Role of Endovascular Stenting in Patients with Traumatic Iliac Artery Injury

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BACKGROUND: Common and external iliac artery injuries (IAI) portend significant morbidity and mortality. The goal of this study was to examine the impact of mechanism of injury and type of repair on outcomes and identify the optimal repair for patients with traumatic IAI using a large, national dataset.

STUDY DESIGN: Patients undergoing operative repair for IAI were identified from the Trauma Quality Improvement Program database during a 5-year timespan, ending in 2019. Age, sex, race, severity of injury, severity of shock, type of iliac repair (open or endovascular), mechanism, morbidity and mortality were recorded. Patients with IAI were stratified by both type of repair and mechanism and compared. Multivariable logistic regression analysis was used to identify independent predictors of mortality.

RESULTS: Operative IAI was identified in 507 patients. Of these injuries, 309 (61%) were penetrating and 346 (68.2%) involved the external iliac artery. The majority of patients were male (82%) with a median age and ISS of 31 and 20, respectively. Endovascular repair was performed in 31% of cases. For patients with penetrating injuries, the type of repair impacted neither morbidity nor mortality. For blunt-injured patients, endovascular repair was associated with lower morbidity (29.3% vs 41.3%; p = 0.082) and significantly reduced mortality (14.6% vs 26.7%; p = 0.037) compared with the open-repair approach. Multivariable logistic regression identified endovascular repair as the only modifiable risk factor associated with decreased mortality (odds ratio 0.34; 95% CI 0.15 to 0.79; p = 0.0116).

CONCLUSIONS: Traumatic IAI causes significant morbidity and mortality. Endovascular repair was identified as the only modifiable predictor of decreased mortality in blunt-injured patients with traumatic IAI. Therefore, for select patients with blunt IAIs, an endovascular repair should be the preferred approach. (J Am Coll Surg 2023;236:753–759. © 2023 by the American College of Surgeons. Published by Wolters Kluwer Health, Inc. All rights reserved.)

Traumatic injury to the common and external iliac vessels remains relatively uncommon, occurring in only 2.3% of abdominal trauma.[1] The majority of iliac artery injuries (IAI) are repaired open with primary repair, interposition graft, or bypass with various conduits. However, despite various improvements in the care of trauma patients, those undergoing open repair for IAI have had little improvement in their survival with in-hospital mortality rates ranging from 28% to 48% in the early 1990s to 19% to 50% more than 2 decades later.[1-6] The use of an endovascular approach for proximal control has been described since 1990 and offers an attractive alternative, in that proximal control can be achieved more rapidly, and does not require retroperitoneal exposure of the iliac vessels.[7]

During the past 2 decades, there has been increased utilization of endovascular techniques for definitive

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Abbreviations and Acronyms

IAI = iliac artery injury
ISS = injury severity score
LOS = length of stay

repair of IAI.[8] In fact, traumatic arterial injuries throughout the body have been managed endovascularly with increasing frequency, success, and proven mortality benefits for select aortic and subclavian artery injuries.[9-11] The goal of this study was to identify the impact of mechanism of injury and repair modality on mortality in patients with traumatic IAI using a large, national dataset.

METHODS

Identification of patients

Over a 5-year period ending in 2019, the Trauma Quality Improvement Program database was queried for patients undergoing operative iliac artery repair by ICD-10 procedure codes. Patients younger than 18 years old, and those undergoing iliac artery repair 12 hours or more after injury were excluded. Patient demographics (age, sex, comorbidities, transfer status), severity of injury (injury severity score [ISS], admission Glasgow coma scale score), severity of shock (admission heart rate, systolic blood pressure), anatomic location of iliac artery injured (common, external), type of iliac artery repair (open vs endovascular), morbidity, and mortality were extracted from the dataset.

Comparisons

All data were analyzed using SAS version 9.4 (SAS Institute, Cary, NC). Comparisons between blunt and penetrating IAIs and open and endovascular repairs were performed in a similar fashion. Wilcoxon rank sum test was used for continuous variables and chi-square analysis for categorical variables. Multivariable logistic regression was performed to determine variables significantly associated with mortality for patients with traumatic IAI. Variables with a significance <0.1 on univariable analysis were chosen as prospective covariates. The final multivariable model identifying independent predictors for mortality in those patients with traumatic IAI was constructed using backwards stepwise elimination. Differences were considered statistically significant at $p < 0.05$. The area under the receiver operating curve was reported with 95% CIs for the final model.

RESULTS

Patient characteristics

Over a 5-year period, 507 patients undergoing procedures for IAI were identified (Table 1). Of these, the majority (61%) had penetrating injuries. Most IAI repairs were performed open (69%). Patients were predominantly male (82%) and had a median age of 31 years, median Glasgow coma scale score of 15, and median ISS of 20. IAIs requiring operative intervention were associated with significant morbidity (33%) and mortality (21%).

Blunt vs penetrating injuries

Blunt-injured patients were older (42 vs 29 years; $p < 0.0001$), more frequently female (20% vs 11%; $p < 0.0001$), and more often transferred from outside hospitals (20% vs 11%; $p = 0.006$) compared with patients sustaining penetrating injuries (Table 1). Blunt injuries were associated with higher admission systolic blood pressure (113 vs 104 mmHg; $p = 0.009$) and ISS (27 vs 18; $p < 0.0001$). Patients with blunt injuries more frequently had common iliac injuries (39% vs 31%; $p = 0.045$), as well as more endovascular repairs (62% vs 11%; $p < 0.0001$). Although overall morbidity was similar between the 2 groups (34% vs 33%; $p = 0.788$), blunt-injured patients experienced more acute kidney injury (17% vs 10%, $p = 0.019$) and stroke (2% vs 0%; $p = 0.023$) and less deep vein thrombosis (6% vs 11%; $p = 0.046$) and cardiac arrest (6% vs 13%; $p = 0.007$). While blunt-injured patients had significantly longer ICU length of stay (LOS) (6 vs 4 days; $p = 0.0001$) and hospital LOS (12 vs 10 days; $p = 0.009$), there was no difference in mortality between the 2 groups (19% vs 22%; $p = 0.447$).

Open vs endovascular repair for penetrating IAI

For patients with penetrating injuries, most (89%) underwent open repair (Table 2). External iliac injuries more frequently had endovascular repairs compared to common iliac injuries. There were no differences in age, sex, race, or transfer status between patients who had open and endovascular repairs. Although admission systolic blood pressure and ISS were similar, heart rate (110 vs 91 beats per minute [bpm]; $p = 0.025$) was higher in patients having open repair compared with endovascular repair. For patients with penetrating injuries, the type of repair did not impact ICU LOS ($p = 0.40$), hospital LOS ($p = 0.13$), morbidity ($p = 0.66$), or mortality ($p = 0.82$).

Table 1. Demographic Comparison of Patients with Iliac Artery Injury from Blunt and Penetrating Mechanisms

Demographic	All	Blunt	Penetrating	p Value
Total patients, n	507	198	309	—
Age, y, median (range)	31 (24, 46)	42 (27, 60)	29 (23, 37)	<0.0001
Sex, m, n (%)	413 (81.5)	138 (69.7)	275 (89)	<0.0001
White race, n (%)	221 (43.6)	131 (66.2)	90 (29.1)	<0.0001
Transfer, n (%)	75 (14.8)	40 (20.2)	35 (11.3)	0.006
Systolic blood pressure, mmHg, median (range)	110 (84, 135)	113 (90, 139)	104 (82, 132)	0.009
Heart rate, bpm, median (range)	108 (84, 126)	108 (85, 128)	108 (82, 126)	0.653
Glasgow Coma Scale score, median (range)	15 (6, 15)	15 (10, 15)	14 (3, 15)	0.071
ICU length of stay, d, median (range)	4 (2, 10)	6 (3, 12)	4 (1, 9)	0.0001
Days ventilated, median (range)	2 (0, 6)	2 (0, 8)	2 (0, 5)	0.083
Length of stay, d, median (range)	11 (5, 23)	12 (6, 29)	10 (4, 20)	0.009
Injury severity score, median (range)	20 (16, 29)	27 (17, 38)	18 (16, 25)	<0.0001
Artery injured, n (%)				
Common iliac	173 (34.1)	78 (39.4)	95 (30.7)	0.045
External iliac	346 (68.2)	125 (63.1)	221 (71.5)	0.048
Operation, n (%)				
Endovascular repair	157 (31)	123 (62.1)	34 (11)	<0.0001
Open repair	350 (69)	75 (37.9)	275 (89)	<0.0001
Deep vein thrombosis, n (%)	44 (8.7)	11 (5.6)	33 (10.7)	0.046
Cardiac arrest, n (%)	51 (10.1)	11 (5.6)	40 (12.9)	0.007
Pulmonary embolism, n (%)	14 (2.8)	4 (2)	10 (3.2)	0.415
Compartment syndrome, n (%)	26 (5.1)	8 (4)	18 (5.8)	0.374
Acute kidney injury, n (%)	65 (12.8)	34 (17.2)	31 (10)	0.019
Myocardial infarction, n (%)	6 (1.2)	4 (2)	2 (0.7)	0.215
Acute respiratory distress syndrome, n (%)	14 (2.8)	7 (3.5)	7 (2.3)	0.395
Cerebrovascular accident, n (%)	4 (0.8)	4 (2)	0 (0)	0.023
Surgical site infection, n (%)	30 (5.9)	9 (4.6)	21 (6.8)	0.295
Ventilator-associated pneumonia, n (%)	10 (2)	5 (2.5)	5 (1.6)	0.523
Overall morbidity, n (%)	168 (33.1)	67 (33.8)	101 (32.7)	0.788
Mortality, n (%)	106 (20.9)	38 (19.2)	68 (22)	0.447

bpm, beats per minute.

Open vs endovascular repair for blunt IAI

For patients injured via blunt mechanisms (Table 3), most had an endovascular repair (62%). Those undergoing endovascular repairs were more often older (46 vs 36 years; p = 0.025) and more frequently female (36% vs 21%; p = 0.032). Although there was no differences in transfer status (p = 0.5), admission heart rate (p = 0.464), ISS (27 vs 30; p = 0.186), or Glasgow coma scale score (15 vs 15; p = 0.1), patients undergoing endovascular repairs had higher systolic blood pressure on admission (123 vs 110 bpm; p = 0.025). The type of repair did not impact the number of ventilator days (p = 0.093), ICU LOS (p = 0.193), hospital LOS (p = 0.810), or morbidity (p = 0.082); however, endovascular repair was associated with a significant reduction in mortality (15% vs 27%; p = 0.037) compared with open repair.

Multivariable logistic regression

A logistic regression model was created for patients with blunt IAI undergoing operative procedures (Table 4). After adjusting for age, sex, systolic blood pressure on admission, and type of repair, multivariable logistic regression analysis found older age and lower systolic blood pressure on admission to be independently associated with increased mortality. Stepwise backwards elimination identified increasing age (odds ratio [OR] 1.040; 95% CI 1.020 to 1.065; p = 0.0002) and lower systolic blood pressure on admission (OR 0.977; 95% CI 0.965 to 0.990; p = 0.0006) to be independently associated with mortality in patients with blunt injuries (c = 0.91; 95% CI 0.85 to 0.93). In contrast, for patients with blunt IAI, multivariable logistic regression identified endovascular

Table 2. Open Repair vs Endovascular Repair for Penetrating Iliac Artery Injury

Demographic	Endovascular	Open	p Value
Total, n	34	275	
Age, y, median (range)	28 (22, 36)	29 (23-37)	0.608
Sex, m, n (%)	33 (97.1)	242 (88)	0.148
White race, n (%)	13 (38.2)	77 (28)	0.215
Transfer, n (%)	2 (5.9)	33 (12)	0.397
Systolic blood pressure, mmHg, median (range)	110 (88, 129)	102 (81, 132)	0.895
Heart rate, bpm, median (range)	91 (65, 114)	110 (85, 126)	0.025
Glasgow Coma Scale score, median (range)	15 (12, 15)	14 (3, 15)	0.539
ICU length of stay, d, median (range)	3 (1, 7)	4 (1, 9)	0.401
Days ventilated, median (range)	1 (0, 3)	2 (0, 5)	0.173
Length of stay, d, median (range)	8 (3, 14)	11 (4, 21)	0.129
Injury severity score, median (range)	17 (10, 25)	18 (16, 25)	0.173
Artery injured, n (%)			
Common iliac	5 (14.7)	90 (32.7)	0.032
External iliac	30 (88.2)	191 (69.5)	0.022
Deep vein thrombosis, n (%)	2 (5.9)	31 (11.3)	0.554
Cardiac arrest, n (%)	4 (11.8)	36 (13.1)	1
Pulmonary embolism, n (%)	0 (0)	10 (3.6)	0.609
Compartment syndrome, n (%)	1 (2.9)	17 (6.2)	0.704
Acute kidney injury, n (%)	4 (11.8)	27 (9.8)	0.761
Myocardial infarction, n (%)	0 (0)	2 (0.7)	1
Acute respiratory distress syndrome, n (%)	0 (0)	7 (2.6)	1
Cerebrovascular accident, n (%)	0 (0)	0 (0)	—
Surgical site infection, n (%)	1 (2.9)	20 (7.3)	0.489
Ventilator-associated pneumonia, n (%)	2 (5.9)	3 (1.1)	0.095
Overall morbidity, n (%)	10 (29.4)	91 (33.1)	0.666
Mortality, n (%)	8 (23.5)	60 (21.8)	0.820

bpm, beats per minute.

repair as the only modifiable risk factor associated with reduced mortality in patients with blunt IAI (OR 0.339; 95% CI 0.147 to 0.786; p = 0.0116).

DISCUSSION

Patients undergoing urgent or emergent traumatic IAI repair have significant overall injury burden with a median ISS of 20 and a mortality rate over 20%. While open repair remains the predominant treatment modality for penetrating IAI (89%) and endovascular repair for blunt injuries (62%), the impact of endovascular repair on mortality has yet been determined. While there was no significant difference in morbidity or mortality in patients with either blunt or penetrating IAI, endovascular repair led to a significant decrease in mortality (14.6% vs 26.7%; p = 0.037) and trended toward decreased morbidity (29% vs 41%; p = 0.082) in patients with blunt IAI.

Blunt and penetrating injuries have different management strategies, as evidenced by the large proportion of penetrating iliac injuries that are treated open. This approach may be secondary to lack of preoperative imaging in the setting of a penetrating injury to the torso or groin, while the majority of blunt-injured patients are more likely to have preoperative CT showing IAI, particularly in hemodynamically stable patients. Another reason for the less frequent use of stent grafts in the penetrating injury group could be the increased incidence of hollow viscus injuries. Magee and colleagues' 2018 review of the National Trauma Database observed that penetrating iliac injuries had much higher incidence of colon injuries (40% vs 9%) and small bowel injuries (60% vs 6.1%) than blunt iliac injuries.[1] In a separate National Trauma Database study examining blunt-injured patients with iliac injuries and pelvic fractures, the incidence of bowel injury was still only 25%.[6] With the increased contamination and concern for stent graft infection, surgeons may be

Table 3. Open Repair vs Endovascular Repair for Blunt Iliac Artery Injury

Demographic	Endovascular	Open	p Value
Total, n	123	75	
Age, y, median (range)	46 (28, 64)	36 (25, 51)	0.025
Sex, m, n (%)	79 (64.2)	59 (78.7)	0.032
White race, n (%)	80 (65)	51 (68)	0.669
Transfer, n (%)	23 (18.7)	17 (22.7)	0.500
Systolic blood pressure, mmHg, median (range)	123 (96, 140)	110 (84, 133)	0.025
Heart rate, bpm, median (range)	107 (85, 126)	110 (87, 130)	0.464
Glasgow coma score, median (range)	15 (13, 15)	15 (3, 15)	0.100
ICU length of stay, d, median (range)	6 (3, 11)	6 (3, 15)	0.193
Days ventilated, median (range)	2 (0, 6)	3 (1, 9)	0.093
Length of stay, d, median (range)	13 (6, 29)	11 (6, 30)	0.810
Injury severity score, median (range)	27 (17, 36)	30 (20, 38)	0.186
Artery injured			
Common iliac, n (%)	45 (36.6)	33 (44)	0.300
External iliac, n (%)	81 (65.9)	44 (58.7)	0.309
Deep vein thrombosis, n (%)	8 (6.5)	3 (4)	0.539
Cardiac arrest, n (%)	5 (4.1)	6 (8)	0.338
Pulmonary embolism, n (%)	1 (0.8)	3 (4)	0.153
Compartment syndrome, n (%)	6 (4.9)	2 (2.7)	0.713
Acute kidney injury, n (%)	16 (13)	18 (24)	0.047
Myocardial infarction, n (%)	2 (1.6)	2 (2.7)	0.635
Acute respiratory distress syndrome, n (%)	2 (1.6)	5 (6.7)	0.107
Cerebrovascular accident, n (%)	2 (1.6)	2 (2.7)	0.635
Surgical site infection, n (%)	7 (5.7)	2 (2.7)	0.487
Ventilator-associated pneumonia, n (%)	4 (3.3)	1 (1.3)	0.652
Overall morbidity, n (%)	36 (29.3)	31 (41.3)	0.082
Mortality, n (%)	18 (14.6)	20 (26.7)	0.037

bpm, beats per minute.

Table 4. Adjusted Odds Ratios for Mortality in Patients with Blunt Iliac Artery Injury

Variable	Adjusted odds ratio	95% Confidence interval	p Value
Age	1.042	1.019–1.064	0.0002
Systolic blood pressure	0.977	0.965–0.990	0.0006
Endovascular repair	0.339	0.147–0.786	0.0116

preferentially choosing open vascular repair in penetrating injury patterns. In addition to more hollow viscus injuries, penetrating trauma also increases the incidence of iliac vein injury (up to 30% of patients), which may also make surgeons more inclined to select open repair of both injuries.[12,13] Endovascular repair offered no survival benefit for those sustaining penetrating injuries with similar mortality rates between the groups. Future studies will be needed to examine outcomes associated with endovascular repair in this setting as it continues to become more common.

Blunt injuries often afford the advantage of preoperative planning in the hemodynamically stable patient. Often these patients have CT angiography performed revealing their IAI before any intervention. In this case, even in the setting of other injuries, a hybrid or purely endovascular approach can be achieved. By utilizing endovascular techniques, blood loss can be minimized, and the injury can be covered before exploratory laparotomy if needed. This approach leads to a clear survival benefit with nearly half the mortality compared to open repair and a much lower incidence of mortality compared to the historically reported 20% to 50%.[1,5,14,15] A single-center study from 2014 where 89% of blunt injuries were managed open found a 50% in-hospital mortality rate with a 35-day

LOS.[16] While preoperative imaging is useful, a hybrid approach with angiography could be considered even in patients where retroperitoneal hematoma is found at the time of exploration. In subclavian artery injuries, recent studies have shown safe management of even unstable subclavian artery injuries endovascularly.[17] By expanding the use of endovascular repair for blunt IAI, hopefully the mortality rate will continue to decline as it has for blunt aortic injuries.[18]

Endovascular management of traumatic arterial injuries has increased in use over the past 2 decades with subsequent improvements in patient outcomes.[8,9] The endovascular revolution had the most obvious impact on the management of blunt aortic injury, reducing mortality for these patients from 30% to less than 10%.[18] In 2014 Branco and colleagues reviewed the National Trauma Database and found that endovascular repair of vascular injuries led to a reduction in in-hospital mortality (12.9% vs 22.4%).[8] Single-center studies have shown good patency and limb salvage rates with iliac stent placement.[19,20] However, there are no studies examining long-term patency rates for this application of iliac stents, particularly in this young patient population. In addition, there may be increased risk of stent thrombosis related to issues with antiplatelet therapy compliance. Future studies will be needed to determine long-term outcomes for these patients. Even in the setting of potential issues with long-term patency, the reduction in mortality suggests that endovascular therapy would be beneficial even if it were simply a bridge to definitive bypass at some point after recovery.

Limitations

There are several limitations to this study. This study only accounts for patients requiring urgent (ie fewer than 12 hours from admission) repair for IAI and is unable to account for the results of delayed repair and nonoperative management. Additionally, there is no data on reintervention rates, short- or long-term patency rates, or conversions to open procedure. In addition, while all injuries required repair, it is unclear if they were diagnosed on preoperative imaging or at time of urgent or emergent operation. Like all national datasets, while it provides strength of sample size, there are limitations associated with coding errors and lack of information about patients' clinical situations. Future prospectively collected or single-institution studies will be needed to further elucidate these findings and help determine other details such as the use of endovascular repair for patients also requiring laparotomy or outcomes of patients with failed endovascular repairs.

CONCLUSIONS

Traumatic IAI is associated with significant morbidity and mortality. For patients with penetrating IAI, the type of repair did not significantly impact morbidity or mortality; however, endovascular repair was uncommonly used, accounting for only 11% of repairs. For patients with blunt IAI, while older age and lower systolic blood pressure on admission were associated with increased mortality, endovascular repair was identified as the only modifiable predictor of decreased mortality. Therefore, for select patients with blunt IAI, endovascular repair should be the preferred approach.

Author Contributions

Conceptualization: Zambetti, Magnotti
Data curation: Zambetti, Patel, Stuber, Zickler, Hosseinpour
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Discussion

DR MARTIN A CROCE (Memphis, TN): This is a fascinating paper. While most in this room don't regularly have to deal with patients who have iliac artery injury, some have, either intentionally or unintentionally. And when a bullet or knife or high-speed vehicle violates the iliac artery before the skin is cut, well, then we have a situation. Many of these patients have confined hematoma with pseudoaneurysm allowing for proximal and distal control. Others have intimal flaps, likely from a car crash and lap-belt injury or a passing missile. While operative repair may be straightforward, the physiologic insult of laparotomy on patients with multisystem injury and profound shock can be devastating. The authors have shown in this database study that endovascular repair of blunt iliac artery injury reduces mortality. Let me say that again. Endovascular repair of blunt iliac artery injury reduces mortality.

I realize the inherent limitations of large database studies, but do you have any information about associated injuries? Specifically, iliac vein injury? Those can be more difficult to manage than the artery. Is stenting an option?

My second question deals with patients with penetrating injuries. Since most injuries are diagnosed by CT scan, do you advocate obtaining preoperative CT scans on all patients with penetrating abdominal trauma? Be careful how you answer—I know where you live.

DR PRESTON R MILLER III (Winston-Salem, NC): Briefly again, this is a review of iliac artery injuries looking at the TQIP database. I will skip to the punch line: although there were no modifiable factors in the management of penetrating injury that the authors discovered in this database study, it was seen that one of the independent predictors for mortality was open repair in the blunt group. So closed repair or endovascular repair was associated with decreased mortality.

The conclusion in the paper is that endovascular repair led to decreased mortality in the blunt cohort and should be the preferred approach in some patients in this population.

Endovascular repair plays an important and growing role in the management of these and many other vascular injuries, but I am a little concerned about your assertion that endovascular repair led to decreased mortality. This may not be completely supported by your data. Reasons for choosing an open vs endovascular approach may play an important role in ultimate outcomes and which approach is chosen may not be modifiable in many cases. Do you have any information about what factors may have influenced the choice of approach? If patients are bleeding or have other pressing needs for laparotomy, then an endovascular approach really may not be feasible.

Similarly, do you have any information as to other procedures occurring concurrently with the endovascular repair, which may certainly have affected outcome and may be covariants?

Additionally, specific patterns of vascular injury can influence operative approach and may also independently contribute to outcomes. For example, ongoing bleeding or ischemic lesions may have a greater, or certainly vastly different, effect than less severe injuries such as dissections or intimal flaps. Do you have any data on the types of injuries or grades of arterial injuries that were managed in each group?

Endovascular repair requires an advanced skill set as well as specialized equipment and personnel. Given that these data, as well as the wealth of data examining the utility of endovascular management in traumatic vascular injuries, continue to grow, are endovascular techniques something that we should be more aggressive about teaching our trauma fellows and residents as we move forward? There