Received: 10 October 2023 | Accepted: 17 January 2024

DOI: 10.1002/ams2.928

ORIGINAL ARTICLE

ACUTE MEDICINE & SURGERY WILEY

Treatment strategy for severe trauma patients requiring aortic occlusion for impending cardiopulmonary arrest in the hybrid emergency room

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Abstract

Aim: Computed tomography (CT) is useful in trauma care. Severely ill trauma patients may not tolerate whole-body CT even without patient transfer. This study examined clinical flow of severe trauma patients requiring aortic occlusion (AO) such as resuscitative thoracotomy or REBOA in the hybrid emergency room (ER) and investigated patient clinical courses prioritizing CT first versus resuscitation including AO first.

Methods: This retrospective, single-center observational study included consecutive trauma patients visiting our ER between May 2016 and February 2023. Patients were divided into the CT first group (whole-body CT preceded AO) and AO first group (AO preceded whole-body CT) and into two subgroups: AO after CT (AO/interventions for hemorrhage performed just after CT in the CT first group), and CT after AO (CT or damage control surgery performed after AO in the AO first group). We investigated 28-day survival rates.

Results: Survival probability by TRISS method was 49% (range: 3.3–94) in the CT first group ($n=6$) and 20% (range: 0.7–45) in the AO first group ($n=7$). Actual 28-day survival rates were 50% and 57%, respectively. Survival rates of the AO after CT subgroup (CT first group) were 75% (3/4) and 0% (0/2), respectively, and those of the CT after AO subgroup (AO first group) were 25% (1/4) and 100% (3/3), respectively.

Conclusion: In severe trauma patients with low predicted probability of survival treated in the hybrid ER, survival rates might be better if resuscitation including AO is performed before CT and if damage control surgery is performed first before CT.

KEYWORDS
CT, hybrid ER, REBOA, resuscitative thoracotomy, trauma

INTRODUCTION

We initially implemented a trauma workflow concept comprising a sliding computed tomography (CT) scanning system with interventional radiology features that allows CT examination and emergency therapeutic interventions in the same room without relocating the patient that we call the hybrid emergency room (hybrid ER). This emergency unit allows four functions: resuscitation, CT, surgery, and angiography.[1,2] We previously showed that this novel trauma workflow allowing immediate CT diagnosis and rapid bleeding control without patient transfer may improve mortality in severe trauma.[3] Another study reported that trauma treatment in a hybrid ER reduced blood transfusion amounts during

resuscitation.[4] As of March 2023, 24 tertiary care hospitals in Japan have a hybrid ER. We can perform multiple emergency procedures in the hybrid ER, including damage control surgery (DCS) and endovascular intervention after early CT diagnosis without relocating the patient. Hybrid ER use has also allowed safe and prompt initiation of other procedures such as extracorporeal membrane oxygenation for internal diseases such as massive pulmonary embolism.[5,6]

Whole-body CT in trauma care is becoming increasingly useful due to improved equipment performance and reduced imaging time and reportedly results in an actual patient survival rate higher than the predicted survival rate.[7,8] Despite proactive efforts to perform CT imaging in trauma care,[9–11] in patients with abdominal trauma requiring emergency surgery, a 1% increase in mortality was reported for every 3-min delay in surgery,[12] which makes CT imaging more prudent in some cases. Although CT results can be very important in developing a treatment strategy, in the severest trauma cases with impending cardiac arrest, even CT scans that do not require patient transfer might be dangerous and not tolerated by the patient. In such patients, whether CT scanning should always be performed first or whether resuscitative procedures including aortic occlusion (AO) should be performed first remains controversial even in centers with a hybrid ER.

This study aimed to describe clinical flow of severe trauma patients who required AO such as resuscitative thoracotomy (RT) or resuscitative endovascular balloon occlusion of the aorta (REBOA) in the hybrid ER and investigate the clinical course of these patients based on prioritization of whole-body CT scanning versus that of resuscitation including AO.

METHODS

Study design

Potentially eligible patients in this retrospective, single-center, observational study included consecutive trauma patients receiving RT with cross-clamping and/or REBOA in the emergency department of Kansai Medical University Medical Center, Osaka, Japan, between May 2016 and February 2023. The inclusion criterion was patients transferred directly from the scene of trauma to our hospital's hybrid ER. The exclusion criteria were patients transferred from another hospital, treated first in other than a hybrid ER, received prophylactic REBOA for bleeding control in laparotomy, non-hemorrhagic shock, and cardiopulmonary arrest (CPA) in the ambulance or at the trauma site. The included population was divided into the CT first group (whole-body CT preceded resuscitation including AO) and the AO first group (resuscitation including AO preceded whole-body CT) (Figure 1). In subgroup analysis, the CT first group was divided into two subgroups: CT followed by AO and by emergency procedures for hemorrhage. Similarly, the AO first group was divided into two subgroups: AO followed by CT and AO followed by DCS. Time courses and survival rates of these subgroups were calculated.

Hybrid ER trauma management policy

Our hybrid ER was installed in the trauma center in May 2016. The medical team leader is a trauma surgeon who performs both RT and REBOA. On arrival, the patients received fluid resuscitation, intubation, and thoracic drainage if necessary. We perform plain and contrast-enhanced CT (pan-scan) and develop treatment strategies such as DCS, transcatheter arterial embolization (TAE), external fixation, and burr hole craniotomy in the hybrid ER. In patients with impending CPA, the lead physician determines whether to proceed with resuscitation including AO before performing CT based on the patient's response to fluid resuscitation.

Data collection

Patients were followed until 28 days after admission. Emergency department variables (systolic blood pressure,

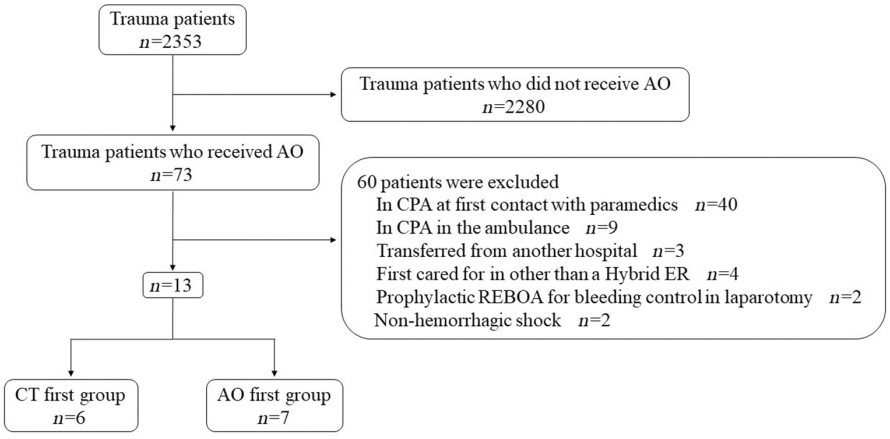

FIGURE 1 Flowchart of this study. AO, aortic occlusion; CPA, cardiopulmonary arrest; ER, emergency room; REBOA, resuscitative endovascular balloon occlusion of the aorta.

heart rate, respiratory rate, body temperature, Glasgow Coma Scale, hemoglobin, pH, base excess, and lactate value) were recorded as the initial set of vital signs and blood gas analyses at arrival. We then calculated the Injury Severity Score 2008, Revised Trauma Score, and probability of survival (Ps) by the Trauma and Injury Severity Score (TRISS) method. We recorded the mechanism of injury, AO type (RT or REBOA), fluid infusion and transfusion (red blood concentrate [RBC], fresh frozen plasma [FFP], platelet concentration [PC], and cryoprecipitate) administered in the hybrid ER, emergency procedure for hemorrhage (DCS, TAE, external fixation, and burr hole craniotomy), and pertinent times (arrival to AO, arrival to CT, arrival to intervention, and CT scanning time), 28-day survival, and cause of death.

Descriptive analysis and ethical concerns

Categorical data are summarized as frequencies and proportion and continuous variables as the median [range] as the data were not normally distributed. Descriptive analysis was performed with SPSS 28.0 software (IBM, NY, USA).

This study was conducted according to the principles of the Declaration of Helsinki and was approved by Kansai Medical University Medical Center—Institutional Review Board (Study Number: 2022329). Due to the retrospective study design, the requirement for written informed consent was waived by the Institutional Review Board.

RESULTS

In total, 2353 patients with trauma were presented to our emergency department between May 2016 and February 2023, among whom RT with cross-clamping or REBOA was performed in 73 patients. After removing the patients meeting the exclusion criteria, 13 patients were included in the analyses (Figure 1).

Baseline characteristics

Baseline characteristics of the included patients are shown in Table 1. This study cohort (median age, 63 [30–69] years) represented a significant injury population with a median ISS of 45 [22–59] and Ps of 34% [0.7%–94%]. Of these 13 patients, six underwent CT imaging before AO (CT first group), and seven underwent resuscitation including AO before CT imaging (AO first group). The TRISS method could be applied to all 13 patients. Fall from a height as the mechanism of injury occurred more frequently in the CT first group versus AO first group (67% vs. 14%). Systolic blood pressure on arrival were lower in the AO first group (71 [54–154] vs 50 [0–115] mm Hg). pH and base excess values were higher in the CT first group (7.36 [7.27 to 7.39] vs 7.11 [6.91 to 7.23] and −7.2 [−15.2 to −4.4] vs -17.5 [−18.4 to −11.1] mmol/L) and lactate was lower (5.1 [3.9 to 10.2] vs 9.8 [5 to 12.8] mmol/L). Ps by TRISS were lower in the AO first group (49 [3.3 to 94] vs 20 [0.7 to 45]).

Types of aortic occlusion, fluid administration, transfusion, and intervention

The numbers of performed AO types (RT with cross-clamping and REBOA) were 2/6 (33%) and 4/6 (67%) in the CT first group and 5/7 (71%) and 4/7 (57%) in the AO first group. The amounts of fluid administration between the CT first group and AO first group were median 2750 and 4000 mL, and numbers of RBC, FFP, PC, and cryoprecipitate transfusions were median 14 and 20 Units, 10 and 10 Units, 0 and 10 Units, and 0 and 0 Units, respectively. The number of patients undergoing emergency procedures for hemorrhage of DCS, TAE, external fixation, and burr hole craniotomy performed in the hybrid ER were 5/6 (83%), 5/6 (83%), 3/6 (50%), and 1/6 (17%) in the CT first group and 4/7 (57%), 5/7 (71%), 2/7 (29%), and 1/7 (14%) in the AO first group, respectively (Table 2).

Times from arrival and outcomes

The time from arrival to AO was longer in the CT first group versus AO first group (median 36 vs 7 min), whereas the time from arrival to CT scan was shorter (median 11 vs 27 min). The times (arrival to intervention and CT scanning time) between the groups (41 vs 27 min, and 5 vs 6 min, respectively). 28-day survivals were equal between the two groups (3/6 [50%] vs 4/7 [57%]). In the CT first group, two patients died of exsanguination and one of respiratory failure, and in the AO first group, two patients died of exsanguination and one of traumatic brain injury (Table 2).

Subgroup survival rates by clinical flow

In the CT first group, the survival rate of the subgroup in which CT, AO, and emergency procedure for hemorrhage were performed in that order was 75% (3/4), and that of the other subgroup (CT, emergency procedure for hemorrhage, and AO performed in that order) was 0% (0/2). In the AO first group, the survival rate of the subgroup in which AO, CT, and emergency procedure for hemorrhage were performed in that order was 25% (1/4), and that of the other subgroup (AO, DCS, CT, and emergency procedure for hemorrhage performed in that order) was 100% (3/3) (Table 3, Figures 2 and 3).

Details of the seven surviving patients

In the AO first group, the predicted Ps from the TRISS method was median 20%, but the actual survival rate was 4/7 (57%). However, in the CT first group, the Ps was median

TABLE 1 Baseline characteristics of the included patients on arrival

Characteristics	Total $N=13$	CT first group $N=6$	AO first group $N=7$
Men, *N*	10 (77%)	5 (83%)	5 (71%)
Age (years)	63 (30–69)	65 (33–69)	56 (30–67)
Mechanical of injury, *N*			
Motor vehicle accident	7 (54%)	2 (33%)	5 (71%)
Fall from a height	5 (38%)	4 (67%)	1 (14%)
Crush between objects	1 (8%)	0 (0%)	1 (14%)
Vital signs			
HR (bpm)	108 (66–152)	100 (66–140)	116 (70–152)
SBP (mm Hg)	60 (0–154)	71 (54–154)	50 (0–115)
RR (/min)	27 (17–49)	26 (17–49)	29 (19–37)
BT (Celsius)	35.8 (35.3–37.2)	35.7 (35.4–37.2)	36.0 (35.3–36.7)
GCS total score	7 (3–15)	9 (6–14)	7 (3–15)
RTS	5.2 (0–7.6)	5.6 (4.5–7.6)	4.7 (0–6.8)
Blood gas analysis			
Hb (g/dL)	11.5 (8.5–14.5)	12.3 (9.5–14.5)	11 (8.5–12.7)
pH	7.23 (6.91–7.39)	7.36 (7.27–7.39)	7.11 (6.91–7.23)
Base excess (mmol/L)	−11.1 (−18.4 to −4.4)	−7.2 (−15.2 to −4.4)	−17.5 (−18.4 to −11.1)
Lactate (mmol/L)	6.2 (3.9–12.8)	5.1 (3.9–10.2)	9.8 (5–12.8)
AIS			
Head	0 (0–5)	0 (0–5)	0 (0–5)
Face	0 (0–2)	0 (0–2)	0 (0–2)
Chest	3 (0–5)	3 (3–5)	3 (0–5)
Abdomen	3 (0–5)	3 (0–5)	4 (0–4)
Extremities	5 (0–5)	4 (0–5)	5 (2–5)
Injury Severity Score	45 (22–59)	43 (22–59)	50 (29–59)
Probability of survival (%)	34 (0.7–94)	49 (3.3–94)	20 (0.7–45)

Note: CT first group included patients in whom CT scan preceded AO. AO first group included patients in whom AO preceded CT scan. Data are expressed as *N* (%) or median (range).

Abbreviations: AIS, Abbreviated Injury Scale; AO, aortic occlusion; BT, body temperature; CT, computed tomography; GCS, Glasgow Coma Scale; Hb, hemoglobin; HR, heart rate; RR, respiratory rate; RTS, Revised Trauma Score; SBP, systolic blood pressure.

49%, and the actual survival rate was 3/6 (50%). Table 4 shows the information of the seven surviving patients (three in the CT first group, four in the AO first group). In the two patients of the CT first group in whom intubation did not precede CT, the times to CT from arrival were 10 and 11 min, respectively, whereas in the patients of the CT first group in whom intubation was performed, the time to CT from arrival was 18 min. Among the four surviving patients in whom AO preceded CT, three underwent DCS before CT, and the other patient underwent TAE, below-knee amputation, and external fixation of pelvic after CT.

DISCUSSION

We described 13 cases of severe trauma requiring AO, divided into the CT first and AO first groups. Although the number of cases was small and statistical analysis was not performed, an AO first strategy might improve survival rates for severe trauma patients with Ps 20%. The seven patients (three in the CT first group, four in the AO first group) who survived were described in detail. The Ps of the surviving patients in the CT first group was 73.4%, 94.1%, and 38.3%, and that in the AO first group was 20.4%, 14.2%, 44.8%, and 1.2%. Lactate values indicating acidosis were 3.9, 5.0, and 5.4 mmol/L in the CT first group and 11.5, 5.0, 12.7, and 9.8 mmol/L in the AO first group. Although limited to survivors, the AO first group tended to have lower Ps and more advanced lactic acidosis, suggesting higher severity of lactic acidosis than the CT first group. Though we generally choose whether to precede with aortic blockade or CT based on the hemodynamics of the trauma patient, the results might be similar in a hybrid ER with the most accessible CT. If treatment of a trauma patient with impeding cardiac arrest were to be preceded by a CT pan scan, a protocol that allows immediate CT (only plain CT, without peripheral venous cannulation, FAST, intubation, etc.) should be developed and implemented.

TABLE 2 Procedures and outcomes in the CT first and AO first groups

	Total $N=13$	CT first group $N=6$	AO first group $N=7$
Type of aortic occlusion, *N*			
RT	7 (54%)	2 (33%)	5 (71%)
REBOA	8 (62%)	4 (67%)	4 (57%)
Administration in hybrid ER			
Fluid (mL)	3500 (2000–14,250)	2750 (2000–6000)	4000 (2250–14,250)
RBC (unit)	16 (4–40)	14 (6–22)	20 (4–40)
FFP (unit)	10 (0–32)	10 (2–30)	10 (0–32)
PC (unit)	0 (0–30)	0 (0–20)	10 (0–30)
Cryoprecipitate (unit)	0 (0–12)	0 (0–12)	0 (0–8)
Intervention, *N*			
DCS	9 (69%)	5 (83%)	4 (57%)
TAE	10 (77%)	5 (83%)	5 (71%)
External fixation	5 (38%)	3 (50%)	2 (29%)
Burr hole craniotomy	2 (15%)	1 (17%)	1 (14%)
Times (min)			
Arrival to AO	29 (3–75)	36 (23–75)	7 (3–48)
Arrival to CT	19 (3–104)	11 (3–18)	27 (19–104)
Arrival to intervention	35 (7–98)	41 (26–56)	27 (7–98)
Time taken for CT scanning	6 (3–16)	5 (3–9)	6 (5–16)
28-day survival, *N*	7 (54%)	3 (50%)	4 (57%)
Cause of death, *N*			
Exsanguination	4 (30%)	2 (33%)	2 (29%)
TBI	1 (8%)	0 (0%)	1 (14%)
Respiratory	1 (8%)	1 (17%)	0 (0%)

Note: CT first group included patients in whom CT scan preceded AO. AO first group included patients in whom AO preceded CT scan. Data are expressed as *N* (%) or median (range).

Abbreviations: AO, aortic occlusion; DCS, damage control surgery; CT, computed tomography; FFP, fresh frozen plasma; PC, platelet concentrate; REBOA, resuscitative endovascular balloon occlusion of the aorta; RBC, red blood cells; RT, resuscitative thoracotomy; TAE, transcatheter arterial embolization; TBI, traumatic brain injury.

TABLE 3 Prognosis and times from arrival of subgroups

	CT first group $N=6$		AO first group $N=7$	
	CT to AO $N=4$	CT to intervention $N=2$	AO to CT $N=4$	AO to DCS $N=3$
Survival, *N*	3 (75%)	0 (0%)	1 (25%)	3 (100%)
Times (min)				
Arrival to AO	35 (23–37)	73 (71–75)	18 (7–48)	7 (6–7)
Arrival to CT	11 (8–18)	9 (3–15)	27 (19–67)	39 (27–104)
Arrival to intervention	43 (30–56)	35 (26–43)	49 (31–98)	9 (7–22)

Note: CT first group included patients in whom CT scan preceded AO. AO first group included patients in whom AO preceded CT scan. CT to AO included patients who underwent AO just after CT, CT to intervention included patients who underwent intervention for hemostasis just after CT, AO to CT included patients who underwent CT just after AO, and AO to DCS included patients who underwent DCS just after AO. Data are expressed as *N* (%) or median (range).

Abbreviations: AO, aortic occlusion; CT, computed tomography; DCS, damage control surgery.

As reported previously, the hybrid ER might improve posttraumatic mortality, especially in patients with higher baseline severity (ISS > 25).[13] To the best of our best knowledge, there are no reports that discuss whether to precede with aortic occlusion or CT using Ps in the hybrid ER, and this is the first study to investigate workflow in the hybrid ER that focuses on prioritization of AO for resuscitation versus that of CT scanning in patients requiring AO for impending CPA.

Although only 13 patients were studied and the statistical power was weak, the survival rates of both groups were similar. In the AO first group, DCS was performed between AO and CT in three patients, and all survived (3/3, 100%). However, in the other four cases in the AO first group, the procedure order was AO, CT, and emergency procedure for hemorrhage, with one patient surviving and three dying. Some patients with trauma severe enough to prioritize AO over CT scanning may not tolerate even a short CT scan that requires no patient transfer

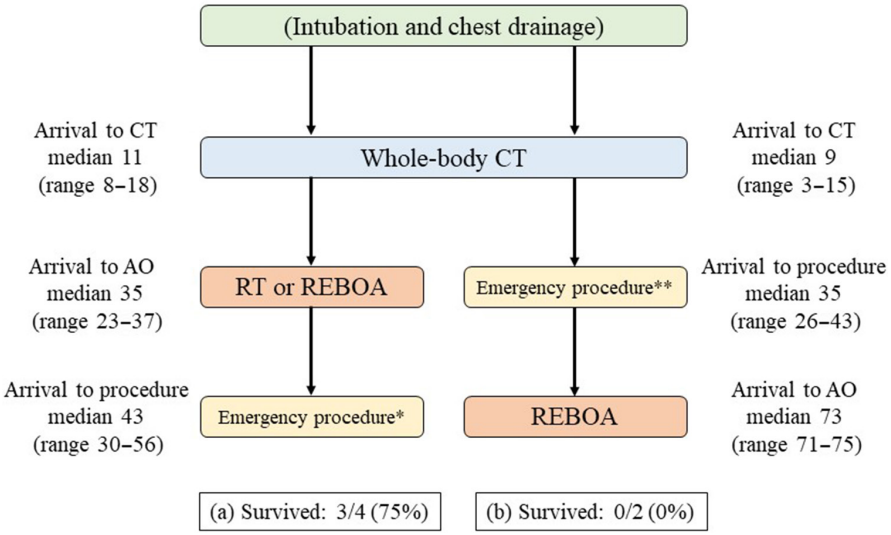

FIGURE 2 Clinical flowchart and times (minutes) of the CT first group and subgroups. The left-side flow shows the subgroup of aortic occlusion (RT or REBOA) performed just after whole-body CT. The right-side flow shows the subgroup of emergency procedures for hemorrhage performed just after whole-body CT. *TAE, DCS, external fixation. **TAE, DCS. CT, computed tomography; DCS, damage control surgery; REBOA, resuscitative endovascular balloon occlusion of the aorta; RT, resuscitative thoracotomy; TAE, transcatheter arterial embolization.

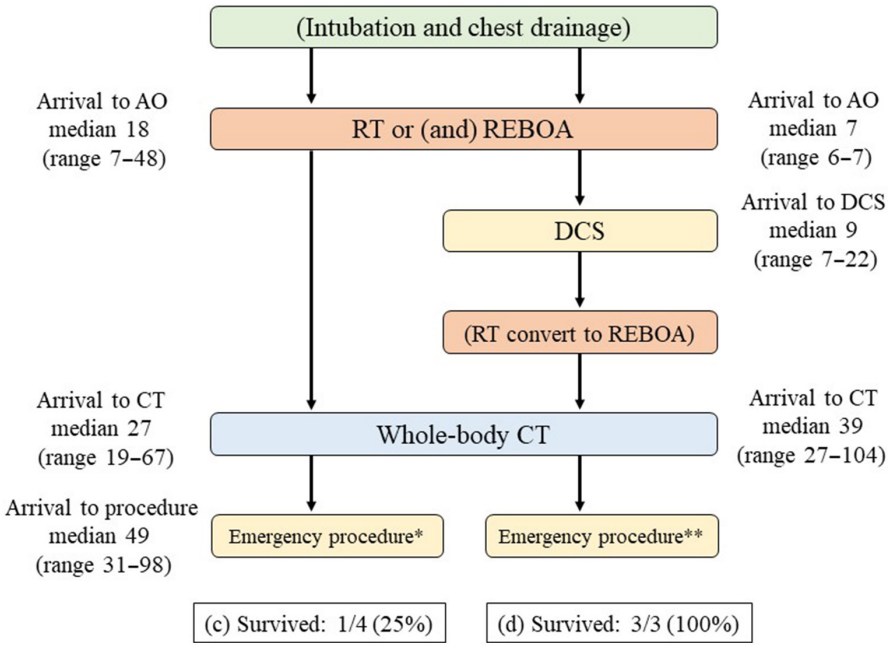

FIGURE 3 Clinical flowchart and times (minutes) of the AO first group and subgroups. The left-side flow shows the subgroup in which CT was performed just after AO. The right-side flow shows the subgroup in which DCS was performed just after AO. *TAE, DCS (An emergency procedure to determine the site of hemorrhage was not performed in one patient). **TAE, definitive surgery. AO, aortic occlusion; CT, computed tomography; DCS, damage control surgery; TAE, transcatheter arterial embolization.

before DCS. We previously reported that whole-body CT performed before emergency bleeding control might be associated with improved survival, especially in severe trauma patients with a TRISS Ps of <50% and even in patients treated in a non-hybrid ER.[8] The time consumed by whole-body CT scanning has always been an issue. In conventional ERs, if skilled staff performed pan-scans, the time from entry to exit of the CT scan can be reduced to within 10 min.[14,15] CT imaging in this study took about 6 min to perform. Even when the hybrid ER eliminates the need for patient transfer, the time during which aggressive resuscitation must be discontinued might be lethal.

The survival rate in the CT first group was higher in the subgroup with AO performed immediately following CT than that in the subgroup with emergency procedure for hemorrhage performed immediately following (3/4 [75%] vs 0/2 [0%]). Although the following factors were not analyzed statistically, the difference in time to AO between the

TABLE 4 Summary of seven surviving patients required aortic occlusion in hybrid ER

				Vital signs on arrival						Blood gas analysis on arrival						Times from arrival (min)			Procedure in hybrid ER (times from arrival [min])	
No.	Diagnosis	Age/ sex	Mechanical of injury	HR (bpm)	SBP (mmHg)	RR (/min)	BT (Celsius)	GCS total score	RTS	Hb (g/dL)	pH	BE (mmol/L)	Lac (mmol/L)	ISS	Ps (%)	To AO	To CT	To first intervention	Before CT	After CT
CT-AO-intervention group																				
1	#1. Liver injury (AAST-OIS Grade IV) #2. Pulmonary contusion #3. Multiple rib fractures	64/M	Motor vehicle accident	66	54	21	35.4	14	6.38	12.4	7.297	−4.4	3.9	25	73.4	37	10	47	FAST (1) PVC (NA)	Intubation (22) Transfusion (33) CVC (36) REBOA (37) DCS (47) TAE (72)
2	#1. Bilateral diaphyseal femur fracture #2. Maxillary fracture #3. Bilateral clavicle fracture #4. Multiple rib fractures #5. Metatarsal fracture	51/M	Fall from a height	102	154	26	36.4	6	5.97	14.5	7.374	−8.7	5	22	94.1	34	18	56	FAST (1) PVC (NA) Transfusion (4) Intubation (6)	CVC (26) REBOA (34) External fixation of bilateral femur (55)
3	#1. Multiple rib fractures #2. Transverse process fracture of lumbar vertebrae 2–4 #3. Bilateral hemopneumothorax #4. Perforation of transverse colon #5. Unstable pelvic fracture	69/M	Motor vehicle accident	97	134	40	35.7	14	7.55	12.1	7.365	−6.2	5.4	59	38.3	35	11	39	FAST (1) PVC (NA)	Thoracic drainage (25) Intubation (27) RT (35) CVC (35) Transfusion (47) TAE (39) DCS (partial colectomy) (81) External fixation of pelvic (216)
AO-intervention-CT group																				
4	#1. Extensive mesenteric injury #2. Omental injury #3. Liver injury (AAST-OIS Grade I) #4. Splenic injury (AAST-OIS Grade I) #5. Bladder injury #6. Pneumothorax #7. Transverse process fracture of lumbar vertebrae 2–5 #8. Iliac fracture	63/M	Crush between objects	117	60	31	36.7	7	4.21	11.3	7.007	−17.3	11.5	29	20.4	17	104	9	FAST (1) PVC (NA) Intubation (NA) RT (7) DCS (gauze packing→ileectomy and right hemicolectomy) (9) CVC (13) Transfusion (13)	

(Continues)

TABLE 4 (Continued)

No.	Diagnosis	Age/sex	Mechanical of injury	Vital signs on arrival					RTS	Blood gas analysis on arrival				ISS	Ps (%)	Times from arrival (min)			Procedure in hybrid ER (times from arrival [min])	
				HR (bpm)	SBP (mmHg)	RR (/min)	BT (Celsius)	GCS total score		Hb (g/dL)	pH	BE (mmol/L)	Lac (mmol/L)			To AO	To CT	To first intervention	Before CT	After CT
5	#1. Open fracture of the iliac sacrum #2. Colon injury #3. Mesenteric injury #4. Sacral fracture #5. Metacarpal fracture #6. Dislocated fracture of wrist #7. Diaphyseal humeral fracture	55/M	Motor vehicle accident	70	50	24	35.3	6	5.44	11	7.226	−12.7	5	50	14.2	6	27	7	PVC (NA) FAST (3) Intubation (6) DCS (gauze packing) (7) RT (6) REBOA (28) Transfusion (12) CVC (13)	TAE (42) Surgery (left hemicolectomy) (66)
6	#1. Unstable open pelvic fracture #2. Rectal injury #3. Bladder injury #4. Degloving injury of the lower extremity #5. Diaphyseal femur fracture #6. Femoral decollement injury	30/F	Motor vehicle accident	152	40	27	35.4	11	4.71	10.4	7.111	−18.4	12.7	45	44.8	7	39	22	PVC (NA) FAST (NA) Intubation (6) Transfusion (6) RT (7) CVC (16) DCS (gauze packing) (22) REBOA (34)	External fixation of pelvic (NA, after CT and before TAE) TAE (63) External fixation of femur (NA, after TAE)
AO-CT-intervention group																				
7	#1. Hemopneumothorax #2. Aortic arch injury #3. Unstable pelvic fracture #4. Iliac venous injury #5. Traumatic below-knee amputation #6. Diaphyseal femur open fracture (Gustilo classification II) #7. Diaphyseal radio-ulna fracture #8. Burst fracture of thoracic vertebra 3 #9. Spinal cord injury	31/M	Motor vehicle accident	PEA	PEA	AR	35.1	3	0	12.7	6.91	−13.1	9.8	41	1.2	7	27	52	Intubation (1) FAST (2) RT (3) CVC (7) Transfusion (NA)	Thoracic drainage (44) TAE (49) External fixation of pelvic (89) Below-knee amputation (142) TEVAR (385)

Abbreviations: AO, aortic occlusion; AR, agonal respiration; BE, base excess; BT, body temperature; CT, computed tomography; CVC, central venous cannulation; DCS, damage control surgery; FAST, focused assessment with sonography for trauma; GCS, Glasgow Coma Scale; Hb, hemoglobin; HR, heart rate; ISS, injury severity score; Lac, lactate; NA, not available; PAE, pulseless electrical activity; Ps, probability of survival; PVC, peripheral vein cannulation; REBOA, resuscitative endovascular balloon occlusion of the aorta; RR, respiratory rate; RTS, Revised Trauma Score; SBP, systolic blood pressure; TAE, transcatheter arterial embolization.

subgroups (35 vs 73 min) was large, whereas that to the emergency procedure for hemorrhage was similar (43 vs 35 min). In the CT first group, AO performed for inadequate bleeding control after interventions for hemostasis might be less effective in improving patient prognosis. The reason could be that AO was performed in the subgroup in which therapeutic interventions were unsuccessful and bleeding remained uncontrolled. It was just a result of the failure of hemostasis or the end-of-life stage of trauma patients, no physician would initially choose the deadly pattern (CT-intervention-AO).

In this study, the early CT group was only whether CT preceded AO, not whether CT imaging was prioritized above all else. The median time to CT imaging in the hybrid ER for trauma patients of ISS over 16 was 11 min, whereas the median time to hemostasis was 47 min in the prior literature.[3] However, for severe trauma patients requiring AO, it was too late to perform CT imaging over 10 min after arrival. We should make efforts to create training and protocols to enable immediate CT imaging. In addition, in this study, the CT first group took 30 min from CT to intervention, which was a long time, and we must make efforts to shorten this time, too.

This study has several limitations. First, as the sample size was not sufficient to perform a valid statistical analysis, this study was descriptive study. Second, deciding to perform CT or AO might have introduced major selection bias because CT was performed at the attending physician's discretion based on patient condition and not according to a predefined protocol. Finally, this was a single-institution retrospective study. As several biases may be present, the study results should be verified in a prospective, multicenter study.

CONCLUSION

In severe trauma patients with advanced acidosis and low predicted Ps treated in a hybrid ER, performing resuscitation including AO first rather than CT first might improve patient survival rate compared with the predicted Ps. In trauma patients receiving AO before CT after arrival in the hybrid ER, it might be better to perform DCS first before CT.

ACKNOWLEDGEMENTS

The authors thank Rise Japan LCC for carefully proofreading this article.

CONFLICT OF INTEREST STATEMENT

Shuhei Maruyama received lecture fees from Canon Medical Systems Co. Dr. Yasushi Nakamori received research grants from Canon Medical Systems Co. Dr. Yasuyuki Kuwagata is an Editorial Board member of AMS Journal and a coauthor of this article. To minimize bias, they were excluded from all editorial decision-making related to the acceptance of this article for publication.

DATA AVAILABILITY STATEMENT

The datasets analyzed in this study are available from the corresponding author on reasonable request.

ETHICS STATEMENT

Approval of the Research Protocol: This study was conducted according to the principles of the Declaration of Helsinki and approved by Kansai Medical University Medical Center—Institutional Review Board (Study Number: 2022329).

INFORMED CONSENT

Due to the retrospective study design, written informed consent was waived by the Institutional Review Board.

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How to cite this article: Maruyama S, Wada D, Yoshihara T, Saito F, Yoshiya K, Nakamori Y, et al. Treatment strategy for severe trauma patients requiring aortic occlusion for impending cardiopulmonary arrest in the hybrid emergency room. Acute Med Surg. 2024;11:e928. https://doi.org/10.1002/ams2.928