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ORIGINAL RESEARCH

Life saving or limb saving? A clinical dilemma in the management of pelvic fracture patients with external iliac arterial injuries

Pei-Hua Li[1], Chien-Hung Liao[1], Chih-Po Hsu[1], Chun-Hsiang Ouyang[1], Shih-Ching Kang[1], Jen-Fu Huang[1], Chi-Tung Cheng[1], Chih-Yuan Fu[1,*]

[1]Department of Trauma and Emergency Surgery, Linkou Chang Gung Memorial Hospital, Chang Gung University, 333423 Taoyuan, Taiwan

***Correspondence**
fucy@cgmh.org.tw
(Chih-Yuan Fu)

Abstract

External iliac artery (EIA) injuries associated with pelvic fractures are uncommon yet serious. High mortality rates due to hemorrhage and the risk of necrosis from disrupted blood flow during hemostasis present significant challenges. Physicians often grapple with the choice between prioritizing life-saving measures and limb salvage. This study seeks to establish a treatment protocol for managing pelvic fracture-related EIA injuries that is both effective and readily implementable. In this retrospective case series and literature review, we examined patients who sustained pelvic fractures with EIA injuries from May 2008 to May 2021, using data from our trauma registry system. Additionally, we conducted a review of the available literature on the subject. We retrieved and analyzed the data regarding patient demographics, clinical presentation, associated injuries, pelvic fracture type, arterial injury location and management, salvage of limbs and mortality. Characteristics of survivors and patients with preserved limbs were analyzed. In the current study, we identified 5 patients from our institution and 22 patients from previous literature that suffered from pelvic fracture with EIA injuries. There was an overall mortality rate of 25.9%. Sixteen patients underwent revascularization of the injured vessels. Eight patients underwent ligation of injured vessels as part of the hemostasis or damage control procedure. The limb preservation rate in survivors was 45.0%. Compared with nonsurvivors, survivors had a significantly higher chance of undergoing revascularization (70.0% *vs.* 28.6%, $p = 0.044$). Among survivors, open fracture was associated with a 21.277-fold higher odds of need for amputation ($p = 0.015$, odds ratio = 21.277). When balancing life-saving efforts with limb preservation, the loss of limbs can sometimes seem unavoidable to save lives. Nevertheless, once hemostasis is attained, we recommend pursuing aggressive revascularization. We observed a poor prognosis in patients with open pelvic fractures and EIA injuries.

Keywords

External iliac artery injury; Limb salvage; Pelvic fracture; Revascularization

1. Background

The reported incidence of injuries to the common iliac artery or external iliac artery (EIA) in the context of moderate to severe pelvic fractures ranged from 0.2% to 3.5% [1]. Compared with internal iliac artery (IIA) injuries related to pelvic fractures, (EIA) injuries are relatively rare in patients with pelvic fractures [2, 3]. Unlike embolization of IIA, which can be performed in cases of injury without long-term complications, EIA blocking for hemostasis may result in limb ischemia and the subsequent need for amputation [4]. Immediate restoration of vascular perfusion is typically required in patients with external iliac artery (EIA) injuries to prevent lower extremity ischemia. Consequently, managing pelvic fracture patients with active hemorrhage from EIA injuries presents a significant challenge. Physicians often face the dilemma of choosing between hemostasis for life-saving purposes and revascularization to preserve the limb.

To our knowledge, only a few sporadic cases have been reported for EIA injuries in patients with pelvic fracture, and there has been no study with a large series of cases. The injury occurs in a scarce population but is frequently associated with severe morbidity and life-threatening conditions. The objective of the current study is to develop a practical therapeutic algorithm for managing pelvic fracture patients with EIA injuries, drawing on experience from a level-I trauma center and a review of the available literature. This algorithm aims to facilitate critical decision-making between life-saving and

limb-saving interventions.

2. Methods

2.1 Study population and literature review

A computerized trauma registry was established to collect trauma data from our institution, a level I trauma center. A retrospective review of patients with pelvic fractures (International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes 808.xx) was conducted for the period from May 2008 to December 2021. Within this cohort, we specifically focused on patients with concomitant EIA injuries (ICD-9-CM code: 902.5). Exclusions were made for patients (1) who had out-of-hospital cardiac arrests with no response to resuscitation, (2) who had severe head or chest injuries (abbreviated injury scale $\geq$3) that could affect mortality outcomes, or (3) who were initially treated at another hospital and subsequently transferred to our Emergency department (ED).

To expand the experience and data from the current literature, we searched the MEDLINE, EMBASE and Web of Science electronic databases. The search was confined to the English language and publication dates between January 1984 and December 2021. The following subject headings were used: "pelvic fracture", "iliac artery", "injury" and "trauma". Fig. 1 shows a search flow of the current review. The details of these publications are shown in Table 1 [2, 3, 5–14]. The references of relevant articles were evaluated to find other eligible studies. Two independent reviewers screened the titles and abstracts to determine the suitability of the studies for inclusion. Only studies in which data was made available were used since this allowed for evaluating treatment details. Furthermore, letters and editorials were excluded. If there was missing data or the if the literature was not presented clearly, we sent letters to the authors to request further data to clarify the course of patients. Data included details about the mechanism of trauma, demographics (age, sex), study methods (study design, case numbers), iliac artery injury site, severity, outcomes, therapeutic options, preservation of the suffering limb and mortality. When missing data were encountered, these data were calculated using information from the publications. The reviewers were not blinded to the authorship or institution. Disagreements regarding the entire review process were resolved by consulting a third reviewer.

2.2 Study setting

Our institution is a Level I trauma center that receives over 25,000 trauma cases annually, with patients primarily arriving at our ED or transferred from other hospitals. We have 24/7 in-house trauma surgeons, orthopedic surgeons, and vascular surgeons ready to perform emergency surgeries. Our angiographic suite and operating rooms are equipped to be ready within one hour for patients requiring emergency hemostatic procedures. Additionally, we have a specialized intensive care unit dedicated to trauma patients.

In our institution, all trauma patients were evaluated and managed under the same protocol by trauma surgeons based on the guidelines of Advanced Trauma Life Support (ATLS) [15]. A contrast-enhanced computed tomographic (CT) scan was used to evaluate the associated vascular injuries in cases of pelvic fracture. Patients with concomitant pelvic fracture and EIA injury could undergo hemostasis or revascularization procedures. For patients with unstable hemodynamics (systolic blood pressure below 90 mmHg despite 1000 mL of fluid resuscitation and four units of blood transfusion within one hour), immediate hemostatic procedures, including surgical ligation of the EIA, were performed. Conversely, stable patients (systolic blood pressure of 90 mmHg or higher) were candidates for revascularization procedures. The revascular-

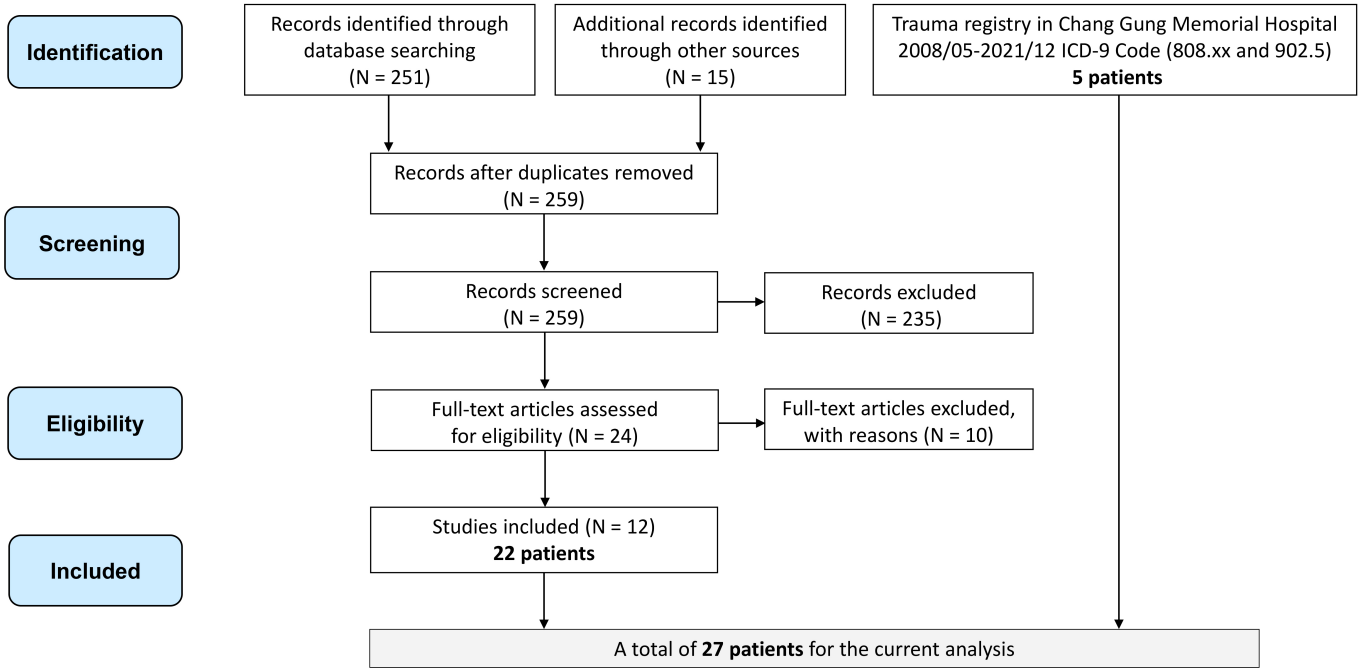

FIGURE 1. The flow diagram of data collection in the current study.

TABLE 1. The details of the included reports in the current study.

Author	Year	Case number	Mean age	Gender M/F	ISS	Open/closed pelvic fracture	Vascular intervention	Outcomes of limbs in survivors	Mortality
Frank JL [2]	1989	2	30	2/0	N/A	1/1	Revascularization (open): 2	Preserved (2)	0
Lankford A [3]	1999	1	43	1/0	N/A	0/1	Revascularization (open): 1	-	1
Ruotolo C [5]	2001	1	32	0/1	N/A	0/1	Revascularization (open): 1	Preserved (1)	0
Shah SH [6]	2003	1	50	1/0	N/A	0/1	Revascularization (endovascular): 1	Preserved (1)	0
Sternbergh WC 3rd [7]	2003	1	27	1/0	N/A	0/1	Revascularization (endovascular): 1	Preserved (1)	0
Teebken OE [8]	2008	1	18	1/0	N/A	0/1	Revascularization (open): 1	Preserved (1)	0
Faisham W [9]	2012	1	16	1/0	N/A	1/0	Ligation: 1	HP (1)	0
Pascarella R [10]	2014	6	32	3/3	42	5/1	Died before intervention: 2 Revascularization (open): 3 Ligation: 1	HP (3)	3
Zong ZW [11]	2016	1	25	1/0	N/A	0/1	Revascularization (open): 1	HP (1)	0
Omura T [12]	2020	1	45	1/0	51	1/0	Ligation: 1	HC (1)	0
Xu Y [13]	2020	4	43	3/1	N/A	1/3	Revascularization (open): 1 Ligation: 2 Observation: 1	Preserved (2) HP (1)	1
Zhang S [14]	2021	2	51	2/0	N/A	0/2	Revascularization (open): 2	Preserved (1) HP (1)	0

M/F: male/female; ISS: injury severity score; HP: hemipelvectomy; HC: hemicorporectomy; N/A: not applicable.

ization procedures included surgical repair or endovascular repair [4, 6, 7]. The selection of procedures depended on the physician's clinical judgment or the patient's condition. In our trauma registry system, data regarding demographics, associated injuries, pelvic fracture type, arterial injury location and management, therapeutic options, limb salvage, and mortality were routinely collected.

2.3 Outcome measurement

The primary outcome of this study was the survival rate of patients with pelvic fractures and EIA injuries upon discharge. Survival and mortality were assessed during hospitalization. The secondary outcome focused on the preservation of limbs affected by EIA injuries.

2.4 Statistical analysis

Nominal data are presented as the number with a percentage and were compared using the Pearson χ^2 test, and numerical data are presented as the mean with standard deviation and were compared using Student's t test. A value of $p < 0.05$ was considered indicative of statistical significance. Statistical analysis was performed using SPSS v.20.0 for Macintosh (SPSS Inc., Chicago, IL, USA).

3. Results

In this study, we identified a cohort of pelvic fracture patients with EIA injuries from our trauma registry system (N = 11). Of these, six patients met the exclusion criteria. Consequently, we included a total of five cases in our study, which spanned from May 2008 to December 2021, identified *via* ICD codes and diagnosis text matching. The characteristics of these patients are presented in the **Supplementary Table 1**.

To expand the experience and data, we also identified 22 patients from previous literature that suffered from pelvic fracture with external or common iliac artery injuries. The literature review yielded a total of 259 publications using search terms

from January 1984 to December 2021 (Table 1). A total of 259 studies were included for full-text analysis. After we reviewed the abstract, 235 articles were excluded due to nontrauma-related injury, pediatric group study, no English-based works of literature, or no full-text available. Finally, 12 publications with 22 cases were included (Fig. 1 and Table 1). The details of each patient from the literature review are shown in the **Supplementary Table 2**. Therefore, 27 patients were included in the current study (5 from our institution and 22 from the literature review).

From the available data, the demographics of all patients in the current study (N = 27) are listed in **Supplementary Table 3**; 70.4% of these patients were male, and 29.6% were female; the average age was 36.7 years. Over half of these patients (51.9%) suffered from open pelvic fractures, and 57.7% of patients presented unstable hemodynamics upon arrival. The mortality rate was 25.9%, and the limb preservation rate in survivors was 45.0% (Table 1).

Among all studied patients (N = 27), one patient did not undergo injured vessel revascularization due to the distal flow from collateral circulation being preserved. This patient underwent conservative management, and the limbs were fully preserved. Sixteen patients (66.7%) of the remaining 24 patients received revascularization of the injured vessels. Among survivors in this group (N = 14), 71.4% (N = 10) had complete or partial preservation of the insulted limbs (8 patients: complete preservation; 2 patients: partial preservation with above-knee amputations). Eight patients (33.3%) who underwent vascular interventions (N = 24) received ligation of injured vessels as part of the hemostasis or damage control procedure. Of these eight patients, three patients died, and the other five survivors eventually underwent hemipelvectomy (Fig. 2).

The comparisons between survivors (N = 20) and nonsurvivors (N = 7) are shown in Table 2. Among nonsurvivors, the proportion of cases of open pelvic fracture was 71.4% (N = 5), whereas the proportion of cases of open pelvic fracture in survivors was only 45.0% (N = 9). In addition, a significantly higher chance of revascularization was observed in survivors than in nonsurvivors (70.0% *vs.* 28.6%, $p = 0.044$) (Table 2).

Further analyses for survivors were performed and are shown in Table 3. Among survivors (N = 20), there was a significantly higher proportion of open pelvic fracture patients with limb amputation (N = 8) than patients with limb preservation (N = 1) (72.7% *vs.* 11.1%, $p = 0.006$). Patients who underwent vascular ligation (N = 5) had no chance of limb preservation. Among patients with limb preservation, there was a significantly higher proportion of limb revascularization cases than cases involving limb amputation (88.9% *vs.* 54.5%, $p = 0.046$). A subsequent logistic regression analysis showed that open fracture was associated with a 21.277-fold higher odds of need for amputation ($p = 0.015$, odds ratio = 21.277, 95% confidence interval = 1.812–250.000).

In patients with open pelvic fracture (N = 14), the mortality rate was double that in patients with closed pelvic fracture (35.7% *vs.* 15.4%). Furthermore, the limb preservation rate was also lower in open pelvic fracture patients than in closed pelvic fracture patients (11.1% *vs.* 72.7%). Even after revascularization procedures, a low limb preservation rate was also observed in these patients (open pelvic fracture: 20.0% *vs.* closed pelvic fracture: 77.8%).

4. Discussion

Pelvic fractures accompanied by EIA injuries constitute a relatively small but clinically significant group, often presenting with life-threatening complications and substantial risk of limb morbidity. According to our retrospective case series and literature review, the observed mortality rate was as high as 25.9%, while the rate of limb preservation among survivors was 45.0%. Notably, the rate differed significantly between open pelvic fractures at 20.0% and closed pelvic fractures at 77.8%.

Pelvic fracture accompanied by hemorrhage and vascular injury leads to a complex and critical situation [16]. Hemorrhage from venous origin accounts for 80–85% of pelvic fracture patients, and arterial injury is rare [10]. However, arterial injury, if not thrombosed autonomously or stopped by hemostatic procedures, is often life-threatening. Tanizaki reported that 97% of pelvic fracture-associated arterial injuries occurred in the IIA and its branches according to angiography [17]. Compared with the IIA injury, which serves as the most common injured artery from the pelvic fracture, the EIA injury represents a scarce population but is frequently associated with severe morbidity and life-threatening conditions [18]. During searching and reviewing of the literature between January 1984 and December 2021, only 12 publications with 22 cases were found (Table 1). The mortality rate of these patients was up to 22.7% (n = 5), nearly double the number of overall mortalities in patients with pelvic fracture, which is approximately 5–16% [19]. Furthermore, some patients even died in the ED before receiving any treatment (n = 2, 9.1%).

In addition to being a source of life-threatening hemorrhage, the EIA is the main trunk that supplies the lower extremities. Disruption of distal blood flow may result in acute limb ischemia, which is strongly associated with ipsilateral lower extremity amputation, and two-thirds of cases eventually culminate in hemipelvectomy [4]. However, per the guidelines of the ATLS, hemostasis should always be performed prior to other limb salvage procedures [15]. When the patient is in the extremes with unstable hemodynamics, one should never hesitate to sacrifice the injured artery to stop the bleeding. Therefore, regarding surgical decision making, physicians are facing a dilemma between the saving of life and the salvaging of the limb in patients with pelvic fracture and concomitant EIA injury. A tough decision without a second choice must be made within a short period. It remains one of the most challenging situations for ED physicians and orthopedic and trauma surgeons.

Resuscitative endovascular balloon occlusion of the aorta (REBOA) has been recognized as an effective adjunct in managing non-compressible torso hemorrhage and pelvic fracture patients [20]. However, challenges in placing REBOA arise in patients with iliac artery injuries, given that these vessels are commonly utilized for vascular access during REBOA procedures. In such cases, cross-clamping the proximal aorta *via* an emergency department thoracotomy (EDT) can be considered a viable method for temporary stabilization in critical situations [21]. The application of either REBOA or EDT for temporary

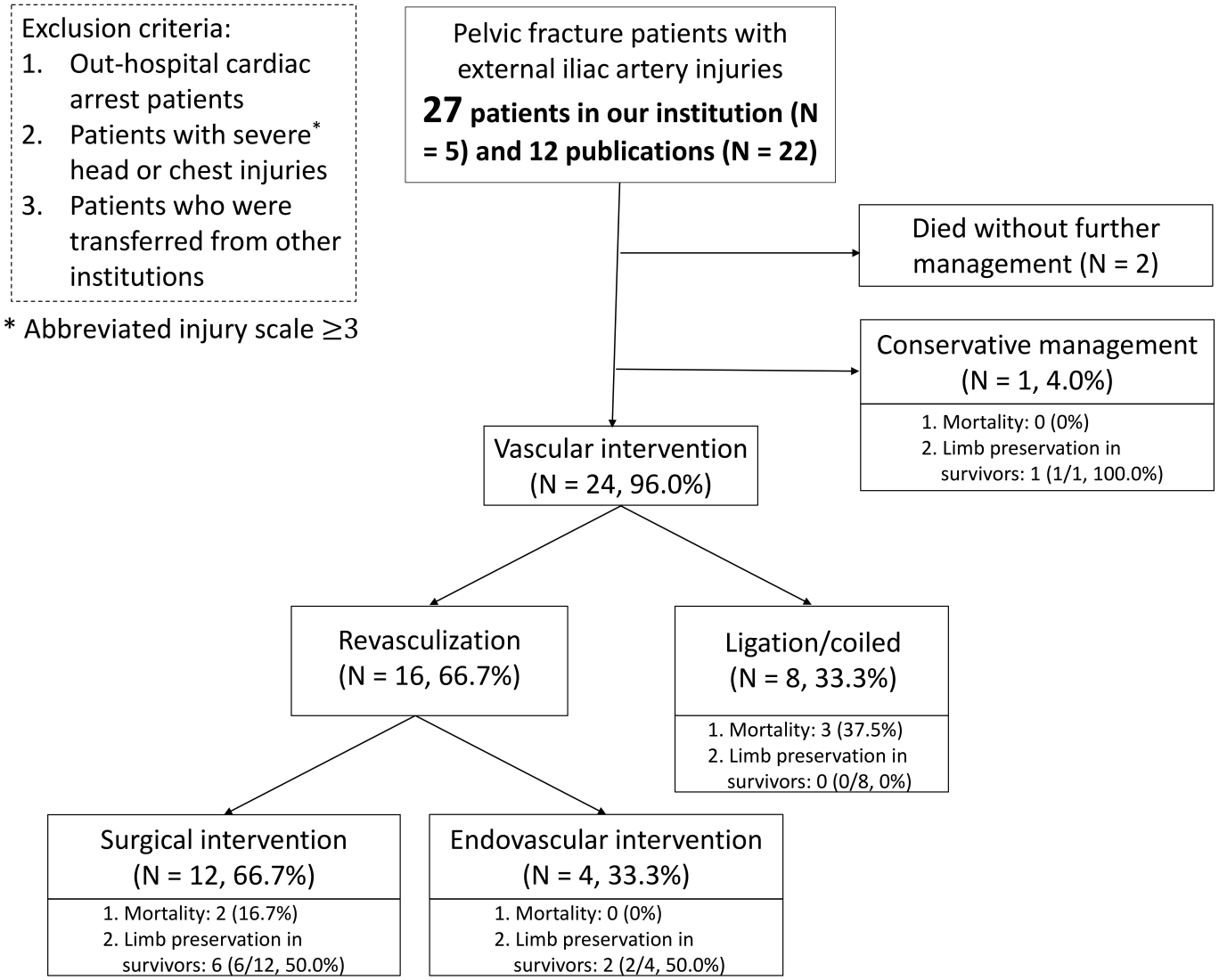

FIGURE 2. Patient demographics with interventions and further outcomes.

hemostatic control has demonstrated encouraging outcomes and has been recently incorporated into the latest guidelines as an interim measure leading to definitive treatment.

In the current study, less than 5% of patients (3.7%, 1/27) could be managed conservatively without interventions. In other words, most patients need interventions, either ligation of the injured EIA or revascularization. A significantly higher proportion of cases of revascularization was observed in survivors as a group than in nonsurvivors (70.0% *vs.* 28.6%, $p < 0.05$). However, this cannot be explained in terms of revascularization providing a survival benefit to patients with concomitant pelvic fracture and EIA injuries. Instead, revascularization may be performed in patients with higher survival opportunities. In the management of these patients, both bleeding status and limb perfusion should be evaluated simultaneously. After hemostasis is achieved and the general condition becomes stable, prompt consideration of common iliac artery or EIA injury and focused, emergent examination and intervention for restoration of blood flow are usually needed, especially for trauma patients with signs of lower extremity malperfusion. Among survivors in the current study, no limbs could be preserved after ligation of the external iliac artery, whereas the limb salvage rate could be 57.14% in survivors (8 in 14 patients) if the surgery for revascularization could be performed. In other words, aggressive reconstruction could be considered in patients with stable hemodynamics who can tolerate surgery for revascularization. In addition to conventional open methods (exploration with primary repair, patch repair, segmental resection and reanastomosis, artificial or vein graft bypass), vascular reconstruction using endovascular interventions (covered stent grafts) has been reported from an increasing number of studies as being successful [22]. Harris *et al.* [4] mentioned that although the endovascular approach requires specialized techniques and availability capabilities, it provides more rapid vascular intervention and facilitates limb reperfusion or hemostasis. In patients with concomitant pelvic fracture and EIA injury, endovascular intervention could be applied selectively with acceptable outcomes [6, 7]. Zambetti *et al.* [22] reported even lower morbidity and mortality rates in the endovascular repair group compared to the open approach for traumatic blunt iliac artery injury. Shunting of the injured vessel as part of the damage control options or temporary balloon control before bridging to definitive management has also been reported [23]. Fig. 3 illustrates a case where the

TABLE 2. Comparisons between survivors and nonsurvivors in the current study.

Variables	Survivor (N = 20)	Nonsurvivor (N = 7)	*p* value
Age	35.6 ± 12.4	39.9 ± 22.1	0.643*
Male gender (%)	16 (80.0%)	3 (42.9%)	0.064†
Mechanism (N, %)			
TA	16 (80.0%)	7 (100.0%)	
Crush	3 (15.0%)	0	0.440†
Fall	1 (5.0%)	0	
Shock on arrival	10/19 (52.6%)‡	5 (71.4%)	0.390†
Sign of limb malperfusion	13/14 (92.9%)‡	3/3 (100.0%)‡	0.633†
Open pelvic fracture	9 (45.0%)	5 (71.4%)	0.228†
Concomitant IIA injury	2 (10.0%)	2 (28.6%)	0.234†
TAE for IIA	3 (15.0%)	1/5 (20.0%)§	0.785†
Iliac management			
Death before intervention	-	2 (28.6%)	
Revascularization	14 (70.0%)	2 (28.6%)	0.044†
Ligation	5 (25.0%)	3 (42.9%)	
Observation	1 (5.0%)	-	
Fasciotomy	9 (45.0%)	2/5 (40.0%)§	0.840†
Limb amputation procedure			
No amputation	9 (45.0%)	3/5 (60.0%)§	
HP	9 (45.0%)	1/5 (20.0%)§	0.564†
AKA	2 (10.0%)	1/5 (20.0%)§	
Received HP in first operation	7/9 (77.8%)§	0	0.107†

†*Chi-square test;* **Student's t test.*
‡*Showing percentage among available data.*
§*The percentage of patients who received intervention (in the survival group, only 9 patients received HP; in the nonsurvivor group, 2 patients died before any intervention, and only the remaining 5 patients received further management).*
TA: traffic accident; TAE: transcatheter arterial embolization; IIA: internal iliac artery; HP: hemipelvectomy; AKA: above-knee amputation.

patient underwent surgical exploration, prioritizing hemostasis first and revascularization second, if feasible.

Multicollinearity between the above two factors, which were associated with limb preservation (open pelvic fracture and vascular reconstruction), was observed. Collinearity analysis showed that the variance inflation factor value was >10. In the management of open pelvic fracture, ligation of the EIA may be needed primarily due to life-threatening bleeding. It is difficult to consider limb preservation under such critical conditions. Therefore, the role of soft tissue injury in open pelvic fracture affects both decision making for vascular intervention and the prognostic outcome after revascularization. Compared with closed pelvic fracture, patients with open pelvic fracture had significantly poorer limb outcomes (limb preserving rate among survivors, open pelvic fracture 11.1% *vs.* closed pelvic fracture 72.7%; limb preserving rate among patients who underwent revascularizations, open pelvic fracture: 20.0% *vs.* closed pelvic fracture 77.8%). Furthermore, the logistic regression analysis showed that open fracture was associated with a 21.277-fold higher odds of need for amputation (p = 0.015, odds ratio = 21.277, 95% confidence interval = 1.812–250.000). In the current study, all of the patients with crush mechanisms received amputation as a result. Soft tissue injury, disruption of skin integrity and impairment of collateral circulation in open pelvic fractures may lead further to infection, sepsis and poor tissue perfusion, jeopardizing limb outcomes [4]. During the literature review regarding blunt common or EIA injury, it was noted that some risk factors for failure of limb preservation, such as high-grade pelvic fractures, pelvic soft tissue wounds, and lower extremity trauma, were also reported [4].

The present study increases our knowledge of this rare trauma and summarizes the management of pelvic fracture with EIA injuries. A suggested algorithm is shown in Fig. 4 based on the current literature review and case studies. With satisfactory hemodynamic status, prompt vascular intervention is encouraged. Endovascular revascularization could be considered for those with less soft tissue injury and fewer risk factors for amputation, such as closed fractures or noncrushing injuries.

TABLE 3. Comparisons between patients with amputation and limb preservation among survivors (N = 20).

Variables	Amputation (N = 11)	Limb preserving (N = 9)	*p* value
Age	35.2 ± 12.8	36.1 ± 12.7	0.873*
Male gender (%)	9 (81.8%)	7 (77.8%)	0.822†
Mechanism (N, %)			
TA	8 (72.7%)	8 (88.9%)	
Crush	3 (27.3%)	0 (0.0%)	0.147†
Fall	0 (0.0%)	1 (11.1%)	
Shock on arrival	6 (54.5%)	4/8 (50.0%)‡	0.845†
Sign of limb malperfusion	6/6 (100.0%)‡	7/8 (87.5%)‡	0.369†
Open pelvic fracture	8 (72.7%)	1 (11.1%)	0.006†
Concomitant IIA injury	2 (18.2%)	0 (0.0%)	0.178†
TAE for IIA	3 (27.3%)	0 (0.0%)	0.089†
Iliac management			
Revascularization	6 (54.5%)	8 (88.9%)	
Ligation	5 (45.5%)	0 (0.0%)	0.046†
Observation	0 (0.0%)	1 (11.1%)	
Fasciotomy	7 (63.6%)	2 (22.2%)	0.064†

†*Chi-square test; *Student's t test.*
‡*Showing percentage among available data.*
TA: traffic accident; TAE: transcatheter arterial embolization; IIA: internal iliac artery.

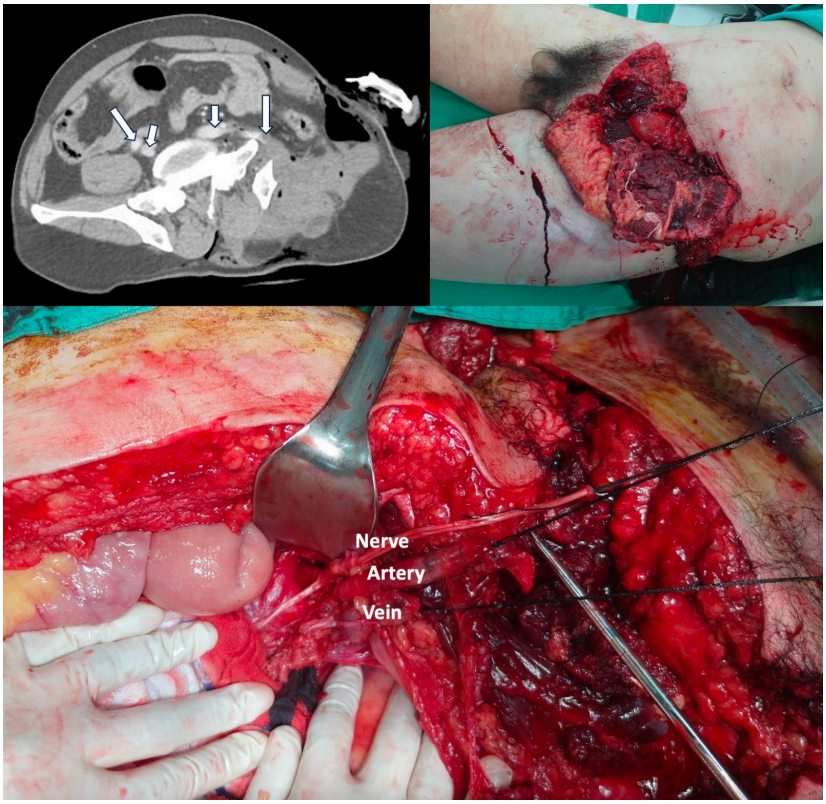

FIGURE 3. A 57-year-old male with a truncal crushing injury presented with an open pelvic fracture and injuries to the external iliac vessels, as detailed in Supplementary Table 1, patient #4. On the CT scan, short arrows point to the intact bilateral IIAs, while long arrows highlight the intact right EIA and the injured left EIA, which showed occlusion with thrombus formation. Notably, the occluded left EIA led to compensatory dilatation of the left IIA, making it larger than the right IIA. During surgery, the injured vein was ligated to achieve hemostasis, and arterial revascularization was accomplished with a graft bypass.

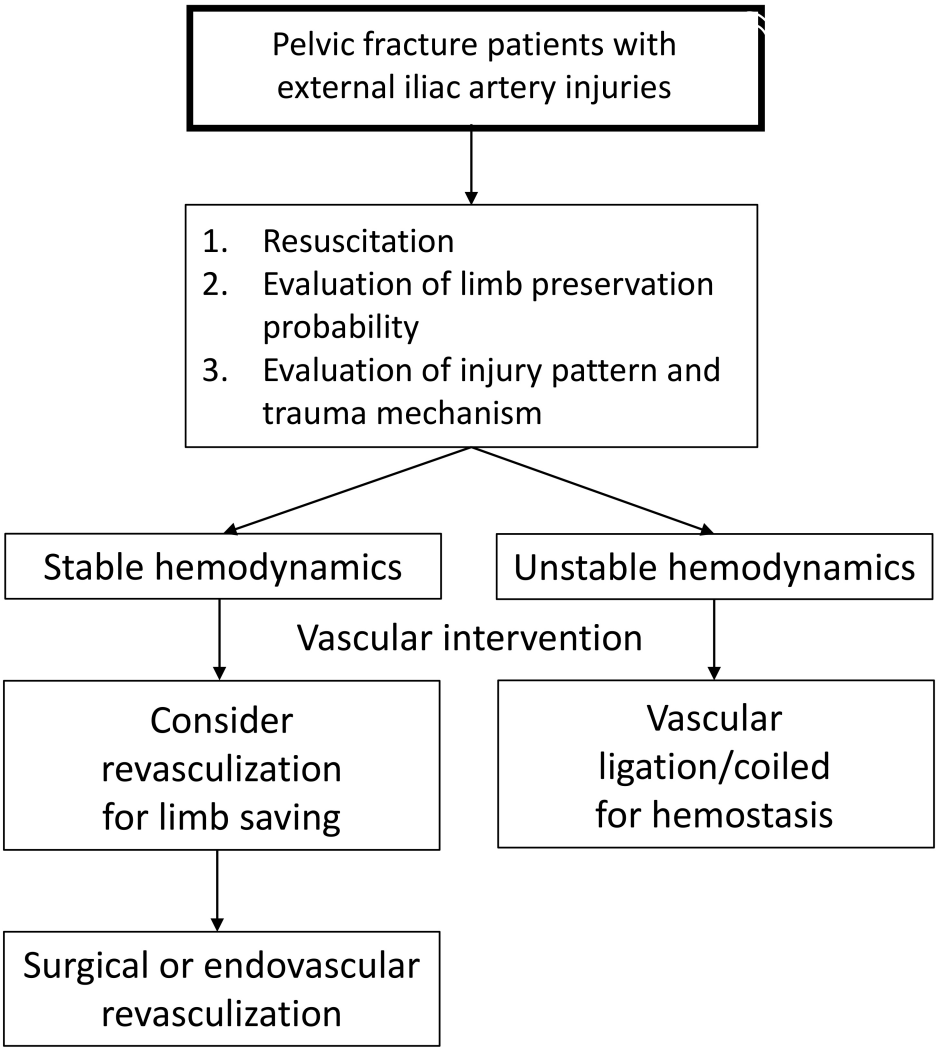

FIGURE 4. Proposed therapeutic algorithm for pelvic fracture patients with external iliac artery injury.

5. Limitations

This study has several limitations. Primarily, it is a retrospective analysis based on data from a single center. Even with the inclusion of cases from previous literature, the sample size remains small, precluding robust statistical analysis and necessitating reliance on descriptive observations. Moreover, incomplete responses to our inquiries have resulted in gaps in detailed patient information. We also acknowledge that variations in institutional resources may limit the applicability of our proposed protocol across different facility levels. Furthermore, patients with isolated EIA injuries were not included in the discussion as high-energy impacts often result in multiple injuries. Nonetheless, by reviewing previous literature and synthesizing it with our experiences in managing these rare yet critical cases, we have begun to delineate a clearer management strategy. Further prospective studies with larger patient cohorts are necessary to refine these management strategies.

6. Conclusions

In the delicate balance between saving lives and limbs, the loss of limbs can sometimes seem inevitable to save lives. However, once hemostasis is secured, aggressive revascularization should be considered. A grim prognosis has been noted in patients with open pelvic fractures accompanied by EIA injuries.

AVAILABILITY OF DATA AND MATERIALS

All data generated or analyzed during this study are included in this published article and its supplementary information files. Please contact the corresponding author for the raw data.

AUTHOR CONTRIBUTIONS

PHL and CHL—Study conception and design; CPH, PHL and CHL—Acquisition of the data; CTC and CYF—Analysis and interpretation of the data; PHL—Drafting of the manuscript; SCK, JFH, CHO and CHL—Critical revision.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This retrospective study was approved by the Institutional Review Board of Chang Gung Memorial Hospital (No: 202200087B0). All methods were carried out in accordance

with the Declaration of Helsinki. The informed consent was waived by the Institutional Review Board of Chang Gung Memorial Hospital because this was a retrospective analysis from a registry system.

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Not applicable.

FUNDING

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.signavitae.com/mre-signavitae/article/1810194222040399872/attachment/Supplementary%20material.docx.

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