{2,3} Khetarpal *et al.* reported that the presence of an attending trauma surgeon on a trauma team made it possible to reduce the time from hospital arrival to the start of surgery for stab wounds or gunshot wounds; however, it did not reduce mortality.² They reported a large difference between the two groups in the number of patients who were managed for penetrating trauma; thus, they considered that the Trauma and Injury Severity Score methodology might not have been able to accurately detect differences in the outcome. Similarly, the mortality did not improve at our institution; this might have been because the AITC group had higher rates of severe head injury and cardiopulmonary arrest on arrival than the BITC group (Table 1). Patients with severe head injury often presented with severe contusions and hemorrhage and, in most cases, it was impossible to save the patients' lives. Furthermore, the sample size was relatively small. Rados *et al.* reported that TTA helped reduce the time to head CT (49.5 to 26 min).³ They attributed this reduction in time to the presence of a trauma surgeon as the team leader. Some reports have suggested the importance of having a trauma team leader.^{3,4} Trauma team activation reduced the time from arrival to the start of contrast-enhanced CT or TAE in the present study. At our institution, general surgeons often lead the trauma team. We believe that the presence of a leader can help reduce the time from arrival to the start of contrast-enhanced CT or TAE. Furthermore, in TTA cases, doctors with backgrounds in different disciplines are involved in the initial treatment from the early phase. In particular, the evaluation of CT findings is useful for some doctors to detect the source of hemorrhage quickly and to promptly decide on the method for achieving hemostasis. Thus, despite the inclusion of trauma call inactivated cases in this study, the times from the arrival to the start of contrast-enhanced CT or TAE were shortened. One reason for this was because many doctors were worried about the occurrence of hemorrhage after the trauma call system was implemented.

A number of reports on TAE have been published recently.^{5–7} Otsuka *et al.* reported that in 16 patients who underwent interventional radiology (IVR) before

surgery to control the main causes of hemorrhage based on CT findings, the mean time from arrival to the start of TAE was 56.3 (± 26.6) min, with no preventable trauma deaths and eight unexpected survivors.⁵ Various reports have described the time from arrival to the start of TAE. At an institution using a hybrid emergency room fitted with an IVR-CT system in the trauma resuscitation room, the time was 73 min before the installation of the IVR-CT system and 48 min after the installation.⁶ Olthof *et al.* reported that the time to TAE for splenic injury was 117 min in hemodynamically stable patients and 46 min in hemodynamically unstable patients at a Dutch level 1 trauma center.⁷ In comparison to these previous findings, our median time from arrival to the start of TAE (84 min) was not very fast. However, the overall time was greatly reduced.

There have also been some reports regarding recommendations for emergency laparotomy. Matsumoto *et al.* reported on the indications of urgent resuscitative surgery in the ED.⁸ Martin *et al.* reported on the utility of bypassing the ED and proceeding directly to the operating room.⁹ Both reports found that patients with a low blood pressure tended to undergo emergency laparotomy within a few minutes of arrival at both locations, and that the observed survival rate was higher than the predicted survival rate. At our institution, we are unfortunately unable to undertake emergency laparotomy in the ED due to a shortage of staff. Furthermore, it is not always possible for surgeons and anesthesiologists to carry out emergency laparotomy immediately because of the large number of previously scheduled surgeries. Thus, the time from arrival to the start of emergency laparotomy for hemostasis did not improve.

We make concerted efforts to rescue trauma patients. To ensure the best chance of saving the patient, we try to reduce the time from arrival to the start of examination and intervention. While our institution cannot provide the same quality medical service to trauma patients as a high-grade trauma center,^{8,9} we try to rescue as many patients as possible and intend to further develop this system.

This study is associated with several limitations, including the small study cohort, the single-center setting, the retrospective design, and the fact that it was not a randomized controlled study. The doctor who provided the initial treatment was not considered. Further studies will be required to confirm our findings.

CONCLUSION

OUR TRAUMA CALL system had no significant effect on mortality of trauma patients with an ISS ≥ 16 .

However, it was effective for reducing the time from arrival to the start of contrast-enhanced CT or TAE.

DISCLOSURE

Approval of the research protocol: This study was approved by the ethics committee of Mitoyo General Hospital.

Informed consent: N/A.

Registry and the registration no. of the study/trial: 17CR-01-043.

Animal studies: N/A.

Conflict of interest: N/A.

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