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Evaluation of Outcomes and Treatment Options Among Trauma Patients with Abdominal Vascular Injuries

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ABSTRACT

Introduction. Abdominal vascular injuries are associated with significant morbidity and mortality. Treatment options include non-operative management, open repair, and endovascular procedures. This study aimed to characterize patients and detail treatment modalities among those who sustained a traumatic abdominal vascular injury.

Methods. A six-year descriptive retrospective study was conducted at a level 1 trauma center and included all adult patients who sustained an abdominal vascular injury. Data abstracted included demographics, admitting characteristics, mechanism of injury, admitting vitals, injury details, diagnostic and treatment information, hospital course, and follow-up data.

Results. Fifty-seven patients were admitted with abdominal vascular injuries, however, 14 patients sustained injuries to smaller vascular branches and were excluded. Most vascular injuries involved the iliac artery (27.9%, n = 12), abdominal aorta (25.6%, n = 11), and inferior vena cava (25.6%, n = 11). Twenty-seven percent (n = 12) of patients sustained an injury to more than one vascular structure. Thirty-four percent of patients (n = 15) died before treatment of the abdominal vascular injury. Among the 28 patients (65.1%) treated for their vascular injuries, 46.4% (n = 13) were treated with open surgery, 32.1% (n = 9) were treated non-operatively, and 21.4% (n = 6) with coil embolization. Sixty-four percent of the patients (n = 18) who survived to discharge presented for follow-up care with a mean follow-up period of 3 ± 4.1 months. There were no vascular reinterventions after discharge for patients who followed up with our hospital.

Conclusions. Study findings suggested that appropriately selected cases of traumatic vascular injuries may be managed non-operatively and safely, as there were no mortalities, complications, or reinterventions among these patients. ***Kans J Med 2023;16:11-16***

INTRODUCTION

Traumatic abdominal aortic injuries are rare, occurring in less than 1% of all blunt traumas and account for less than 5% of vascular injuries.[1-6] Patients often arrive in shock, are hypotensive, have massive blood loss, and have multiple associated injuries.[1-12] Traumatic abdominal aortic injuries are associated with significant morbidity and mortality. Reported in-hospital mortality ranged from 25% to 54% and one study noted that 68% of abdominal aortic injury related-deaths occurred in the first 24 hours.[3,7,11-14]

Abdominal vascular injuries can be challenging to treat, with rapid hemorrhage control the primary focus.[3,8,9] Treatment options include non-operative management or surgical management which can be via open or endovascular procedures. The standard treatment for vascular injuries has been open repair and remains the first choice for patients who actively are bleeding, in shock, or have a penetrating mechanism of injury.[9,12,15] However, there has been an increase in the non-operative management of patients with acute traumatic aortic injuries.[16]

The guidelines published by the Society for Vascular Surgery recommended non-operative management for grade I (intimal tear) and endovascular repair for grade II-IV (intramural hematomas, aortic pseudoaneurysm, free rupture) injuries.[13] However, these guidelines only applied to thoracic vascular injuries. In 2014, the Western Trauma Association published recommendations for the treatment of blunt abdominal vascular injuries, noting that intimal tears and uncomplicated large intimal flaps (LIF) can be treated non-operatively with blood pressure control.[3] The American Association for the Surgery of Trauma-World Society of Emergency Surgery published more recent guidelines on diagnosing and managing abdominal vascular injuries.[9] Their guidelines indicated that grade I and grade III injuries also can be managed non-operatively.

Several retrospective studies have demonstrated the viability of non-operative management for minimal aortic lesions (grade I-II); however, these studies vary with regard to the highest grade of injury that may be managed non-operatively, making the indications for the management of these injuries unclear.[3-5,13,16] One study concluded that grade I lesions can be managed non-operatively and safely, but these patients remained at risk for complications (e.g., exsanguination, thrombosis) and had to be monitored long thereafter.[16] Other studies have reported favorable outcomes for patients with higher-grade injuries such as dissections and pseudoaneurysms who were treated non-operatively.[4,5]

Current abdominal vascular research has offered limited descriptions of the specific blood vessels and types of injuries studied. Most studies that reported safe non-operative treatment of injuries to vessels other than the aorta did not include analysis of other abdominal vessels (e.g., inferior vena cava, ileocolic vessels).[13,15-17] Other studies lacked details such as the type of vascular injuries treated (e.g., intimal tear, intramural hematoma).[1,6,7,8,14,17] This study aimed to characterize patients and detail treatment modalities among those who sustained a traumatic abdominal vascular injury.

METHODS

A retrospective review of the trauma registry and medical charts of patients admitted to an American College of Surgeons verified Level 1 trauma center was performed. Patients included were 15 years or older, admitted with a traumatic abdominal vascular injury between January 1, 2014, and February 29, 2020. To identify patients with abdominal vas-

cular injuries, ICD10 codes for injury to blood vessels in the abdomen, lower back, and pelvis (S35.0 to S35.99), and ICD9 codes for injury to blood vessels of the abdomen and pelvis (902.0 to 902.9) were used. Included in the study were patients admitted with traumatic injuries to the abdominal aorta, inferior vena cava (IVC), visceral vessels (celiac artery, ileocecal artery, ileocolic artery, mesenteric artery, mesenteric vein, short gastric artery, hepatic artery, colic artery, renal arteries), and iliac vessels. Patients with injuries to smaller abdominal or pelvic vessels (gluteal artery, iliolumbar artery, epigastric artery, lumbar artery, and pudendal artery) were excluded from this study.

Variables abstracted from the trauma registry and each patient's medical records included demographics, admitting characteristics, mechanism of injury, admitting vitals, Injury Severity Score (ISS), Glasgow Coma Score (GCS), and injury details (vessel injured, grade of injury, concurrent injuries). Diagnostic and treatment information (non-operative, open repair, or endovascular procedures), hospital course, and in-hospital complications also were collected. Follow-up data (need for reintervention, assessment of injury) were abstracted from the electronic medical records for patients who were either re-admitted or presented to the trauma clinic during the study period.

To summarize patient characteristics, descriptive statistics were performed. Categorical data were presented as percentages. Based on the distribution of the data, continuous data were reported as the mean ± standard deviation or as medians with an interquartile range. Data were collected, organized, and summarized using SPSS release 19.0 (IBM® Corp, Somers, New York). This project was approved by the Institutional Review Board of Ascension Via Christi Hospital Wichita, Inc and by the Human Subjects Committee of the University of Kansas School of Medicine-Wichita.

RESULTS

During the study period, 57 patients were admitted with traumatic abdominal vascular injuries, however, 14 patients sustained injuries to smaller vascular branches and were excluded. Patient demographics, injury severity, and presenting characteristics among the remaining 43 patients are presented in Table 1. Most patients were male (n = 33, 76.7%) and the mean age was 38.7 ± 16.9 years. Gunshot wounds (n = 12, 27.9%) accounted for most injuries followed by motor vehicle crashes (n = 10, 23.3%). The mean Injury Severity Score (ISS) was 27.9 ± 13.5 and the mean Glasgow Coma Scale (GCS) was 8.7 ± 5.6. At arrival, 34.9% (n = 15) of patients were tachycardic (heart rate greater than 100 beats per minute), 30.2% (n = 13) were pulseless, 11.6% (n = 5) were hypotensive (systolic blood pressure less than 90 mmHg), and 7.0% (n = 3) were bradycardic (heart rate less than 60 beats per minute).

Most vascular injuries involved the iliac artery (n = 12, 27.9%), abdominal aorta (n = 11, 25.6%), and inferior vena cava (n = 11, 25.6%; Table 2). Twenty-seven percent of patients (n = 12) sustained an injury to more than one vascular structure. The most common vascular injuries were lacerations (n = 21, 48.8%) and transections (n = 7, 16.3%). Non-vascular injuries were common (n = 40, 93.0%) and included liver lacerations (n = 17, 39.5%), rib fractures (n = 6, 37.2%), pelvic fractures (n = 14, 32.6%), and small bowel and colon injuries (n = 12, 27.9%, each).

Table 1. Demographics, injury details, and presenting vitals among patients with abdominal vascular injuries.

	Total Population (N = 43)
Male, n (%)	33 (76.7%)
Age, years, mean (SD*)	38.7 ± 16.9
Mechanism of injury, n (%)	
Gunshot wounds (GSW)	12 (27.9%)
Motor vehicle crash (MVC)	10 (23.3%)
Motorcycle crash (MCC)	6 (14.0%)
Stabbing	6 (14.0%)
Other	4 (9.3%)
Pedestrian vs. motor vehicle	3 (7.0%)
Fall	2 (4.7%)
Injury Severity Score (ISS), mean (SD)	27. 9 ± 13.5
Glasgow Coma Scale (GCS), mean (SD)	8.7 ± 5.6
Hypotensive, n (%)	5 (11.6%)
Pulseless, n (%)	13 (30.2%)
Bradycardia, n (%)	3 (7.0%)
Tachycardic, n (%)	15 (34.9%)
Cardiac arrest, n (%)	13 (30.2%)
Hemorrhagic shock, n (%)	16 (37.2%)

*SD = Standard Deviation

Table 2. Injury details among patients with abdominal vascular injuries.

	Total Population (N = 43)
Vascular injury location, n (%)	
Iliac artery	12 (27.9%)
Abdominal aorta	11 (25.6%)
Inferior vena cava (IVC)	11 (25.6%)
Iliac vein	6 (14.0%)
Superior mesenteric artery (SMA)	4 (9.3%)
Superior mesenteric vein (SMV)	3 (7.0%)
Ileocolic artery	3 (7.0%)
Renal artery	3 (7.0%)
Hepatic vein	2 (4.7%)
Hepatic artery	1 (2.3%)
Celiac artery	1 (2.3%)
More than 1 vascular injury, n (%)	12 (27.9%)
Vascular injury type, n (%)	
Laceration	21 (48.8%)
Transection	7 (16.3%)
Hematoma	2 (4.7%)
Tear	2 (4.7%)
Perforation	2 (4.7%)
Pseudoaneurysm	2 (4.7%)

Table 2. Injury details among patients with abdominal vascular injuries. *continued.*

	Total Population (N = 43)
Vascular injury type, n (%)	
Contusion	1 (2.3%)
Dissection	1 (2.3%)
Hole	1 (2.3%)
Non-vascular related injuries, n (%)	40 (93.0%)
Traumatic brain injury	10 (23.3%)
Chest injuries	
Rib fractures	16 (37.2%)
Hemothorax	10 (23.3%)
Pneumothorax	8 (18.6%)
Abdominal injuries	
Liver injury	17 (39.5%)
Small bowel injury	12 (27.9%)
Colon injury	12 (27.9%)
Kidney injury	9 (20.9%)
Splenic injury	4 (9.3%)
Fractures/dislocations	
Pelvic	14 (32.6%)
Vertebral	11 (25.6%)
Upper extremity	7 (16.3%)
Lower extremity	7 (16.3%)

Diagnostic and treatment modalities are described in Table 3. Focused assessment with sonography in trauma (FAST) was performed on 74.4% (n = 32) of patients, and 16.3% (n = 7) were positive for free fluid. Forty-one percent of patients (n = 18) had an initial computed tomography (CT) before treatment, and 25.6% (n = 11) of patients had at least one follow-up CT during their hospital stay. The most frequent non-vascular related procedures were exploratory laparotomies (n = 21, 48.8%) and orthopedic procedures (n = 9, 20.9%).

Thirty-four percent of patients (n = 15) died before treatment of their vascular injury. Most of these patients sustained gunshot wounds (n = 7, 46.7%) and arrived pulseless (n = 12, 80%). Sixty percent (n = 9) died in the trauma bay, and 20% died (n = 3) in either the operating room or the intensive care unit. Among the 28 patients (65.1%) who survived to vascular injury treatment, 46.4% (n = 13) were treated with open surgery, 32.1% (n = 9) were treated non-operatively, and 21.4% (n = 6) with coil embolization (Table 4). Most patients treated with open repair had a penetrating injury (n = 9, 69.2%), while no patients managed non-operatively sustained a penetrating injury. Sixty-one percent of patients (n = 8) treated with open repair arrived in shock, while only 22.2% (n = 2) of those treated non-operatively arrived in shock.

Table 3. Diagnostic and treatment modalities among patients with abdominal vascular injuries.

	Total Population (N = 43)
Focused assessment with sonography in trauma (FAST), n (%)	32 (74.4%)
FAST positive, n (%)	7 (16.3%)
Computed Tomography (CT) of abdomen, n (%)	18 (41.9%)
Repeat CT (initial hospital stay), n (%)	11 (25.6%)
Surgical procedures, n, %	
Exploratory laparotomy	21 (48.8%)
Orthopedic	9 (20.9%)
Aorta cross clamped	7 (16.3%)
Emergency department thoracotomy	4 (9.3%)
Resuscitative endovascular balloon occlusion of the aorta	1 (2.3%)

Among those treated with open repair (n = 13), most injuries involved the IVC (n = 4, 30.8%), ileocolic artery (n = 3, 23.1%), or iliac vessels (n = 3, 23.1%; Table 5). Nearly all patients treated with embolization (n = 6) had an iliac artery injury (n = 5, 83.3%) and most were lacerations (n = 4, 66.7%). Most injuries treated non-operatively (n = 9) were abdominal aortic injuries (n = 5, 55.6%) and transections (n = 7, 77.8%). Primary repair was the most frequent form of open repair (n = 7, 53.8%) and blood pressure control was used in 55.6% (n = 5) of patients treated non-operatively. All endovascular procedures involved coil embolization.

Patients treated non-operatively required the least amount of packed red blood cells transfused (938 ± 464) and those treated endovascularly required the most (1893 ± 1971; Table 6). Most complications occurred in patients treated with open repair and all deaths occurred in these patients (n = 3, 23.0%). Two of these deaths occurred in the operating room and one in the intensive care unit (ICU) after exploratory laparotomy was halted due to the severity of the patient's injuries.

Sixty-four percent (n = 18) of the patients who survived to discharge presented for follow-up care with a mean follow-up period of 3 ± 4.1 months. Within one month of discharge, an open surgery patient was readmitted for an ileus, a coil embolization patient was readmitted for worsening pelvic pain, and a non-operative patient was readmitted for a urinary tract infection. There were no vascular reinterventions after discharge for patients who followed up with our hospital.

Table 4. Presenting features among patients treated for an abdominal vascular injury.

Patient	Hypotensive	Hemorrhagic Shock	GCS < 8	Mechanism of Injury*	CT
Open Repair					
1	No	Yes	No	MCC	No
2	No	Yes	No	MCC	No
3	Yes	Yes	Yes	GSW	No
4	No	Yes	Yes	GSW	No
5	No	Yes	No	Stabbed	No
6	No	No	No	Stabbed	No
7	No	No	No	MVC	Yes
8	Yes	No	No	Stabbed	No
9	No	No	No	MVC	Yes
10	No	No	No	Stabbed	No
11	No	Yes	No	GSW	No
12	No	Yes	Yes	Stabbed	No
13	NA	Yes	Yes	GSW	No
Endovascular Repair					
14	No	Yes	No	GSW	Yes
15	No	No	No	MVC with pedestrian	Yes
16	No	No	No	Fall	Yes
17	No	Yes	No	MCC	Yes
18	No	Yes	Yes	Stabbed	Yes
19	No	No	No	Thrown from horse	Yes
Non-Operative					
20	No	Yes	No	MCC	Yes
21	No	No	No	Struck by cow	Yes
22	No	No	No	MVC	Yes
23	No	No	Yes	MVC	Yes
24	No	No	No	Fall	Yes
25	No	No	No	MVC with pedestrian	Yes
26	No	No	No	MVC	Yes
27	No	No	No	MVC	Yes
28	No	Yes	Yes	MVC	Yes

*CT = Computed Tomography, GCS = Glasgow Comma Scale, MCC = Motorcycle Crash, MVC = Motor Vehicle Crash, GSW = Gunshot Wound.

Table 5. Injury and management details among patients treated for an abdominal vascular injury.

Patient	ISS*	Injured Vessel	Injury Type	Management
Open Repair				
1	50	Inferior vena cava	Laceration	Primary repair
2	30	Inferior vena cava	Laceration	Primary repair
3	41	Superior mesenteric vein	Grade IV transection	Primary repair
4	16	Iliac vein, iliac artery	Lacerations	Ligation
5	16	Gastric artery	Laceration	Ligation
6	17	Iliac vein, epigastric artery	Laceration, grade IV transection	Ligation
7	22	Ileocolic artery	Laceration	Hemicolectomy
8	10	Ileocecal artery	Laceration	Hemicolectomy
9	41	Right colic artery, ileocolic artery	Thrombosis, laceration	Hemicolectomy
10	9	Superior mesenteric artery/vein	Lacerations	Primary repair
11	20	Inferior vena cava	Laceration	Primary repair
12	16	Inferior vena cava	Laceration	Primary repair
13	32	External iliac artery	Grade IV transection	Primary repair
Endovascular Repair				
14	27	Internal iliac artery	Grade III transection	Coil embolization
15	22	Internal iliac artery	Laceration	Coil embolization
16	14	Internal iliac artery	Laceration	Coil embolization
17	34	Azygos vein, internal iliac artery	Lacerations	Coil embolization
18	20	Right hepatic artery	Laceration	Coil embolization
19	18	Internal iliac artery	Perforation	Coil embolization
Non-Operative				
20	34	Celiac artery	Grade II transection	-
21	9	Inferior vena cava	Contusion	Observation
22	14	Renal artery	Focal infarct	Observation
23	29	Iliac artery	Grade IV transection	Observation
24	24	Abdominal aorta	Grade II transection	BP* control
25	25	Abdominal aorta	Grade I transection	BP control
26	25	Abdominal aorta	Grade II transection	BP control
27	41	Abdominal aorta	Grade II transection	BP control
28	43	Abdominal aorta	Grade I transection	BP control

*ISS = Injury Severity Score, BP = Blood Pressure

Table 6. In-hospital outcomes and complications among patients with abdominal vascular injuries.

	Open Repair (n = 13)	Endovascular Repair (n = 6)	Non-Operative (n = 9)
Packed red blood cells, mean (SD*)	1246 ± 1464	1893 ± 1971	938 ± 464
Mechanical ventilation, n (%)	9 (69%)	3 (50%)	3 (33%)
Days on ventilation, mean (SD)	3 ± 5	5 ± 8	4 ± 8
Intensive care unit (ICU) admit, n (%)	11 (85%)	6 (100%)	7 (78%)
Days in ICU mean (SD)	7 ± 7	8 ± 8	8 ± 10
Hospital length of stay, mean, SD	11 ± 8	14 ± 9	11 ± 9
Blood loss greater than 5 liters, n (%)	3 (23%)	0	0
Complications, n (%)			
Deep vein thrombosis	3 (23.1%)	0	0
Ileus	3 (23.1%)	3 (50.0%)	1 (11.1%)
Respiratory failure	2 (15.4%)	0	0
Renal failure	1 (7.7%)	0	0
Dehiscence/ evisceration	1 (7.7%)	0	0
Reintervention	1 (7.7%)	0	0
Mortality, n (%)	3 (23%)	0	0
Vascular-related mortality	2 (15%)	0	0
Follow-up, n (%)	8 (61.5%)	4 (66.7%)	6 (66.7%)
With CT*	4 (50.0%)	1 (25.0%)	4 (66.7%)
Readmit, n (%)	1 (7.7%)	1 (16.7%)	1 (11.1%)

*SD = Standard Deviation, CT = Computed Tomography

DISCUSSION

Management of abdominal vascular injuries includes open repair, endovascular procedures, or a non-operative approach. Previous studies noted that the type and location of vascular injuries can affect treatment options.[2,3,6,9-13,16] A Western Trauma Association multicenter study by Shalhub et al.[3] found that among 113 patients with blunt abdominal vascular injuries, 89.5% of intimal tears were managed non-operatively while 100% of ruptures were treated with open surgery. In our study, among the vascular injuries that were treated, 75% of grade IV transections were treated with open repair. In addition, all abdominal aorta injuries were managed non-operatively, 80% of IVCs were treated with open repair, and 62% of iliac artery injuries were treated embolized.

According to findings from Kobayashi et al.[9], hemodynamically unstable patients should go directly to the operative room for exploration. Webb et al.[12] also recommended patients with abdominal vascular injuries go directly to the operating room if they arrive in shock and have a penetrating injury. Our results showed the majority of patients treated with open repair had sustained a penetrating injury. These patients also had the most grade IV injuries and the highest frequency of patients arriving in shock. No penetrating injuries were treated non-operatively and each patient treated non-operatively was normotensive on arrival and assessed with CT scans. At our hospital, CT scans are obtained for trauma cases based on attending physicians' assessments of patients' vital signs, high-risk mechanisms of injury, and suspicion of injury.

Several thoracic vascular injury studies noted improved patient outcomes with endovascular repair.[18-20] However, with the infrequent use of endovascular procedures reported in abdominal vascular studies, these findings are not well documented.[1,6,10,15-17] One study by Branco et al.[17] noted that with increased use of endovascular procedures there was an associated decrease in mortality among patients who sustained blunt abdominal aortic injuries. In the current study, only six patients were treated with coil embolization, most of which involved the iliac artery (83.3%). Of note, we successfully treated one grade III iliac transaction and one iliac perforation with coil embolization.

Several studies agreed that minimal aortic injuries, such as intimal tears, successfully can be managed nonoperatively.[2-5,13,16] On follow-up imaging, Osgood et al.[13] found that among blunt grade I-II injuries treated non-operatively, 55% had complete resolution, 40% were stable, and 5% had injury progression. Some studies also indicated that higher grade injuries such as large intimal defects and pseudoaneurysms safely can be managed non-operatively in select patients.[3-5] Shalhub et al.[3] reported that 44.7% of uncomplicated LIFs and 33% of pseudoaneurysm successfully were managed non-operatively. A study by Mosquera et al.[16], however, found that non-operative management in high-grade aortic injuries (> grade I) had three times the risk for aortic-related compilations (odds ratio, 3.05; p = 0.021).

The current study added to a growing body of literature that will determine the safety and parameters of non-operatively managing abdominal vascular injuries. For instance, our study suggested that appropriately selected cases of vascular traumatic injuries may be managed safely and non-operatively due to the lack of reinterventions or complications noted during patient follow-up. The one grade IV transection of the iliac artery that was observed did not result in complications. Additional findings indicated that injuries treated via open repair had the most complications, but the patients in this group were the least hemodynamic stable. A future multi-center study with a greater number of patients and longer follow-up is desirable.

Limitations. This study was limited by its retrospective nature. Additionally, the small sample size limited the generalizability of our findings and prevented us from performing a comparative analysis between the treatment groups. The lack of patient follow-up data was also an issue. Since we received a large number of patients from rural communities, many patients did not return to our facility for routine follow-up. Furthermore, there were very few endovascular procedures and no thoracic endovascular aortic repair (TEVAR) cases. The inclusion of TEVAR cases would serve as a useful comparison to open surgery and medical management.

CONCLUSIONS

Slightly more than one-third of our patients died before their vascular injuries were treated and within the first 24 hours of admission. Most patients who survived to vascular injury treatment were either treated with an open repair or were managed non-operatively. Study findings suggested that appropriately selected cases of abdominal vascular traumatic injuries safely may be managed non-operatively, as there were no mortalities, complications, or reinterventions among these patients.

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