Effective use of the hybrid emergency Department system in the treatment of non-traumatic critical care diseases

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ARTICLE INFO

ABSTRACT

Background: The hybrid emergency room (ER) system can provide resuscitation, computed tomography imaging, endovascular treatment, and emergency surgery, without transferring the patient. However, although several reports have demonstrated the effectiveness of the hybrid ER for trauma conditions, only a few case reports have demonstrated its usefulness for non-traumatic critical diseases. In this observational cohort study, we aimed to identify endogenous diseases that may benefit from treatment in the hybrid ER.
Methods: We retrospectively reviewed the clinical characteristics of patients with non-traumatic conditions treated in a hybrid ER between August 2017 and July 2022 at our institution. Patients who underwent surgery, endoscopy, or interventional radiology (IR) in the hybrid ER were selected and pathophysiologically divided into a bleeding and non-bleeding group. The rate of shock or cardiac arrest, blood transfusion, and death within 24 h of admission or in-hospital death were compared among the groups using Fisher's exact test. Multivariable logistic regression analysis was performed to confirm the relationships among in-hospital mortality, transfusion, and hemorrhagic conditions in patients who underwent endoscopy and IR.
Results: Among the 726 patients with non-traumatic conditions treated in a hybrid ER system, 50 (6.9%) experienced cardiac arrest at or before admission to the hybrid ER, 301 (41.5%) were in shock, 126 (17.4%) received blood transfusions, 42 (5.8%) died within 24 h of admission to the hybrid ER, and 141 (19.4%) died in the hospital. Emergency surgery was performed in 39 patients (7 in the bleeding group and 32 in the non-bleeding group). Significantly more blood transfusions were administered in the bleeding group (71.4% vs. 18.8%, $P = 0.01$); there were no significant differences in the rate of shock or cardiac arrest, death within 24 h, or in-hospital death between groups. Endoscopy was performed in 122 patients (80 in the bleeding group and 42 in the non-bleeding group). The bleeding group had a significantly higher rate of shock or cardiac arrest (87.5% vs. 66.7%, $P = 0.008$) and rate of blood transfusion (62.5% vs. 4.8%, $P < 0.0001$); there was no significant difference in death within 24 h and in-hospital death between groups. IR was performed in 100 patients (68 in the bleeding group and 32 in the non-bleeding group). Significantly more blood transfusions were administered in the hemorrhage group (67.7% vs. 12.5%, $P < 0.0001$); there was no difference in the rate of shock or cardiac arrest, death within 24 h, or in-hospital death between groups. Multivariable analysis in patients who underwent endoscopy showed a trend toward more in-hospital deaths in non-hemorrhagic conditions than in hemorrhagic conditions (odds ratio = 3.8, 95% confidence interval: 0.88–17, $P = 0.073$); however, no significant relationship with in-hospital death was observed for any of the adjusted variables.
Conclusion: Among endogenous diseases treated in the hybrid ER, there is a possible association between in-hospital mortality and hemorrhagic conditions. Future studies are needed to focus on diseases to demonstrate the effectiveness of the hybrid ER.

Abbreviations: ER, Emergency room; IR, Interventional radiology; CT, Computed tomography; CA, Cardiac arrest; CI, Confidence interval; DCS, Damage control surgery.
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1. Introduction

The hybrid emergency room (ER) is an emergency department equipped with a self-propelled computed tomography (CT) and angiography system. The hybrid ER was introduced for the first time in Japan in

2011 [1]. The hybrid ER can provide initial care, resuscitation, CT imaging, endovascular treatment, and emergency surgery, including damage control surgery (DCS), without transferring the patient. The first study introduced a rotary table hybrid ER system in 2017 [2]. Additionally, another study reported that treatment in the hybrid ER contributed to a reduction in blood transfusion doses in patients with severe trauma [3]. Several reports, mostly published in Japan, demonstrated the effectiveness of a hybrid ER system in patients with trauma [1,3-12]. However, most of these reports focus on trauma care, and to our knowledge, few case reports and case series except extracorporeal cardiopulmonary resuscitation and stroke have shown the usefulness of hybrid ER systems in non-traumatic diseases [4-15].

We have used the hybrid ER not only for patients with trauma but also for critically ill patients with endogenous diseases. Our hybrid ER system has one bed with standard intensive care unit (ICU) equipment (e.g., ventilator, anesthesia machine, defibrillator) including a function of resuscitation room and provide this specific full service for 24 h on 365 days. Some endogenous diseases, including various conditions, can be quickly diagnosed and treated using the hybrid ER, whereas others may not be as effectively treated as in a conventional emergency department setting.

This study aimed to identify endogenous diseases that might benefit from treatment in the hybrid ER. Toward this goal, we reviewed the clinical characteristics of patients with non-traumatic conditions treated in a hybrid ER and discuss the type of patients who benefitted from hybrid ER treatment. By limiting the targeted diseases, we expect that our findings will lead to the effective use of the hybrid ER, a limited medical resource, in the future.

2. Methods

2.1. Study design

This was an observational study that retrospectively examined the clinical characteristics (i.e., age, gender, disease type, route of admission, presence of shock, procedures performed, administration of blood transfusion, and outcome after admission) of patients with non-traumatic or non-burn conditions treated at our hybrid ER between August 2017 and July 2022. Shock was defined as systolic blood pressure <90 mmHg, physical signs of shock, and use of catecholamines during hospitalization or prehospital treatment. All hospitalized patients evaluated had been admitted for >24 h. Patients who underwent blood transfusion during the examination were classified as the blood-transfusion group. We had six units of type O Rh + red blood cells, and six units of type AB Rh + fresh-frozen plasma in our hybrid ER. Patients who used the arranged transfusions (including heterotypic transfusions) were classified as the emergency-transfusion group. Death within 24 h was defined as death within 24 h from admission to the ICU, while in-hospital death was defined as death in the ICU or the ward after ICU discharge. Patients who underwent gastrointestinal endoscopic examination and treatment in the hybrid ER were classified as the endoscopy group. Patients who underwent emergency surgery and interventional radiology (IR) in the hybrid ER were classified as the surgery group and IR group, respectively. Prognosis was evaluated as death within 24 h of admission and death during hospital stay. Patients who underwent surgery, endoscopy, or IR in the hybrid ER were selected and pathophysiologically divided into two groups: the bleeding and non-bleeding groups. The severity of illness (i.e., rate of shock or cardiac arrest [CA]), transfusion, and prognosis were compared between the two groups.

2.2. Statistical analysis

The JMP® Pro 16.1.0 software (SAS Institute Japan) was used for statistical analysis. Fisher's exact test was used for between-group comparisons. We examined the relationship between in-hospital mortality

and blood transfusions, emergency transfusions, or hemorrhagic conditions. Multivariable logistic regression analysis was performed, with adjustment for age, gender, shock, transfusion, emergency transfusion, and hemorrhagic conditions as potential confounding factors. A *P*-value <0.05 was considered to indicate a significant difference.

3. Results

Among the 2561 patients treated in our hybrid ER between August 2017 and July 2022, 1996 trauma and burn patients were excluded from this study. During the same period, 161 hospitalized patients were treated in the hybrid ER. In total, 726 patients with endogenous disease (426 men and 300 women; median age: 72 years, interquartile range: 54–84 years) were included in this study (Fig. 1). Gastrointestinal hemorrhage was the most common cause (117 cases, 16.1%), followed by acute abdomen (116 cases, 16.0%) and intra-abdominal infection (112 cases, 15.4%). CA, the cause of which was difficult to determine, occurred in 45 cases (6.2%). Overall, 76 patients (10.5%) had perinatal disease. Of the 726 patients, 565 (77.8%) were admitted to the hybrid ER from the emergency department, and 161 (22.2%) were hospitalized patients (Table 1). Since the rapid response system was established in April 2019, 141 hospitalized patients had been transferred to the hybrid ER, of whom 31 (22.0%) had been admitted to the hybrid ER after undergoing a systemic evaluation by the rapid response team. The rapid response team is primarily responsible for initial assessment and response to the emergence of airway, respiratory, circulatory, and conscious abnormalities in the hospitalized patients.
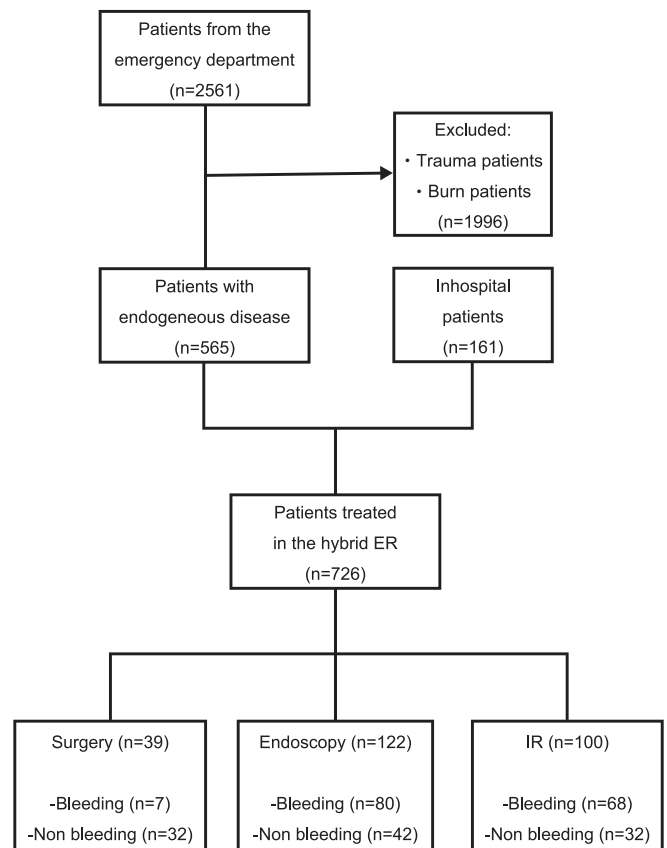

Fig. 1. Patient selection flowchart.
Non-trauma, non-burn patients treated in our hybrid ER were included in this study. Among them, a cohort that underwent emergency surgery, gastrointestinal endoscopy, and IR in the hybrid ER was selected for secondary analysis.
ER: emergency room, IR: interventional radiology.

Table 1
Clinical characteristics of the patients with non-traumatic conditions treated in the hybrid emergency room (*n* = 726).

Gender, *n* (%)	
Male	426 (58.7)
Age (years), median [IQR]	72 [54–84]
0–20	7 (1)
21–60	201 (27.7)
>61	518 (71.3)
Disease category, *n* (%)	
Abdominal aortic aneurysm	4 (0.6)
CA	45 (6.2)
HCC rupture	6 (0.8)
Thoracic aortic aneurysm	3 (0.4)
Iatrogenic hemorrhage	2 (0.3)
Acute abdomen	116 (16)
Hematological disease	2 (0.3)
Acute respiratory failure	15 (2.1)
Perinatal disease	76 (10.5)
Cardiovascular disease	25 (3.4)
Gastrointestinal bleeding	117 (16.1)
Neurological disease	52 (7.2)
Aortic dissection	7 (0.9)
Soft tissue infection	2 (0.3)
Sepsis	17 (2.3)
Urinary tract disease	13 (1.8)
Intra-abdominal infection	112 (15.4)
Intra-abdominal hemorrhage	32 (4.4)
Hemoptysis	5 (0.7)
Others	75 (10.3)
Route of admission, *n* (%)	
Out of hospital[*]	565 (77.8)
In hospital[†]	161 (22.2)
Shock, *n* (%)	
CA	50 (6.9)
+	301 (41.5)
−	375 (51.6)
Blood transfusion, *n* (%)	126 (17.4)
Emergency transfusion, *n* (%)	84 (11.6)
Death within 24 h, *n* (%)	42 (5.8)
In-hospital death, *n* (%)	141 (19.4)

Abbreviations: ER, emergency room; IQR, interquartile range; CA, cardiac arrest; HCC, hepatocellular carcinoma.
[*] Direct admission to the hybrid ER.
[†] Admission of hospitalized patients to the hybrid ER.

Table 2
Characteristics of patients who underwent surgery in the hybrid emergency room (*n* = 39).

Disease category, *n* (%)	
CA	3 (7.7)
Thoracic aortic aneurysm	1 (2.6)
Iatrogenic hemorrhage	1 (2.6)
Acute abdomen	9 (23.1)
Hematological disease	1 (2.6)
Perinatal disease	2 (5.1)
Cardiovascular disease	7 (17.9)
Neurological disease	2 (5.1)
Aortic dissection	1 (2.6)
Sepsis	5 (12.8)
Intra-abdominal infection	2 (5.1)
Intra-abdominal hemorrhage	3 (7.7)
Others	2 (5.1)
Shock, *n* (%)	
CA	4 (10.2)
+	20 (51.3)
−	15 (38.5)
Blood transfusion, *n* (%)	11 (28.2)
Emergency transfusion, *n* (%)	10 (25.6)
Death within 24 h, *n* (%)	7 (17.9)
In-hospital death, *n* (%)	12 (30.8)

Abbreviations: CA, cardiac arrest.

Overall, 50 patients (6.9%) were in CA at or before admission to the hybrid ER, and 301 patients (41.5%) had shock, excluding those in CA. Blood transfusions were performed in 126 patients (17.4%), of whom 84 (11.6%) received emergency transfusions (including heterotypic transfusions) that were always available in our hybrid ER. There were 42 patients (5.8%) who died within 24 h of admission to the hybrid ER, and 141 (19.4%) died in hospital.

Emergency surgery was performed in the hybrid ER in 39 patients (Table 2). Acute abdomen, cardiovascular disease, and sepsis were common; however, their frequency was not significantly greater that of other conditions. Of the 39 patients, 7 (17.9%) had hemorrhagic conditions, and most surgeries were performed for non-hemorrhagic diseases.

To better estimate the efficacy of hybrid ER in non-traumatic diseases, the patients were divided into bleeding and non-bleeding groups and compared (Table 3). The bleeding group tended to have more patients with shock or CA than the non-bleeding group; however, the difference was not significant (6 [85.7%] vs. 18 [56.3%], *P* = 0.2159). Blood transfusions and emergency transfusions were significantly more frequent in the bleeding group than in the non-bleeding group (blood transfusion: 5 [71.4%] vs. 6 [18.8%], *P* = 0.0122; emergency transfusions: 5 [71.4%] vs. 5 [15.6%], *P* = 0.0071). Nevertheless, no significant difference in prognosis was observed between the two groups (Table 3). Multivariable analysis was not performed because of the small number of cases. Eighty-seven patients underwent surgery in the operating room after leaving the hybrid ER, and this number was more than the number of patients who underwent emergency surgery in the hybrid ER.

Gastrointestinal endoscopy was performed in the hybrid ER in 122 patients (Table 4). Gastrointestinal bleeding was the most common cause, followed by intra-abdominal infection and acute abdomen. Overall, 98 of these patients (80.0%) were in shock or CA. Blood transfusions and emergency transfusions were performed in 52 (42.6%) and 33 (27.0%) patients, respectively. The number of deaths within 24 h and in-hospital deaths was 3 (2.5%) and 20 (16.4%), respectively. Similarly, patients who underwent gastrointestinal endoscopy were compared between the bleeding and non-bleeding groups (Table 5). Shock and CA were more frequent in the bleeding group (70 [87.5%] vs. 28 [66.7%], *P* = 0.0084). Blood transfusion and emergency transfusion were also significantly more frequent in the bleeding group (blood transfusion: 50 [62.5%] vs. 2 [4.8%], *P* < 0.0001; emergency transfusion: 32 [40.0%] vs. 1 [2.4%], P < 0.0001). No significant difference in prognosis was observed between the two groups (Table 5). Multivariable analysis showed a trend toward more in-hospital deaths in nonhemorrhagic conditions (odds ratio = 3.8, 95% CI: 0.88–17, *P* = 0.073); however, no significant relationship with in-hospital death was observed for any of the adjusted variables (Table 6).

IR was performed in the hybrid ER in 100 patients (Table 7). Gastrointestinal bleeding was the most common condition, followed by intra-abdominal bleeding and perinatal disease. Overall, 79 of these patients (79.0%) were in shock or CA. Blood transfusion was performed in 50 patients (50.0%), and 3 (3.0%) deaths within 24 h and 17 (17.0%) in-hospital deaths were recorded. Similar to the surgery and endoscopy

Table 3
Comparison between the bleeding and non-bleeding groups which underwent surgery in the hybrid emergency room (*n* = 39).

	Bleeding group (*n* = 7)	Non-bleeding group (*n* = 32)	*P*-value
Background, *n* (%)			
Shock or CA	6 (85.7%)	18 (56.3%)	0.2159
Transfusion, *n* (%)			
Blood transfusion	5 (71.4%)	6 (18.8%)	0.0122
Emergency transfusion	5 (71.4%)	5 (15.6%)	0.0071
In-hospital mortality, *n* (%)			
Death within 24 h	4 (57.1%)	3 (9.4%)	0.12
In-hospital death	4 (57.1%)	8 (25.0%)	0.1716

Abbreviations: CA, cardiac arrest.

Table 4
Characteristics of patients who underwent gastrointestinal endoscopy in the hybrid emergency room (n = 122).

Disease category, n (%)	
CA	1 (0.8)
Acute abdomen	9 (7.4)
Gastrointestinal bleeding	79 (64.8)
Intra-abdominal infection	30 (24.6)
Hemoptysis	1 (0.8)
Others	2 (1.6)
Shock, n (%)	
CA	1 (0.8)
+	97 (79.5)
−	24 (19.7)
Blood transfusion, n (%)	52 (42.6)
Emergency transfusion, n (%)	33 (27.0)
Death within 24 h, n (%)	3 (2.5)
In-hospital death, n (%)	20 (16.4)

Abbreviations: CA, cardiac arrest.

groups, the IR group was further divided into two groups, i.e., the bleeding and non-bleeding groups (Table 8). The number of patients with shock and CA were higher in the bleeding group, although the difference was not significant (55 [80.9%] vs. 23 [71.9%], P = 0.3145). Blood transfusions and emergency transfusions were significantly more common in the bleeding group (blood transfusion: 46 [67.7%] vs. 4 [12.5%], P < 0.0001; emergency transfusion: 30 [44.1%] vs. 3 [9.4%], p = 0.0005). No significant difference in prognosis was observed between the two groups (Table 8). Similar to the results for patients who underwent endoscopy, multivariable analysis showed no significant relationship with in-hospital mortality for any of the adjusted variables (Table 9).

4. Discussion

This study showed that the hybrid ER may be suitable for patients with shock or CA requiring endoscopic or IR hemostasis. Meanwhile, there may be little benefit for diseases that do not require hemostasis, such as sepsis, even if the patient is in septic shock. For CA, severe pulmonary embolism, and myocardial infarction that would require extracorporeal cardiopulmonary resuscitation, the number of patients in this study was too small to determine the effectiveness of treatment in the hybrid ER. To our best knowledge, this study is the first to clarify the characteristics of patients with comprehensive endogenous diseases treated in the hybrid ER. In addition, this is the first cohort observational report on non-traumatic patients treated in the hybrid ER. We identified various endogenous diseases that might benefit from treatment in the hybrid ER to limit the target diseases and improve the effective use of the limited medical resources of the hybrid ER.

The hybrid ER can be used for performing CT imaging, endovascular treatment, and emergency surgery including DCS without transferring the patient, making it more effective for prompt diagnosis and

Table 5
Comparison between the bleeding and non-bleeding groups which underwent gastrointestinal endoscopy in the hybrid emergency room (n = 122).

	Bleeding group (n = 80)	Non-bleeding group (n = 42)	p-value
Background, n (%)			
Shock or CA	70 (87.5%)	28 (66.7%)	0.0084
Transfusion, n (%)			
Blood transfusion	50 (62.5%)	2 (4.8%)	<0.0001
Emergency transfusion	32 (40.0%)	1 (2.4%)	<0.0001
In-hospital mortality, n (%)			
Death within 24 h	2 (2.5%)	1 (2.4%)	1
In-hospital death	10 (12.5%)	10 (23.8%)	0.1269

Abbreviations: CA, cardiac arrest.

Table 6
Multivariable analysis of in-hospital mortality in patients who underwent gastrointestinal endoscopy in the hybrid emergency room (n = 122)

	Odds ratio	95% CI	P-value
Age	1.0	0.99–1.1	0.101
Gender (male)	4.4	0.066–0.91	0.066
Shock or CA	1.6	0.36–7.1	0.536
Blood transfusion	1.0	0.15–7.1	0.965
Emergency transfusion	3.0	0.51–18	0.222
Hemorrhagic condition (non-bleeding)	3.8	0.88–17	0.073

Abbreviations: CA, cardiac arrest; CI, confidence interval.

treatment of hemodynamically unstable patients [1-3]. Hemodynamic instability in endogenous diseases can be caused by various factors, such as hemorrhage, sepsis, and obstructive shock. Gastrointestinal bleeding, acute abdomen, and intra-abdominal infection accounted for most non-traumatic cases treated in our hybrid ER in the last 5 years, with the total number of these cases reaching approximately 50% of the non-trauma cases. Rapid identification of the bleeding point and prompt hemostatic treatment are particularly important in hemorrhagic shock due to gastrointestinal bleeding [16].

The current study showed that among conditions requiring gastrointestinal endoscopy, hemorrhagic conditions were more significantly associated with shock or CA than non-hemorrhagic conditions. The patients with these conditions required rapid diagnosis and hemostasis. If the patients were transferred to the hybrid ER, bleeding sites may be detected by CT scan immediately after loading, and hemostasis by endoscopy may be performed quickly without transferring the patients. Therefore, the hybrid ER system may be suitable for the treatment for the patients with gastrointestinal bleeding.

In recent years, the demand for minimally invasive treatment by IR has increased [17-20]. IR is performed not only for hemostasis of bleeding due to trauma but also for rupture of hepatocellular carcinoma and intra-abdominal aneurysm, postoperative bleeding, and various other conditions. The understanding of vascular anatomy and bleeding points prior to CT-based treatment is essential for IR hemostasis; therefore, IR without this information dramatically increases the difficulty of the procedure. In general, emergency rooms, CT rooms, and angiography rooms are located at different places in most hospitals. The movement of critically ill patients among these rooms can be fatal. In addition, delayed hemostasis induces prolonged hemorrhagic shock and coagulopathy,

Table 7
Characteristics of patients who underwent interventional radiology in the hybrid emergency room (n = 100).

Disease category, n (%)	
CA	4 (4.0)
HCC rupture	5 (5.0)
Acute abdomen	4 (4.0)
Hematological disease	1 (1.0)
Perinatal disease	11 (11.0)
Cardiovascular disease	4 (4.0)
Gastrointestinal bleeding	23 (23.0)
Neurological disease	1 (1.0)
Sepsis	4 (4.0)
Urinary tract disease	5 (5.0)
Intra-abdominal infection	8 (8.0)
Intra-abdominal hemorrhage	22 (22.0)
Hemoptysis	4 (4.0)
Others	4 (4.0)
Shock, n (%)	
CA	6 (6.0)
+	72 (72.0)
−	22 (22.0)
Blood transfusion, n (%)	50 (50.0)
Emergency transfusion, n (%)	33 (33.0)
Death within 24 h, n (%)	3 (3.0)
In-hospital death, n (%)	17 (17.0)

Abbreviations: CA, cardiac arrest; HCC, hepatocellular carcinoma.

Table 8
Comparison between the bleeding and non-bleeding groups which underwent interventional radiology in the hybrid emergency room (*n* = 100).

	Bleeding group (*n* = 68)	Non-bleeding group (*n* = 32)	*P*-value
Background, *n* (%)			
Shock or CA	55 (80.9%)	23 (71.9%)	0.3145
Transfusion, *n* (%)			
Blood transfusion	46 (67.7%)	4 (12.5%)	<0.0001
Emergency transfusion	30 (44.1%)	3 (9.4%)	0.0005
In-hospital mortality, *n* (%)			
Death within 24 h	2 (2.9%)	1 (3.1%)	1
In-hospital death	11 (16.2%)	6 (18.8%)	0.7795

Abbreviations: CA, cardiac arrest.

making it more difficult to complete hemostasis [17-20]. Our data showed no difference in mortality rate between the bleeding group with shock or CA and the non-bleeding group. The hybrid ER may therefore help reduce the risks associated with this transfer and facilitate rapid hemostasis.

Approximately 80% of patients undergoing endoscopy or IR in the hybrid ER presented with shock, most of them with hemorrhagic conditions. Although patients with hemorrhagic conditions were administered significantly more blood transfusions than those with non-hemorrhagic conditions, no significant difference in prognosis was observed. Further, although patients who underwent endoscopy in the bleeding group presented with significantly greater shock and received more blood transfusions, multivariable analysis showed a non-significant trend toward improved prognosis in the group with hemorrhagic conditions. These results could be attributed to prompt hemostatic treatment in the hybrid ER, as well as appropriate transfusion strategies. Prompt initiation of transfusion is a common strategy in trauma care [21-23]. Moreover, approximately 60% of patients administered transfusions received emergency transfusions in the hybrid ER; therefore, adaptation of these appropriate transfusion strategies to endogenous disease may also have been effective. Thus, for endogenous diseases, the hybrid ER may contribute to the treatment for hemorrhagic conditions that require hemostasis by endoscopy or IR.

The effectiveness of DCS in trauma care has already been reported in many cases [8,10,12,24,25]. Additionally, a previous study reported the effectiveness of DCS for intra-abdominal infections that present with septic shock [26]. However, the present results show that only a small number of patients admitted to the hybrid ER underwent surgery in the hybrid ER. This finding may be because most diseases requiring surgery were intra-abdominal infections that required contamination control, rather than diseases requiring rapid hemostasis for bleeding, such as trauma. Compared to hemorrhagic shock, septic shock has a relatively longer time window before hemodynamic instability occurs. Perhaps because surgery for intra-abdominal infections often requires more complex operations than DCS for trauma, it may be ideally performed in better-equipped operating rooms. However, this does not mean that the start of surgery for septic shock should be delayed. If patients with septic shock are hemodynamically unstable, performing rapid lesion search and decontamination surgery in a hybrid ER would be of great benefit to the patients [27].

Table 9
Multivariable analysis of in-hospital mortality in patients who underwent interventional radiology in the hybrid emergency room (*n* = 100).

	Odds ratio	95% CI	*P*-value
Age	1.0	0.99–1.1	0.161
Gender (male)	2.5	0.71–8.6	0.155
Shock or CA	1.3	0.26–6.2	0.775
Blood transfusion	2.1	0.27–16	0.481
Emergency transfusion	2.8	0.50–15	0.247
Hemorrhagic condition (non-bleeding)	2.8	0.57–13	0.207

Abbreviations: CA, cardiac arrest; CI, confidence interval.

This study has some limitations. First, we only retrospectively observed patients treated in the hybrid ER and did not compare the hybrid and non-hybrid ER group. The installation of the hybrid ER has drastically changed the strategy for treating critically ill patients, thus reducing the opportunity to treat them in a setting without the hybrid ER. These factors made it difficult to compare the effectiveness of the hybrid ER to that of a non-hybrid ER in critically ill patients. Future study designs comparing these groups need to be developed to demonstrate this efficacy more robustly. Second, the indication for admission to the hybrid ER is left to the physician in charge, and no standardized criteria have been established. The absence of clinically standardized admission criteria may have led to bias in the selection of patients to be admitted and in their condition at the time of admission. Third, our study was a single-center, retrospective, observational study. Because of the various biases that could have occurred in our study, a multicenter prospective study should be conducted to verify these results. Fourth, the pathophysiology of endogenous diseases varies widely, and some diseases may not have been adequately studied because of their low frequency. Since only a few hospitals have hybrid ERs, a multicenter study is desirable for further investigation. Fifth, the situations leading up to admission to the hybrid ER varied. Some patients were in the hospital, and they may have already been diagnosed or subjected to preparation for treatment.

5. Conclusions

The hybrid ER can simultaneously provide rapid diagnosis; appropriate treatment; and resuscitation, including blood transfusion, without transferring the patient. For non-traumatic conditions, hybrid ERs may be effective in the treatment of critical patients, especially for those with hemorrhagic conditions requiring endoscopic or IR hemostasis. Further studies are needed to establish the efficacy of the hybrid ER for these diseases.

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee at Shimane University Faculty of Medicine "Shimane University Institutional Committee on Ethics" on September 27, 2021 (approval number 20210624-1). The board waived the need for informed consent owing to the retrospective nature of the study.

Consent for publication

Written informed consent for publication of clinical details and clinical images was obtained from the patient. Consent to participate in this study was waived in accordance with the Ethical Board's decision as described above.

Author contributions

R. M. conceived and designed the study. R. M., S. K., T. M., K. O., Y. S., A. K.,

E.H., and H. W. participated in data collection and analysis. R. M. participated in writing.

CRediT authorship contribution statement

Ryo Matsumoto: Writing – original draft, Project administration, Formal analysis, Data curation. **Shunsuke Kuramoto:** Project administration. **Tomohiro Muronoi:** Project administration. **Kazuyuki Oka:**

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