

Emergency trauma laparotomy and/or thoracotomy in the emergency department: risks and benefits

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ABSTRACT

Background It is not mandatory for Japanese trauma centers to have an operating room (OR) and OR team available 24 hours a day/7 days a week. Therefore, emergency laparotomy/thoracotomy is performed in the emergency department (ED). The present study was conducted to assess the safety of this practice.

Methods The data were reviewed from 88 patients who underwent emergency trauma laparotomy and/or thoracotomy performed by our acute care surgery group during the period from April 2013 to December 2017. Operation was performed in the ED for 43 of 88 patients (51%, ED group), and in the OR for 45 of 88 patients (49%, OR group). The perioperative outcomes of the two groups were compared.

Results Compared with the OR group, the ED group had a higher Injury Severity Score (30 ± 15 vs. 13 ± 10 , $p < 0.01$), greater incidence of blunt trauma (74% (32/43) vs. 36% (16/45), $p < 0.01$), larger volume of red blood cell transfusion (18 ± 18 units vs. 5 ± 10 units, $p < 0.01$), higher incidence of new-onset shock after sedation among patients who received sedation in the ED (59% (17/29) vs. 25% (6/24), $p < 0.01$), and higher in-hospital mortality rate (49% (21/43) vs. 0, $p < 0.01$). All five patients who underwent laparotomy followed by thoracotomy died in the ED; none of these patients underwent preoperative placement of resuscitative endovascular balloon occlusion of the aorta (REBOA). Of the 21 patients in the ED group who died, 17 (81%) died immediately postoperatively; furthermore, 12 of the 22 patients who survived (55%) were not in shock prior to operation.

Discussion Emergency trauma laparotomy and/or thoracotomy outcomes were related to injury severity. The resources for trauma operations in the ED seemed suboptimal. The outcome of trauma operations may be improved by reviewing the protocols for anesthetic care, and by the usage of REBOA rather than aortic cross-clamping.

Level of evidence IV

INTRODUCTION

It is well known that timely surgical intervention is crucial for trauma patients with intra-abdominal bleeding.¹⁻³ To ensure that trauma laparotomy is performed in a timely fashion, the American College of Surgeons Committee on Trauma requires level I trauma centers in the USA to have an operating room (OR) and OR staff (including anesthesiologists and scrub nurses) available 24 hours a day/7 days a week.⁴ In contrast, the Japanese Association for the Surgery of Trauma (JAST) does not mandate constant OR availability,⁵ and so an OR and/or

anesthesiologists are not always available for emergency trauma operation. Thus, trauma surgeons in Japan sometimes perform trauma laparotomy and/or thoracotomy in the trauma resuscitation room located in the emergency department (ED). However, this practice is not standard in western countries; therefore, there are few studies published regarding the safety of laparotomy and/or thoracotomy for trauma patients in the ED. The present study was conducted to describe the outcomes and assess the risks and benefits of this practice pattern.

PATIENTS AND METHODS

A retrospective review of the medical records was performed for patients who underwent emergency trauma laparotomy/thoracotomy performed by the acute care surgery service in our institution. The assessed variables included patient demographics, mechanism of injury, Injury Severity Score (ISS), Revised Trauma Score (RTS), Trauma and Injury Severity Score probability of survival (TRISS Ps), type of operation, location of operation, time from admission to operation, incidences of shock, usage of sedation, preoperative endovascular procedures, transfusions, length of intensive care unit (ICU) stay, surgical site infection rate, and in-hospital mortality rate. For patients who underwent operation in the ED, risk factors associated with in-hospital mortality were analyzed.

We defined shock as a systolic blood pressure (SBP) of less than 90 mm Hg. We followed the resuscitation protocol of the Japan Advanced Trauma Evaluation and Care (JATEC)⁶ edited by the JAST. The JATEC protocol is essentially the same as that of the advanced trauma life support.⁴ The same resources were available in every ED and every OR used in the present study.

In the ED, operations were performed in the trauma resuscitation room. A regular stretcher was used as an operating table. The packaged laparotomy and thoracotomy sets were stored on a shelf in the room, and were immediately available in patients requiring operation. These sets included basic surgical instruments to perform damage control operation. If definitive complex operations were needed, the patient was moved to the OR once hemostasis was achieved. There were no scrub technicians in the ED. Some ED nurses had some training in assisting with instruments during operation. If these nurses were not available, one of the ED physicians sometimes scrubbed in. The intraoperative anesthetic care was given by surgeons or ED physicians.

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**Table 1** Patient characteristics

	OR group (n=45)	ED group (n=43)	P value
Males, n (%)	31 (69)	29 (67)	0.88
Age (years), mean±SD	45±19	44±20	0.18
Blunt trauma, n (%)	16 (36)	32 (74)	<0.01
Injury Severity Score, mean±SD	13±10	30±15	<0.01
Revised Trauma Score	7±1	6±2	<0.01
TRISS probability of survival, %	92±19	67±37	<0.01
Systolic blood pressure at admission, mm Hg	119±25	92±46	<0.01
Heart rate at admission, beats per minute	92±24	100±39	0.04

OR group: trauma patients who underwent emergency operation in the operating room; ED group: trauma patients who underwent emergency operation in the emergency department.

ED, emergency department; OR, operating room; TRISS, Trauma and Injury Severity Score.

Trauma operations in the OR were performed in the same setting as elective operations. Anesthesiologists, scrub technicians, and circulating nurses were involved.

RESULTS

From April 2013 to December 2017, a total of 88 patients underwent emergency trauma laparotomy and/or thoracotomy performed by our acute care surgery group. Operation was performed in the ED for 43 of 88 patients (49%, ED group), and in the OR for 45 of 88 patients (51%, OR group). The patient characteristics of both groups are summarized in [table 1](#). Compared with the OR group, the ED group had a higher incidence of blunt trauma. The ED group also had a higher ISS and lower RTS than the OR group; thus, the TRISS Ps was lower in the ED group. The ED group were more hypotensive and tachycardic at admission compared with the OR group ([table 1](#)).

The preoperative variables are summarized in [table 2](#).

Table 2 Preoperative variables

	OR group (n=45)	ED group (n=43)	P value
Time from the scene to hospital (min), mean±SD	22±20	31±50	0.04
Shock (SBP <90 mm Hg) at the scene, n (%)	9 (20)	19 (44)	0.02
Shock at admission, n (%)	5 (11)	17 (40)	<0.01
Shock prior to operation, n (%)	8 (18)	25 (58)	<0.01
Cardiopulmonary arrest at admission, n (%)	0	5 (12)	0.02
Administration of sedation in the emergency department, n (%)	24 (53)	29 (67)	0.18
New-onset shock after sedation, n (%)	6/24 (25*)	17/29 (59*)	<0.01

OR group: trauma patients who underwent emergency operation in the operating room; ED group: trauma patients who underwent emergency operation in the emergency room.

ED, emergency department; OR, operating room; SBP, systolic blood pressure.

Table 3 Procedure-related variables

	OR group (n=45)	ED group (n=43)	P value
Preoperative IR, n (%)	1 (2)	3 (7)	0.28
REBOA, n (%)	1 (2)	5 (12)	0.08
Time from admission to operation (min), mean±SD, median (range)	196±238 111 (43–1340)	85±168 43 (0–1069)	0.09
Within 90 min, n (%)	14 (31)	33 (77)	<0.01
Type of operation			<0.01
Laparotomy only, n (%)	37 (82)	23 (54)	
Thoracotomy only, n (%)	8 (18)	5 (12)	
Laparotomy then thoracotomy, n (%)	0	5 (12)	
Thoracotomy then laparotomy, n (%)	0	3 (7)	
Retroperitoneal pelvic packing, n (%)	0	7 (16)	

OR group: trauma patients who underwent emergency operation in the operating room; ED group: trauma patients who underwent emergency operation in the emergency department.

ED, emergency department; IR, interventional radiology; OR, operating room; REBOA, resuscitative endovascular balloon occlusion of the aorta.

The time taken for the patient to be transported from the scene of the injury to the hospital was shorter in the OR group than the ED group. The incidences of shock at all timepoints were higher in the ED group than the OR group. Among the patients who received any type of sedation in the ED, new-onset shock was more frequent in the ED group than in the OR group.

The procedure-related variables are summarized in [table 3](#).

The ED group tended to undergo endovascular procedures (including transcatheter arterial embolization or resuscitative endovascular balloon occlusion of the aorta (REBOA)) more frequently than the OR group, although this intergroup difference was not significant. The ED group underwent operation more quickly than the OR group; operation was performed within 90 minutes from the time of admission more often in the ED group than the OR group. The majority of the OR group underwent laparotomy only, whereas laparotomy plus thoracotomy as well as retroperitoneal pelvic packing (RPPP) were performed more frequently in the ED group.

Postoperative outcomes are shown in [table 4](#).

Compared with the OR group, the ED group received a larger transfusion volume and had a longer ICU stay. The incidence of surgical site infection tended to be greater in the ED group compared with the OR group, although this intergroup difference was not significant. The in-hospital mortality rate was higher in the ED group than the OR group (in which there were no deaths); 17 of the 21 in-hospital deaths (81%) in the ED group occurred within 24 hours of operation.

[Table 5](#) shows the factors associated with mortality in the ED group.

Compared with the patients who survived, the patients who died had a lower RTS and TRISS Ps, more commonly had an etiology of blunt trauma, had higher incidences of REBOA placement and laparotomy followed by thoracotomy, and had a lower incidence of laparotomy alone. There were 12 patients who met the criteria for REBOA, but did not receive the procedure and died. The median time from arrival to occlusion was 61 minutes (range 27–65 minutes). The median duration of occlusion was 21 minutes (range 3–205 minutes). REBOA placement was performed after the failure of hemostasis during laparotomy

Table 4 Postoperative outcomes

	OR group (n=45)	ED group (n=43)	P value
Units of RBC transfused in 24 hours	5±6	18±19	<0.01
Units of FFP transfused in 24 hours	5±6	13±15	<0.01
Units of platelets transfused in 24 hours	4±8	12±15	<0.01
ICU stay, days	5±6	6±9	0.10
Total length of stay, days	26±60	18±31	0.55
Surgical site infection, n (%)	4 (9)	6 (14)	0.45
Death within 24 hours, n (%)	0	17 (40)	<0.01
Death while in hospital, n (%)	0	23 (49)	<0.01

Values are given as the mean±SD unless stated otherwise.

OR group: trauma patients who underwent emergency operation in the operating room; ED group: trauma patients who underwent emergency operation in the emergency department.

ED, emergency department; FFP, fresh frozen plasma; ICU, intensive care unit; OR, operating room; RBC, red blood cells.

or RPPP; the type of definitive hemorrhage intervention was laparotomy in four patients and RPPP in one patient.

DISCUSSION

Compared with trauma patients who underwent emergency operation in the OR, those who underwent emergency operation in the ED were more severely injured, with a larger requirement for transfusions, and a higher rate of mortality. Newly developed shock after the administration of sedative medication was more frequently observed in the ED group than the OR group. All five patients who underwent laparotomy followed by thoracotomy for aortic cross-clamping died. All five patients who received REBOA also died.

It is notable that 12 of the 21 deaths (81%) that occurred in the ED group were 'table deaths'; these patients may have been unsalvageable regardless of the location of operation. Among the 22 patients in the ED group who survived, 12 (54%) were not in shock prior to operation; these patients may have survived even after being transferred to the OR. Similar findings were reported from Norway.⁷ In Norway, trauma laparotomy was initially performed in the ED; however, from 2006 onwards, emergency trauma laparotomies have been performed in the OR, as the conditions in the ED were considered suboptimal for laparotomy.⁷ The Norwegian study reported that the time to operation was longer in the patients where laparotomy was performed in the OR rather than the ED⁷; however, the delay caused by performing the laparotomy in the OR did not increase the mortality.⁷

Aside from the surgical set-up, the other concern was the absence of anesthesiologists during operation in the ED group. In the ED, the anesthetic care is typically given by ED physicians with or without critical care training. One dose of sedative medication and neuromuscular blockade are typically given before intubation. After the sedative medication was given in the ED, newly developed shock occurred in 17 of 29 (59%) patients. It is possible that formal anesthetic care could have prevented these occurrences. Another possible reason for the deterioration of vital signs is that the resuscitation administered before the administration of sedatives may have been inadequate. Most of

Table 5 Risk factors for mortality in the ED group

	Survived (n=22)	Died (n=21)	P value
Age (years), mean±SD	38±19	51±19	0.89
ISS, mean±SD	25±14	35±15	0.86
RTS, mean±SD	7±1	5±3	0.01
TRISS Ps, %	81±29	51±40	0.02
Blunt trauma, n (%)	13 (59)	19 (91)	0.03
Time from admission to operation >90 min, n (%)	16 (73)	17 (81)	0.72
Shock (SBP <90 mm Hg) at the scene of the injury, n (%)	8 (36)	11 (52)	0.36
Shock at admission, n (%)	6 (27)	11 (52)	0.12
Shock prior to operation, n (%)	10 (46)	15 (71)	0.12
Shock after the induction of anesthesia, n (%)	10 (46)	7 (33)	0.54
REBOA placement, n (%)	0	5 (24)	0.02
Laparotomy alone, n (%)	18 (82)	5 (24)	<0.01
Thoracotomy alone, n (%)	1 (5)	14 (19)	0.19
Laparotomy then thoracotomy, n (%)	0	5 (24)	0.02
Thoracotomy then laparotomy, n (%)	1 (5)	2 (10)	0.61
Retroperitoneal pelvic packing, n (%)	2 (9)	5 (24)	0.10
Units of RBC transfused within 24 hours, mean±SD	19±15	22±21	0.13
Units of FFP transfused within 24 hours, mean±SD	14±14	12±15	0.67
Units of platelets transfused within 24 hours, mean±SD	14±15	10±15	0.15

ED group: trauma patients who underwent emergency operation in the emergency department.

ED, emergency department; FFP, fresh frozen plasma; ISS, Injury Severity Score; RBC, red blood cells; REBOA, resuscitative endovascular balloon occlusion of the aorta; RTS, Revised Trauma Score; SBP, systolic blood pressure; TRISS Ps, Trauma and Injury Severity Score probability of survival.

the included patients did not receive any intravenous fluids in the prehospital setting. After arriving in the trauma bay, patients who were in shock tended to be hurriedly intubated with minimal resuscitative fluids or transfusion. Some studies have suggested that patients with hemorrhagic shock should be resuscitated before intubation to avoid hypotension after the administration of sedative medications.^{8,9} This aspect of trauma care definitely needs improvement at our institution.

Another concerning finding in our study was the poor outcome of laparotomy followed by thoracotomy. These patients initially underwent laparotomy for intra-abdominal bleeding. When the abdominal bleeding was uncontrollable, thoracotomy was added to enable cross-clamping of the thoracic aorta for proximal control. Recent evidence revealed that REBOA could replace the performance of thoracotomy in the ED.¹⁰ Recent guidelines also recommend REBOA placement for patients with hemorrhagic shock due to bleeding below the diaphragm.¹¹ In retrospect, thoracotomy could have been omitted if REBOA was placed in the early stage of treatment.

In our series, poor outcomes were also exhibited by patients who received REBOA placement. During the study period, our institution had no standardized training program for REBOA placement, and no standardized indications for REBOA.



Therefore, REBOA placement was performed by untrained providers in patients who were almost dying after hemostasis had failed during laparotomy or RPPP. The median time from admission to REBOA placement was 61 minutes (range 27–65 minutes). A recent study reported that early arterial access (within 20 minutes) for REBOA is associated with better survival in trauma patients.¹² Because of these poor outcomes of REBOA, we have implemented a new REBOA protocol. REBOA is now only performed by trained surgeons, ED physicians, and interventional radiologists. A 5 Fr femoral sheath is used for trauma patients who present with an SBP of <90 mm Hg. If hemorrhage below the diaphragm is identified and the patient remains hypotensive after the administration of initial resuscitative fluids, the 5 Fr sheath is replaced by a 7 Fr sheath for REBOA before laparotomy or RPPP.

The limitations of our study include the retrospective study design, small sample size, and performance within a single institution. A matched cohort of patients treated in the ED versus the OR could be a better measure of potential differences in outcomes. However, not enough patients in the OR group were able to be matched to patients in the ED group. Furthermore, as we operated on any unstable patients in the ED, only hemodynamically stable patients were brought to the formal OR. Our institution recently installed a hybrid emergency room system (HERS), which is defined as a trauma resuscitation room equipped with a CT scanner, fluoroscopy, and an OR set-up.^{6,13} The HERS is located in the ED, and enables damage control operations and angioembolizations to be done in one place without transferring patients to the OR or the angiogram suite.^{14,15} We expect more operations to be performed in the ED in the era of the HERS.

Our study implied that the environment in the ED was not adequate for the performance of major trauma operation. We think that a high-level trauma center should have the full capability to perform emergency trauma operation involving surgeons and an OR team (anesthesiologists and scrub technicians). It might be more important to develop better collaboration between the trauma team and the OR team rather than performing trauma operations in the ED in a suboptimal setting.

Further study is warranted to assess the outcomes of trauma operations performed in the ED, and to establish a standard practical protocol that enables clinicians to provide the safest care in the timeliest fashion for severely injured patients.

CONCLUSIONS

The outcomes of emergency trauma laparotomy and/or thoracotomy performed in the ED seem to depend on the severity of injury. The resources for trauma operations in the ED seemed suboptimal. To improve the outcomes of operations, there needs to be a review of the protocols for anesthetic care, and the use of REBOA as a replacement for cross-clamping of the aorta.

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