Original Article
J Trauma Inj 2024;37(1):20-27
https://doi.org/10.20408/jti.2023.0072

Journal of Trauma and Injury JTI
pISSN 2799-4317 • eISSN 2287-1683

Emergency department laparotomy for patients with severe abdominal trauma: a retrospective study at a single regional trauma center in Korea

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Purpose: Severe abdominal injuries often require immediate clinical assessment and surgical intervention to prevent life-threatening complications. In Jeju Regional Trauma Center, we have instituted a protocol for emergency department (ED) laparotomy at the trauma bay. We investigated the mortality and time taken from admission to ED laparotomy.

Methods: We reviewed the data recorded in our center's trauma database between January 2020 and December 2022 and identified patients who underwent laparotomy because of abdominal trauma. Laparotomies that were performed at the trauma bay or the ED were classified as ED laparotomy, whereas those performed in the operating room (OR) were referred to as OR laparotomy. In cases that required expeditious hemostasis, ED laparotomy was performed appropriately.

Results: From January 2020 to December 2022, 105 trauma patients admitted to our hospital underwent emergency laparotomy. Of these patients, six (5.7%) underwent ED laparotomy. ED laparotomy was associated with a mortality rate of 66.7% (four of six patients), which was significantly higher than that of OR laparotomy (17.1%, 18 of 99 patients, P=0.006). All the patients who received ED laparotomy also underwent damage control laparotomy. The time between admission to the first laparotomy was significantly shorter in the ED laparotomy group (28.5 minutes; interquartile range [IQR], 14–59 minutes) when compared with the OR laparotomy group (104 minutes; IQR, 88–151 minutes; P<0.001). The two patients who survived after ED laparotomy had massive mesenteric bleeding, which was successfully ligated. The other four patients, who had liver laceration, kidney rupture, spleen injury, and pancreas avulsion, succumbed to the injuries.

Conclusions: Although ED laparotomy was associated with a higher mortality rate, the time between admission and ED laparotomy was markedly shorter than for OR laparotomy. Notably, major mesenteric hemorrhages were effectively controlled through ED laparotomy.

Keywords: Laparotomy; Wounds and injuries; Hospital emergency service

Received: October 1, 2023
Revised: October 31, 2023
Accepted: November 7, 2023

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INTRODUCTION

Background

Trauma remains a significant global public health challenge and is an important cause of morbidity and mortality [1–3]. Abdominal trauma is highly challenging, and because such cases are often accompanied by significant hemorrhage, they require rapid clinical assessment and immediate surgical intervention to prevent life-threatening complications [4,5]. Because of this reason, the term "golden hour" was coined. Currently, the treatment of hemodynamic unstable abdominal injuries involves damage control laparotomy (DCL), damage control resuscitation, resuscitative endovascular occlusion of aorta (REBOA), or angioembolization [6,7]. The concept of "damage control" emphasizes prompt hemostasis. For this, expeditious hemostasis of the main bleeder is crucial, and it is often achieved via laparotomy. Indeed, prognosis varies significantly as time progresses following injury and it can range from full recovery to irreversible organ damage or fatality [4]. However, patients with severe blood loss may not be stable enough to be transferred to the operating room (OR).

To overcome these challenges, the strategy of direct-to-OR (DOR) resuscitation has been proposed [8]. This approach seeks to expedite critical intervention by eliminating potential delays at the emergency department (ED). However, bypassing the ED may not be feasible at many hospitals because of the cooperation between anesthesiologists and nursing staff in the OR. At many hospitals, performing laparotomy at the ED without anesthesiologists may be more appropriate. Few studies have reported the use of ED laparotomy to treat severely unstable patients and its efficacy and safety are unclear [9–12]. Moreover, ED environments are not always set up for such surgical procedures because the specialized facilities, essential instruments, and requisite personnel, including anesthesiologists and surgical nursing staff, are often not provided in these settings. This limitation underscores the urgent need for structured protocols and resources dedicated to managing such cases.

Despite such limitations, a protocol for performing ED laparotomy at the trauma bay was instituted at our trauma center in 2020. This approach was specifically meant to cater to cases of severely unstable abdominal injuries.

Objectives

Here, we investigated the mortality after ED laparotomy and time taken from admission to ED laparotomy.

METHODS

Ethics statement

This study was approved by the Institutional Review Board of Cheju Halla General Hospital (No. 2023-L14-01). The requirement for informed consent was waived due to the retrospective nature of the study.

Study design and patients

Data for the study was obtained from the Korean Trauma Database by reviewing entries made by Jeju Regional Trauma Center (Jeju, Korea) between January 2020 and December 2022 and retrieving the records on patients who underwent laparotomy because of abdominal trauma. Patients who underwent laparotomy more than 8 hours following admission, those who underwent laparoscopy, or those who underwent preperitoneal pelvic packing only, were excluded from the study.

Patient demographic and clinical data, including injury mechanism, age, sex, laboratory findings, vital signs, Glasgow Coma Scale (GCS) score, Injury Severity Score (ISS), Abbreviated Injury Scale (AIS) score, transfusion, postoperative outcomes, the place where the laparotomy was performed, bedside procedures (such as resuscitative endovascular balloon occlusion of the aorta [REBOA]), and ED thoracotomy, were collected and analyzed.

Laparotomies performed at the trauma bay or the ED were classified as ED laparotomy, whereas those done at the OR, were classified as OR laparotomy. Because patients undergo two or more surgeries in damage control settings, we divided the patients into the ED laparotomy or the OR laparotomy group based on where the first laparotomy was done. Our trauma center has two dedicated trauma bays, two ORs, and one interventional radiology room close to the trauma bay. These facilities are equipped with point-of-care ultrasonography, a REBOA kit, a portable x-ray, and surgical equipment for ED laparotomy and thoracotomy, for use by a dedicated trauma staff. For the treatment of hemodynamically unstable patients, we have protocols for carrying out REBOA, ED thoracotomy, and ED laparotomy. The indications for REBOA are unstable vital signs (systolic blood pressure [SBP], <90 mmHg) and severe intra-abdominal or pelvic hemorrhage [13]. Patients with impending cardiac arrest (before or after REBOA), underwent ED thoracotomy. After the return of spontaneous circulation, the aortic clamp used during the thoracotomy was converted into REBOA. In cases requiring hemostasis but transfer to the OR was expected to be delayed, ED laparotomy was performed appropriately (Fig. 1). This study's primary and secondary outcomes were in-hospital mor-

Fig. 1. Emergency department laparotomy for prompt hemostasis.

tality and the length of time between admission and the first laparotomy, respectively.

Statistical analysis

Continuous data are presented as median and interquartile range (IQR). Categorical data are presented as proportions. Statistical differences between continuous variables were compared using the Mann-Whitney U-test, whereas differences between proportions were compared using the chi-square test or Fisher exact test, as appropriate. A P-value of <0.05 indicates statistically significant differences. All statistical analyses were performed using R ver. 4.3.1 (R Foundation for Statistical Computing).

RESULTS

Between January 2020 and December 2022, 105 trauma patients underwent emergency laparotomy within 8 hours of admission at our hospital. Table 1 summarizes the comparison between the patients who underwent OR laparotomy versus those who received ED laparotomy. Of the total 105 patients, 99 patients (94.3%) underwent OR laparotomy, whereas six (5.7%) received ED laparotomy. The mortality rate in the ED laparotomy group (four patients, 66.7%) was significantly higher than in the OR laparotomy group (18 patients, 17.1%; P=0.006). In the ED laparotomy group, all six patients (100%) underwent DCL, and the number of patients who underwent REBOA (four patients, 66.7%) was significantly higher than in the OR laparotomy group (10 patients, 10.1%; P<0.001). SBP was significantly lower in the ED laparotomy group than in the OR laparotomy group (40.5 mmHg [IQR, 0–105 mmHg] vs. 123 mmHg [IQR, 99–144 mmHg]; P=0.005). Heart rate was significantly lower in the ED laparotomy group than in the OR laparotomy group (30 beats/min [IQR, 0–95 beats/min] vs. 89 beats/min [IQR, 79.5–103 beats/min]; P=0.038). GCS score was significantly lower in the ED laparotomy group than in the OR laparotomy group (5.5 [IQR, 3–12] vs. 15 [IQR, 13–15]; P=0.004). Abdominal AIS score was significantly higher in the ED laparotomy group than in the OR laparotomy group (4 [IQR, 3–5] vs. 3 [IQR, 2–3.5]; P=0.013). Patients in the ED laparotomy group received significantly more packed red blood cell (PRBC) than those in the OR laparotomy group (8 U within 4 hours [IQR, 5–13 U] vs. 2 U within 4 hours [IQR, 0–5 U]; P=0.038). Notably, the time between patient admission and the first laparotomy was significantly shorter for patients in the ED laparotomy group than those in the OR laparotomy group (28.5 minutes [IQR, 14–59 minutes] vs. 104 minutes [IQR, 88–151 minutes]; P<0.001).

To minimize selection bias, we compared the patients who underwent ED laparotomy with those who underwent OR laparotomy and received more than 4 U of PRBCs within 4 hours after admission (Table 2). The time between admission and the first laparotomy was also shorter in the ED laparotomy group than in the group that underwent OR laparotomy and received over 4 U of PRBCs within 4 hours (28.5 minutes [IQR, 14–59 minutes] vs. 100 minutes [IQR, 88–133.5 minutes]; P=0.004).

The characteristics of the patients who underwent ED laparotomy are summarized in Table 3. One patient had a penetrating injury, whereas five patients had blunt injuries. All patients underwent DCL. However, only the two patients with massive mesenteric bleeding, which was controlled via ligation during ED laparotomy, survived. The other four patients, who had liver laceration, kidney rupture, spleen injury, and pancreas avulsion, underwent pad packing, followed by OR laparotomy, but they did not survive their injuries. In three patients (50.0%), ED laparotomies were performed within 30 minutes of admission.

DISCUSSION

In this study, we found that the mortality rate of patients who underwent ED laparotomy was 66.7%. Although only two patients survived, we believe that ED laparotomy is not always futile. Expeditious hemostasis can be achieved through ED laparotomy, especially in cases of mesenteric massive bleeding. We managed to ligate mesenteric bleeding during ED laparotomy. However, ED laparotomy was ineffective in patients with liver laceration, pancreatic avulsion, spleen injury, and kidney rupture. Although ED laparotomy appears to be effective in controlling mesenteric bleeding, more complicated procedures, such as nephrectomy,

https://doi.org/10.20408/jti.2023.0072

Table 1. Comparison between patients who underwent ED laparotomy versus those who received OR laparotomy

Variable	Total (n=105)	OR laparotomy (n=99, 94.3%)	ED laparotomy (n=6, 5.7%)	P-value
Damage control laparotomy	24 (22.9)	18 (18.2)	6 (100)	<0.001
REBOA	14 (13.3)	10 (10.1)	4 (66.7)	<0.001
ED thoracotomy	2 (1.9)	0	3 (50.0)	<0.001
Male sex	77 (73.3)	72 (72.7)	5 (83.3)	0.924
Age (yr)	55 (43–67)	54 (43–67)	56 (50–70)	0.664
Systolic blood pressure (mmHg)	121 (97–141)	123 (99–144)	40.5 (0–105)	0.005
Heart rate (beats/min)	89 (78–103)	89 (79.5–103)	30 (0–95)	0.038
Respiratory rate (breaths/min)	20 (20–24)	20 (20–24)	11 (0–23)	0.175
Injury mechanism				0.842
Penetrating	30 (28.6)	29 (29.3)	1 (16.7)	
Blunt	75 (71.4)	70 (70.7)	5 (83.3)	
Glasgow Coma Scale	15 (12–15)	15 (13–15)	5.5 (3–12)	0.004
Injury severity				
Injury Severity Score	17 (9–27)	17 (9–27)	26 (22–34)	0.071
Abbreviated Injury Scale				
Head	0 (0–0)	0 (0–0)	0 (0–2)	0.777
Neck	0 (0–0)	0 (0–0)	0 (0–0)	0.632
Face	0 (0–0)	0 (0–0)	0 (0–0)	0.899
Thorax	1 (0–3)	1 (0–3)	3 (0–3)	0.437
Abdomen	3 (3–4)	3 (2–3.5)	4 (3–5)	0.013
Upper extremity	0 (0–0)	0 (0–0)	0 (0–0)	0.178
Lower extremity	0 (0–2)	0 (0–1.5)	0 (0–2)	0.892
External	0 (0–0)	0 (0–0)	0 (0–0)	0.007
Transfusion within 4 hr (U)				
PRBC	2 (0–5)	2 (0–5)	8 (5–13)	0.038
FFP	2 (0–4)	1 (0–3.5)	4.5 (4–10)	0.020
Platelet	0 (0–0)	0 (0–0)	0 (0–0)	0.632
Transfusion within 24 hr (U)				
PRBC	2 (0–8)	2 (0–6)	9.5 (8–13)	0.056
FFP	2 (0–7)	2 (0–5.5)	7 (4–13)	0.095
Platelet	0 (0–0)	0 (0–0)	3 (0–8)	0.115
Mortality	18 (17.1)	14 (14.1)	4 (66.7)	0.006
Cardiopulmonary resuscitation	4 (3.8)	4 (4.0)	0	>0.999
Morbidity				
Acute kidney injury	5 (4.8)	5 (5.1)	0	>0.999
Acute respiratory failure	4 (3.8)	4 (4.0)	0	>0.999
Bedsore	4 (3.8)	4 (4.0)	0	>0.999
Deep vein thrombosis	3 (2.9)	3 (3.0)	0	>0.999
Pneumonia	6 (5.7)	6 (6.1)	0	>0.999
Pulmonary thromboembolism	1 (1.0)	1 (1.0)	0	>0.999
Superficial SSI	1 (1.0)	1 (1.0)	0	>0.999
Urinary tract infection	4 (3.8)	4 (4.0)	0	>0.999
Time from arrival to first operation (min)	102 (85–147)	104 (88–151)	28.5 (14–59)	<0.001

Values are presented as number (%) or median (interquartile range).
ED, emergency department; OR, operating room; REBOA, resuscitative endovascular balloon occlusion of aorta; PRBC, packed red blood cell; FFP, fresh frozen plasma; SSI, surgical site infection.

Table 2. Comparison between the patients who underwent ED laparotomy with those who underwent OR laparotomy and received over 4 U of PRBC transfusion within 4 hours (n=33)

Variable	OR laparotomy (n=27)	ED laparotomy (n=6)	P-value
Damage control laparotomy	15 (55.6)	6 (100)	0.115
REBOA	10 (37.0)	4 (66.7)	0.383
ED thoracotomy	0	3 (50.0)	0.002
Male sex	19 (70.4)	5 (83.3)	0.890
Age (yr)	60 (38–68)	56 (50–70)	0.815
Systolic blood pressure (mmHg)	95 (72–120.5)	40.5 (0–105)	0.174
Heart rate (beats/min)	102 (87.5–118.5)	30 (0–95)	0.022
Respiratory rate (breaths/min)	24 (20–24.5)	11 (0–23)	0.098
Injury mechanism			>0.999
Penetrating	4 (14.8)	1 (16.7)	
Blunt	23 (85.2)	5 (83.3)	
Glasgow Coma Scale	11 (7–15)	5.5 (3–12)	0.199
Injury severity			
Injury Severity Score	27 (21.5–36.5)	26 (22–34)	0.542
Abbreviated Injury Scale			
Head	0 (0–3)	0 (0–2)	0.441
Neck	0 (0–0)	0 (0–0)	0.535
Face	0 (0–0)	0 (0–0)	0.769
Thorax	3 (0–3)	3 (0–3)	0.579
Abdomen	4 (3–4)	4 (3–5)	0.254
Upper extremity	0 (0–0)	0 (0–0)	0.224
Lower extremity	0 (0–2.5)	0 (0–2)	0.671
External	0 (0–0)	0 (0–0)	0.041
Transfusion within 4 hr (U)			
PRBC	9 (6–14.5)	8 (5–13)	0.557
FFP	6 (4–8)	4.5 (4–10)	0.796
Platelet	0 (0–0)	0 (0–0)	0.344
Transfusion within 24 hr (U)			
PRBC	12 (7–22)	9.5 (8–13)	0.413
FFP	12 (5–18.5)	7 (4–13)	0.261
Platelet	6 (0–10)	3 (0–8)	0.546
Mortality	10 (37.0)	4 (66.7)	0.383
Cardiopulmonary resuscitation	1 (3.7)	0	>0.999
Morbidity			
Acute kidney injury	3 (11.1)	0	0.943
Acute respiratory failure	1 (3.7)	0	>0.999
Bedsore	2 (7.4)	0	>0.999
Deep vein thrombosis	2 (7.4)	0	>0.999
Pneumonia	5 (18.5)	0	0.607
Pulmonary thromboembolism	0	0	>0.999
Superficial SSI	1 (3.7)	0	>0.999
Urinary tract infection	3 (11.1)	0	0.943
Time from arrival to first operation (min)	100 (88–133.5)	28.5 (14–59)	0.004

Values are presented as number (%) or median (interquartile range).
ED, emergency department; OR, operating room; PRBC, packed red blood cell; REBOA, resuscitative endovascular balloon occlusion of aorta; FFP, fresh frozen plasma; SSI, surgical site infection.

https://doi.org/10.20408/jti.2023.0072

Table 3. Summary of the patients who underwent ED laparotomy

Patient no.	Sex	Age (yr)	Injury mechanism	SBP (mmHg)	GCS	ISS	Operation	Remark	Final diagnosis	Mortality	Time from admission to first laparotomy (min)
1	Male	30	Blunt	105	8	27	Bleeder ligation, DCL	Blunt, admitted with ongoing CPR, REBOA (+), FAST (pneumothorax, intra-abdominal fluid collection)	Massive mesenteric bleeding	No	59
2	Male	50	Blunt	0	3	34	Liver pad packing, DCL	Blunt, REBOA (+), ED thoracotomy (+), FAST (intra-abdominal fluid collection)	Liver laceration (segment 2, 3, 6, 7, 8)	Yes	22
3	Female	56	Blunt	116	15	22	Pad packing, DCL	Blunt, CPR before CT, REBOA (+), FAST (intra-abdominal fluid collection)	Kidney rupture, perigastric vessel bleeding, liver cirrhosis	Yes	105
4	Male	56	Penetrating	81	12	16	Bleeder ligation, DCL	Penetrating, FAST (intra-abdominal fluid collection)	Mesentery laceration, sigmoidal artery transection, sigmoid colon transection, psoas muscle injury	No	35
5	Male	70	Blunt	0	3	25	Pad packing, DCL	Blunt, admitted with ongoing CPR, failure of REBOA, ED thoracotomy (+), FAST (not reported)	Pancreas avulsion, celiac trunk rupture, SMA rupture, left renal vein rupture	Yes	14
6	Male	73	Blunt	0	3	34	Pad packing, DCL	Blunt, admitted with ongoing CPR, REBOA (+), ED thoracotomy (+), FAST (not reported)	Left kidney injury, spleen injury	Yes	9

ED, emergency department; SBP, systolic blood pressure; GCS, Glasgow Coma Scale; ISS, Injury Severity Score; DCL, damage control laparotomy; CPR, cardiopulmonary resuscitation; REBOA, resuscitative endovascular balloon occlusion of aorta; FAST, Focused Assessment with Sonography for Trauma; CT, computed tomography; SMA, superior mesenteric artery.

splenectomy, or controlling lacerated liver bleeding, were less feasible during ED laparotomy. Nonetheless, larger datasets and prospective studies are needed to estimate the effect size of ED laparotomy.

In 1979, Mattox et al. [11] reported the performance of 51 laparotomies at an ED, which underwent concurrent ED thoracotomy. However, only 11 of the 51 patients reached the OR, and none of the 51 patients survived, leading to the conclusion that although ED laparotomy was technically possible, it did not improve survival. In 2011, Lund et al. [10] described 44 ED laparotomies, which were associated with a 41% survival rate after 30 days. Notably, they reported that blunt trauma patients admitted with a blood pressure of < 60 mmHg were associated with poor outcomes (15% survival) when compared with those who had penetrating trauma (60% survival). In our study, the survival rate was very poor (33.3%) and our cohort had only one patient with a penetrating injury. A retrospective study by Groven et al. [14], which involved 87 OR laparotomies and 80 ED laparotomies, reported a tendency of decreasing ED laparotomy but not increasing mortality. They noted a dedicated trauma OR. Although our trauma center has two dedicated trauma ORs, it generally takes 30 to 60 minutes to prepare the equipment and staff. Moreover, some patients may be too unstable to survive this short duration. Thus, ED laparotomy may benefit a subset of unstable patients. A retrospective study by Ito et al. [12], which involved 50 ED laparotomies and 55 OR laparotomies, reported that ED laparotomy was associated with a shorter duration between admission and operation when compared with OR laparotomy (median, 43 minutes vs. 109 minutes). In our study, we found that ED laparotomy was associated with a markedly shorter duration between admission and the operation when compared with OR laparotomy (28.5 minutes [IQR, 14.0–59.0 minutes] vs. 104.0 minutes [IQR, 88.0–151.0 minutes]). Ito et al. [12] observed higher infectious complications in the ED laparotomy group when compared with the OR laparotomy group (14.0% vs. 7.3%), although the difference was not statistically significant. In our study, we did not observe infectious complications, such as pneumonia or surgical site infection. However, because our study has a small sample size, this requires further investigation.

Expeditious bleeding control is most crucial in patients with significant intra-abdominal hemorrhage, which requires laparotomy. A recent retrospective analysis of the Prospective Observational Multicenter Major Trauma Transfusion (PROMMTT) study [4] analyzed data from patients who underwent laparotomy within 90 minutes of admission and had a Focused Assessment with Sonography for Trauma (FAST) performed. That study found that delayed operation was associated with increased early and late in-hospital mortality in patients with FAST positive finding. Several early intervention strategies, such as directly moving the patient to the OR have been proposed, and several studies have reported direct resuscitation in the OR [8,15,16]. Some hospital designs contain ORs within the emergency department, directly next to the trauma bay's entrance (EDOR) [16]. A retrospective study involving 120 patients compared with data on 120 patients from the National Trauma Data Bank (NTDB) using propensity score matching, found that EDOR was associated with a shorter time to incision when compared with the NTDB dataset (25.5 minutes vs. 40.0 minutes). However, it was reported that the staff involved in trauma activation included trauma surgeons, attending anesthesiologists, and OR nurses in the EDOR system [16]. In our country, it is not easy to set up an OR in a trauma bay because of infection prevention regulations. Thus, in situations with limited facilities and human resources, ED laparotomy might be a practical alternative.

In our study, only two patients survived, and both had mesenteric bleeding injuries. This type of injury is relatively easy to control using clamp and packing. However, in ED laparotomy settings, more sophisticated procedures like liver bleeding control, nephrectomy, splenectomy, or major vessel injury control, may be inappropriate. Such procedures are more time-consuming and require more support from anesthesiologists to manage the patients' vitality. In this study, after reaching the OR, patients with liver, kidney, spleen, or major vessel injuries underwent definite hemostasis, such as nephrectomy or splenectomy. However, attempting ED laparotomy might be valuable because accurate diagnosis is often difficult in hemodynamically unstable patients.

Limitations

This study has some limitations. First, because it is retrospective, it may have substantial selection and survival bias. Second, the number of patients who underwent ED laparotomy was small. Thus, multivariable analysis could not be done. In the future, larger studies may include propensity score matching for ED laparotomy to compare patients with similar severities. Here, we compared patients who had received more than 4 U of PRBC. Third, we did not report the result of FAST because 45.7% of patients had missing FAST results in our dataset. Finally, despite our ED laparotomy protocol, OR laparotomy might still be done if it is preferred by the surgeon, which may represent selection bias. Indeed, only 5.7% of laparotomies were done in the ED.

Conclusions

Although ED laparotomy was associated with a higher mortality rate, when compared with OR laparotomy it had a markedly shorter duration between admission and laparotomy. Thus, ED laparotomy allows quicker hemostasis. Notably, major mesenteric hemorrhages were effectively managed using ED laparotomy. Thus, in situations of delayed OR laparotomy, ED laparotomy might be a valuable alternative.

ARTICLE INFORMATION

Author contributions

Conceptualization: YJL, WSK; Data curation: all authors; Formal analysis: YJL, WSK; Methodology: YJL, WSK; Project administration: WSK; Supervision: WSK; Visualization: WSK; Writing–original draft: YJL, WSK; Writing–review and editing: all authors. All authors read and approved the final manuscript.

Conflicts of interest

Wu Seong Kang is an Editorial Board member of the *Journal of Trauma and Injury*, but was not involved in in the peer reviewer selection, evaluation, or decision process of this article. The authors have no other conflicts of interest to declare.

Funding

The authors received no financial support for this study.

Data availability

Data analyzed in this study are available from the corresponding author upon reasonable request.

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