

Iliac vessel injuries: difficult injuries and difficult management problems

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Abstract

Introduction Injury to the iliac vessels poses a serious and frustrating treatment dilemma for all trauma surgeons. Generally, patients present in profound shock secondary to severe hemorrhage from either iliac arterial, venous, or combined injuries. Despite improvements in our emergency medical services (EMS), rapid transport, standard training of trauma surgeons, and improved technology, the morbidity and mortality from iliac vessel injuries remain high, ranging from 25 to 40 %.

Materials and methods A systematic review of the literature, with emphasis placed on the diagnosis, treatment, and outcomes of these injuries, incorporating the author's experience.

Conclusions Injuries to the iliac vessel remain a daunting task, even after great advances in anatomic injury grading and damage control as well as advances in surgical techniques and critical care. Despite all the advances in treatment and appropriate management strategies, the morbidity and mortality from iliac vessel injuries remain high, demonstrating the complex challenge their treatment presents to even the modern-day trauma surgeon.

Keywords Vascular trauma · Abdominal trauma · Pelvic trauma

Introduction

Injury to the iliac vessels poses a serious and frustrating treatment dilemma for all trauma surgeons. Throughout both civilian and military history, injuries to the iliac vessels have been devastating, due to the often uncontrollable hemorrhage and severe associated injuries that accompany them. Generally, patients present in profound shock secondary to severe hemorrhage from either iliac arterial, venous, or combined injuries. The associated problems and injuries that further complicate management include spillage and contamination from associated small and/or large bowel and genitourinary tract injuries. Pelvic fractures are more commonly present in blunt trauma, and are associated with blunt injury of the internal iliac artery, vein, and their branches. Even after struggling to obtain proximal and distal control of the vessels, the majority of patients will succumb to the deadly effects of acidosis, hypothermia, and coagulopathy, as well as the sequelae of reperfusion injury. Despite improvements in our emergency medical services (EMS), rapid transport, standard training of trauma surgeons, and improved technology, the morbidity and mortality from iliac vessel injuries remain high, ranging from 25 to 40 %.

Historical perspective

Significant advances in the field of trauma surgery have emerged from both the military and the civilian arenas of warfare. The earliest known documents concerning vascular trauma date from 1600 B.C. [1–3]. The Ebers papyrus reported the Egyptians' use of styptics consisting of vegetable matter, lead sulfate, and copper sulfate to staunch hemorrhage [1–3]. The Chinese, in the year 1000 B.C.,

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were first to use tight bandaging to control hemorrhage from wounds in conjunction with the use of styptics for hemorrhage [1–3]. The treatment of choice for vascular injuries throughout the Middle Ages consisted of cautery with boiling oil. In 1497, Jerome of Brunswick [1–3] published his work on ligatures as a treatment for bleeding gunshot wounds. Ambroise Paré was first to report the use of ligatures to control hemorrhage from vessels during amputation [1, 2]. Paré was also credited with the development of the first hemostat, “Le Bec de Corbin” [1, 2, 4]. The first attempt at vascular reconstruction was attempted by Hallowell in 1759, when he reported the repair of a brachial artery with the farrier’s or veterinarian’s stitch. Some 127 years would pass until vascular repair was attempted again.

The latter part of the nineteenth century saw such pioneers as Jassinowsky and Postemski revive the idea of direct vascular repair [1, 3]. Israel, in 1883, described the first successful primary repair of a laceration to the iliac artery [1, 3]. In 1897, Murphy of Chicago [1, 2, 5] completed the first successful end-to-end anastomosis of a femoral artery, while Goyanes of Spain [1, 2, 6] in 1906 was first to report the use of a saphenous vein graft to repair a popliteal artery.

Attempts at vascular repair emerged during the Balkan Wars (1912–1913), where Soubotitch [1, 2, 7] reported a series of 80 false aneurysms and arteriovenous fistulas from penetrating injuries, which were managed with ligation (45), arteriorrhaphies (19), venorrhaphies (13), and with 11 end-to-end arterial anastomoses and 4 end-to-end venous anastomoses. In this series, there were few reported repair failures and infection was avoided in almost all of the procedures. Further advances and refinements in the technique of vascular anastomosis were reported by Carrel [1, 2, 8, 9] in 1902 with the tripartite suture, and by Frouin [1, 2] in 1908 with his quadrangulation method.

During World War I, vascular repair emerged with promise, as German surgeons attempted and successfully treated more than 100 arterial injuries in multiple vessels. However, the face of this conflict was about to change with the introduction of high-explosive ordinance to the battlefields of World War I [1–3]. The increase in the numbers of wounded at one time added to the poor evacuation process and, accompanied by a high rate of gangrene, curbed the initial experiences of German military surgeons. By the same token, the poor follow-up of those that were successfully treated led many to question the long-term patency of those repairs [1–3, 10, 11].

Despite these setbacks, there were those who proceeded with promising results. Weglowski [1, 2] presented a series consisting of over 600 patients during his service in the Russian Army and subsequently as the Surgeon General of the Polish Army. In his 1919 report, he recommended that

all arterial injuries and associated post-traumatic aneurysms should be repaired immediately after the injury or, if this was not feasible, one month later for any pulsatile masses. This included all extremity injuries, as well as carotid, aortic, subclavian, and iliac arteries. In 1924, he reported his personal experience with 193 vascular repairs, including 46 lateral repairs, 12 end-to-end anastomoses, and 56 venous grafts. Wound infection forced him to revert to ligation for the remaining 79 patients. His results and data were surprisingly good, and have been unfortunately overlooked [1, 2].

During World War II, Debakey and Simeone [12] reported results that were not as promising as the WWI results. A total of 2,471 arterial injuries were collected; nearly all were treated with ligation, resulting in an amputation rate of 49 %. There were only 81 attempts at repair, among which 78 required lateral suture repair, and only 3 end-to-end anastomoses were performed. The authors summarized their findings by pronouncing that ligation of the damaged artery was applicable, and that no other procedure should be attempted: “It is not a procedure of choice. It is a procedure of stern necessity, for the basic purpose of controlling hemorrhage” [12].

Despite these findings, there were isolated attempts by surgeons on both sides of the conflict, who reported some success with arterial repair. Possible reasons for such poor results included irreparable injuries from multiple types of high-velocity weaponry; the increased destructive power of ordinance, resulting in higher numbers of casualties; and significant transport delays, resulting in irreversible ischemia. Inadequate timely evacuation to higher echelons of surgical care along with understaffed and poorly supplied field hospitals added to the high incidence of ligation rates and high rate of amputations.

The Korean Conflict [13–18] saw greater success in arterial repairs, based not only on the advances made in the surgical techniques of the past wars, but also on other factors, such as improvements in anesthesia, the advent of antibiotics, and the development of blood transfusions, all of which were responsible for improving the success rate of vascular repairs. Perhaps the single greatest factor was the development of forward aid stations accompanied by rapid evacuation of the wounded by helicopter. Wound infection was less rampant due to the acceptance and practice of debridement of dead tissue, delayed primary closure, and antibiotics. The US Army established specialized research groups to improve treatment of vascular injuries in 1952 [13–18]. There were significant contributions from Jahnke [13, 14] in 1953, followed by Hughes [15–18] in 1955 and 1958. During the Korean conflict, a series by Hughes [15] reported 304 arterial injuries, of which 269 were repaired and 35 ligated [6]. The overall amputation rate was significantly reduced from the WWII rate of 13–49 %.

During the Vietnam conflict [19–22], advances in evacuation and transport along with a higher number of surgeons who were trained to perform vascular repairs resulted in improved outcomes, along with the creation of the Vietnam Vascular Registry at Walter Reed [19] to provide follow-up for the wounded with vascular injuries. The first 500 patients had sustained 718 vascular injuries, including carotid, subclavian, axillary, brachial, aorta, renal, iliac, femorals, and popliteals. Rich [22], in 1969, reported the amputation rate during the Vietnam conflict to be approximately 8 %, which was subsequently revised by Rich [22] and Hughes to 13 %, as they included amputations performed within the first month following injury. According to the initial report, 126 end-to-end anastomoses were performed, 127 vein grafts, 29 lateral sutures, and 2 prosthetic grafts were recorded. The registry was expanded several times to include many patients treated by other branches of the military, so it became an invaluable resource in the development of vascular surgery.

Incidence

De Bakey and Simeone [12] reported a total of 43 iliac artery injuries out of 2,471 patients for an incidence of

1.7 %. The incidence of iliac injury was similar for both the Korean War and the Vietnam War [2]. In 1958 [15], Hughes reported an incidence of 2.3 % for the Korean conflict, while Rich [1, 2, 19–22] in 1970 reported an incidence of 2.6 % for the Vietnam conflict. Interestingly enough, a number of different institutions have reported their own experiences with iliac vessel injuries over the past several decades, with surprisingly similar incidences, morbidities, and mortalities [1, 2, 7, 10–31] (see Tables 1, 2).

The incidence of iliac vessel injuries has increased in the civilian arena, secondary to increases in violence seen in urban trauma centers. Overall, the incidence of iliac vessel injury has been reported to be ~10 % for penetrating injury and gunshot wounds [23–25]. Stab wounds and/or impalement account for 2 % of iliac vessel injuries [23–25]. The most infrequent injuries are those due to blunt trauma, accounting for 5 % of injuries in Asensio's series [25] consisting of 185 iliac vessel injuries. The internal iliac vessels were most commonly injured from blunt trauma; the mechanism of injury results in the stretching of the vessel over the bony pelvis, resulting in intimal tears and thrombosis.

The incidence of iliac vessel injuries during different major military conflicts has remained the same. De Bakey

Table 1 Wartime incidence of iliac vessel injuries

Conflict	Author(s)	Year	Total vascular injuries	Iliac vessel injuries	Incidence (%)
WWI	Makins	1919	1,191 (Isolated art.)	6	0.5
WWII	Debakey and Simeone	1946	2,471 (Isolated art.)	44	1.7
Korea	Hughes	1958	304 (Isolated art.)	7	2.3
Vietnam	Rich	1970	1,000 (Isolated art.)	26	2.6
Iraq	Clouse	2007	408 (301 art. and 107 vein)	14	3.4
Iraq–Afghanistan	White	2011	1,570 (art. and vein)	61	3.8

Table 2 Civilian incidence of iliac vessel injuries

Author(s)	Year	Total injuries	Iliac injuries			Incidence (%)
			Artery	Vein	Total	
Mattox [23] ^b	1989	5,760	232	289	521	9.0
Bongard [24] ^b	1990	478	–	–	–	10–15
Asensio [25] ^a	2000	504	60	52	112	23.4
Davis [26] ^a	2001	489	72	100	172	35.2
Tyburski [27] ^a	2001	731	118	104	222	30.4
Paul [28] ^a	2010	167	24	32	56	33.5
Clouse [29] ^b	2007	408	9	5	14	3.4
White [30] ^b	2011	1,570	19	17	61 (25 comb)	3.8
Total						

^a Series reporting abdominal vascular injuries

^b Series reporting cardiovascular injuries

[12] reported an incidence of 1.7 % of iliac vessel injuries in World War II. Hughes [15–18] reported an incidence of 2.3 % for the Korean Conflict, while Rich [19] reported an incidence of iliac vessel injury of 2.6 % for the Vietnam War.

Anatomy

The retroperitoneum is divided into three anatomical zones. Zone I is the central retroperitoneum, from the diaphragm all the way down to the bifurcation of the aorta and the cava. Zone II includes the lateral and superior aspects of the retroperitoneum. Zone III involves the medial and lateral portions of the lower retroperitoneum and the pelvis. The abdominal aorta divides, on the left side of the body at the fourth lumbar vertebra, into the two common iliac arteries. Each is about 5 cm in length. They diverge from the termination of the aorta, travel down and lateralwards, and divide, opposite the intervertebral fibrocartilage between the last lumbar vertebra and the sacrum, into two branches, the external iliac and internal iliacs; the former supplies the lower extremity; the latter, the viscera and parietes of the pelvis [2, 32].

The right common iliac artery is somewhat longer than the left, and passes more obliquely across the body of the last lumbar vertebra. In front of it are the peritoneum, the intestines, branches of the sympathetic nerves, and, at its point of division, the ureter. Behind, it is separated from the bodies of the fourth and fifth lumbar vertebra, and the intervening fibrocartilage, by the termination of the two common iliac veins and the commencement of the inferior vena cava. Laterally, its relations are: above, with the inferior vena cava and the right common iliac vein; and, below, with the psoas major. Medial to it, above, is the left common iliac vein [2, 32].

In front, the left common iliac artery is in relation with the peritoneum, the intestines, branches of the sympathetic nerves, and the superior hemorrhoidal artery; it is crossed at its point of bifurcation by the ureter. It rests on the bodies of the fourth and fifth lumbar vertebrae, and the intervening fibrocartilage. The left common iliac vein lies partly medial to and partly behind the artery; laterally, the artery is in relation with the psoas major [2, 32].

The common iliac arteries supply small branches to the peritoneum, psoas major, ureters, and the surrounding loose areolar tissue, and occasionally give rise to the ilio-lumbar or accessory renal arteries. Their point of origin varies according to the bifurcation of the aorta. In three-quarters of cases, the aorta bifurcates either upon the fourth lumbar vertebra or upon the fibrocartilage between it and the fifth lumbar vertebra; the bifurcation being, in one case out of nine, below this point, and in one out of eleven,

above it. In about 80 % of the cases the aorta bifurcates within 1.25 cm above or below the level of the crest of the ilium; more frequently below than above [2, 32].

The point of division is subject to great variety. In two-thirds of a large number of cases it was between the last lumbar vertebra and the upper border of the sacrum; being above that point in one case out of eight, and below it in one case out of six. The left common iliac artery divides lower down more frequently than the right [2, 32].

The relative lengths of the two common iliac arteries also vary. The right common iliac was the longer in 63 cases; the left in 52; while they were equal in 53. The length of the arteries varied, in five-sevenths of the cases examined, from 3.5 to 7.5 cm; in about half of the remaining cases the artery was longer, and in the other half, shorter; the minimum length being less than 1.25 cm, the maximum, 11 cm. In rare instances, the right common iliac has been found wanting, with the external iliac and internal iliac arising directly from the aorta [2, 32].

Collateral circulation of the common iliac artery includes the anastomoses of the hemorrhoidal branches of the internal iliac with the superior hemorrhoids from the inferior mesenteric; of the uterine, ovarian, and vesical arteries of the opposite sides; of the lateral sacral with the middle sacral artery; of the inferior epigastric with the internal mammary, inferior intercostal, and lumbar arteries; of the deep iliac circumflex with the lumbar arteries; of the iliolumbar with the last lumbar artery; of the obturator artery, by means of its pubic branch, with the vessel of the opposite side and with the inferior epigastric [2, 32].

Clinical presentation

Abdominal vascular injury should always be suspected in the presence of penetrating injuries to the abdomen, pelvis, and buttocks, either from gunshot or stab wounds or impalements (Fig. 1). The presence of a distended abdomen, hemorrhagic shock, and/or diminished or absent pulses in the lower extremities is virtually pathognomonic. Associated injuries may also indicate potential iliac vessel injuries. Gross hematuria suggests renal or bladder injury, which may place the iliac vessel within the path of injury. Bright red blood on rectal exam or gross spillage of stool indicates an injury to the colon and or rectum, and also places the iliac vessel in proximity to the potential area of injury [1, 2, 25, 31].

Blunt trauma to the iliac vessels is usually associated with fractures to the pelvis (Fig. 2). The loss of or decreases in lower extremity pulses in the presence of an unstable pelvis is highly suggestive of an iliac injury. Patients that present in shock after sustaining blunt pelvic trauma must be evaluated for the presence of

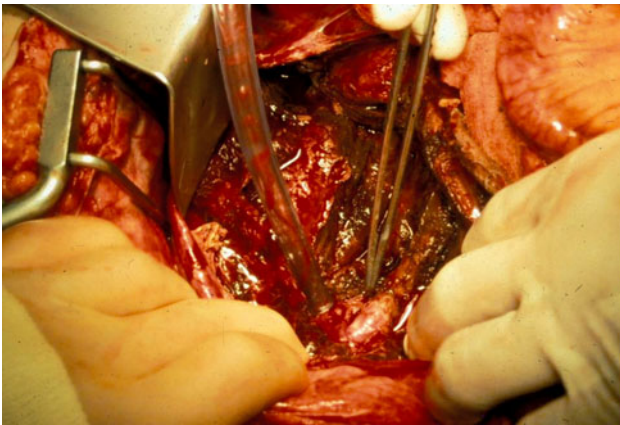


Fig. 1 37-year-old male who sustained a gunshot wound to the pelvis. A transected right common iliac artery and a thrombosed right common iliac vein were sustained. The forceps are holding the transected right common iliac vein, which was subsequently ligated

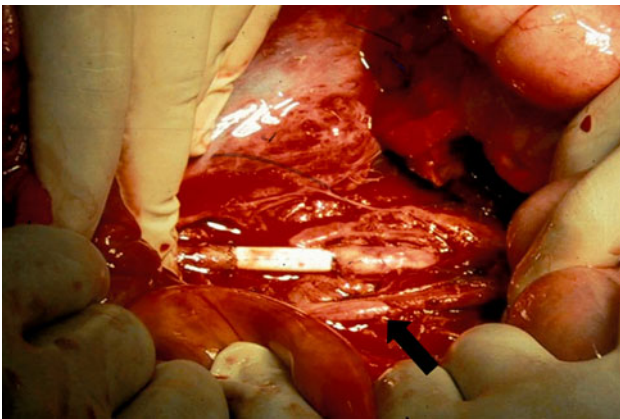


Fig. 2 End-to-end common iliac 8 mm PTFE/graft replacing the injured right common iliac artery. Note the right ureter (arrow)

intraperitoneal hemorrhage (Fig. 3). Continued hemorrhage from the internal iliac vessels or branches is a common cause of persistent hypotension and shock in blunt pelvic trauma. These patients may harbor an unstable pelvis on physical exam, which is suspicious for fractures as well as a sacroiliac joint disruption, should be confirmed immediately by radiographic exam [1, 2, 25, 31]. Temporary pelvic volume reduction with a pelvic binder will reduce pelvic hemorrhage by tamponade and slow the expansion of the hematoma. These patients, in the absence of other sources of intraperitoneal hemorrhage, should undergo angiography for evaluation and possible embolization of bleeding vessels [1, 2, 25, 31]. Regardless of the mechanism of injury, stabilization and resuscitation must be immediate, and the need for operative intervention determined quickly to affect a positive outcome.

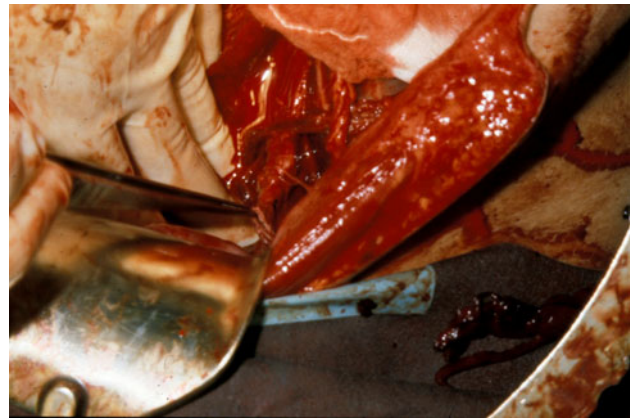


Fig. 3 27-year-old male who sustained a transpelvic gunshot wound. Arrived in shock. He sustained a left external iliac artery injury which was ligated to control the exsanguinating hemorrhage. The patient also sustained a sigmoid colon destructive injury along with massive fecal contamination, as well as an associated bladder injury with large urinary spillage. The forceps is holding the proximal end of the ligated left external iliac artery

Diagnosis

Patients that present with penetrating abdominal injury and are suspected of harboring abdominal vascular injury require no other intervention than resuscitation and immediate transport to the operating room (OR) for exploration. Diagnostic exams and radiographic evaluation should not delay the transport of an unstable patient to the OR. Hemodynamically stable patients with penetrating trauma may benefit from a cross-table lateral X-ray of the chest and abdomen to better identify the path and location of the projectile, which may predict iliac vessel involvement [1, 2, 25, 31].

The Focused Assessment with Sonography for Trauma (FAST) exam may also suggest an iliac injury with positive findings in the pelvis consistent with the path of injury. Blunt injuries in the hemodynamically stable patient may require a more in-depth workup starting with radiographic study of the chest, pelvis, and involved lower extremities. Orthopedic findings associated with iliac vessel injury include sacroiliac joint disruption, bilateral superior and inferior pubic rami fractures (“butterfly fracture”), and symphysis pubis diastasis greater than 2.5 cm [1, 2, 25, 31].

The abovementioned radiologic findings should prompt the use of angiography and external fixation (Figs. 4, 5). CT scan of the abdomen and pelvis with arterial contrast has become a viable part of the diagnostic workup in hemodynamically stable patients. This is most beneficial in patients with pelvic fractures diagnosed on baseline pelvic films. A contrast blush demonstrates an area of arterial injury and suspected bleed for which angiography followed

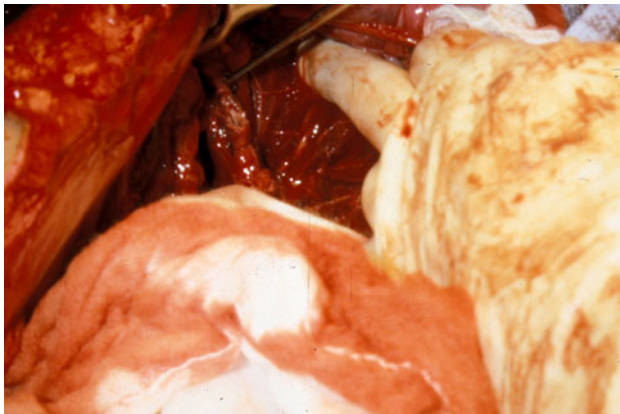


Fig. 4 Ligated left distal external iliac artery as it is about to become the common femoral artery

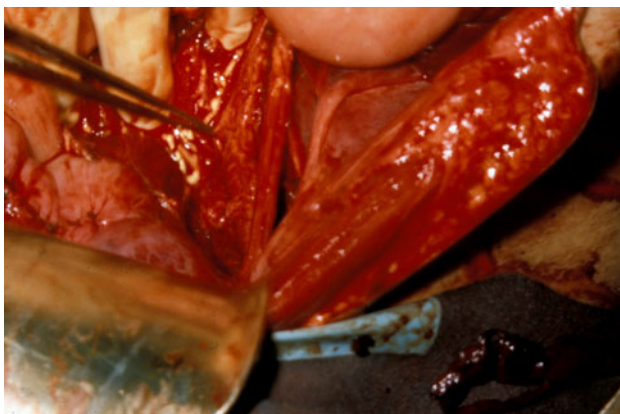


Fig. 5 Preserved left ureter

by embolization provides the definitive treatment. However, there are limitations to its use. Blunt trauma resulting in pelvic fractures benefits from its diagnostic ability and the ability to angioembolize and stop extravasation from the internal iliac artery and branches. There is some benefit to addressing intimal tears and occlusions of the external or common iliac arteries, and temporizing any active bleeding with balloon occlusion until surgical intervention is available [1, 2, 25, 31].

Surgical management

Prior to exploratory laparotomy for a suspected iliac vessel injury, arrangements should be made for blood to be in the room, in addition to a massive transfusion protocol. All possible efforts should also be made to keep the patient normothermic. Broad-spectrum antibiotics should be administered prior to incision, and the patient prepped and draped under the usual sterile conditions from the sternal

notch and axilla bilaterally to the knees. If a zone III hematoma is encountered secondary to penetrating trauma, it must be explored [1, 2, 23–31].

Initial control of an exsanguinating vessel is achieved by direct compression and subsequently by obtaining proximal and distal control. This may be obtained in one of two ways: direct dissection down onto the vessel, or transection of the avascular line of Toldt paracolic peritoneum and medial rotation of the descending colon and sigmoid on the left or ascending colon on the right. Care must be taken on either side during dissection not to injure the ureters, as they cross over the common iliac artery at the bifurcation as well as the iliac vein coursing beneath the artery [1, 2, 23–31].

The level at which cross-clamping is done for both proximal and distal control will vary depending on the area of injury; injuries to the common iliac near or at the bifurcation can be proximally controlled by aortic cross-clamping. Distal control can be obtained by progressive dissection along the artery or, if the distal external artery is involved, a groin incision may be needed to obtain control at the proximal common femoral artery or distal external iliac, which can be achieved by transecting the inguinal ligament (Figs. 6, 7, 8, 9). Vascular clamps or alternatively vessel loops may be used to occlude flow [1, 2, 25–31]. An alternative method of proximal and distal vessel control may include endoluminal blockade using large-bore Fogarty catheters, small Foley catheters, or an aortic occlusion balloon. This is very infrequently feasible, as most patients sustaining iliac vessel injuries arrive in shock, with multiple other associated injuries that require immediate control [23–26, 31, 41]. Similarly, the vast



Fig. 6 Left groin incision with the tunnel beneath the left inguinal ligament in anticipation of vascular reconstruction with a primary distal left external iliac to proximal left common femoral reverse saphenous vein interposition graft. The right groin depicts the site for harvesting the saphenous vein. In the senior author's extensive experience in the management of vascular injuries, this is the only patient who had a greater saphenous vein of sufficient size to perform this interposition graft



Fig. 7 Depicts the proximal anastomosis between the left distal external iliac artery prior to its entrance into the left inguinal canal. Notice the ilioinguinal nerve

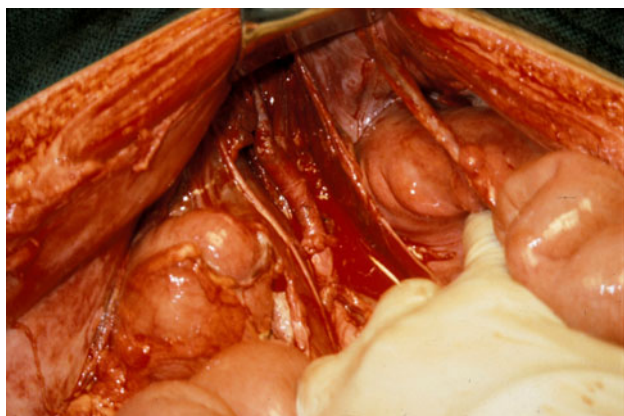


Fig. 8 A different view showing the interposition graft passing through the left inguinal canal. Notice the ilioinguinal nerve

majority of America's busiest trauma centers lack hybrid operating rooms.

Lacerations or partial transections to the common or external iliac arteries may be repaired primarily with a 4-0 or 5-0 Prolene suture in either interrupted or running fashion. Whichever method is chosen, great care must be taken to avoid narrowing the artery or cause stenosis [13]. Fogarty catheters should be sized appropriately and used to clear distal and proximal arteries of potential clots; this should be performed prior to the completion of the repair or anastomosis. As with any injury, damaged or devitalized tissue must be debrided, even if this renders primary repair no longer a feasible option. End-to-end anastomosis is an option following proper debridement as long as there is adequate length to perform the repair without any tension. Patch repair with either PTFE or vein may be appropriate in very selective semi-circumferential injuries. Again, care must be taken not to create stenosis of the artery or to cause aneurysmal dilation with a poorly sized patch [1, 2, 25–31].



Fig. 9 Depicts the distal anastomosis to the proximal left common femoral artery

Interposition grafts are indicated when there has been significant vessel destruction and primary end-to-end anastomosis is not feasible. PTFE is an excellent choice for conduit: it is available in variable sizes and shows moderate resistance to contaminated fields. Saphenous vein is very rarely adequate in size, and spiraling a vein graft is too time consuming in a hypotensive patient and is thus not recommended [1, 2, 25–31].

Extra-anatomic bypass, including the classic axillofemoral bypass, has been used as an option for patients that have sustained significant associated colonic injuries with massive contamination. Several forms of internal iliac artery interposition bypasses have been described in the literature, but all are time consuming and technically difficult, especially in hypotensive, acidotic, and coagulopathic patients [1, 2, 25–31]. For these patients, and those with multiple injuries, damage control should be instituted early. Vascular shunting should be utilized early. Temporary Argyle vascular shunts, pediatric chest tubes, and even nasogastric tubes provide for temporizing and lifesaving measures, and may be placed in both artery and vein. In the face of prolonged ischemic time and/or shunting for damage control, it is advisable to perform lower extremity fasciotomies on both the lower and upper leg [1, 2, 25–42].

The controversy over PTFE graft versus extra-anatomic bypass in contaminated fields has been the subject of much debate. Burch [41] reviewed 233 penetrating iliac artery injuries. Some of these injuries had associated gastrointestinal and urological injuries. He stated that the presence of contamination did not impact the operative decision or outcome of graft repair. However, with severe contamination, extra-anatomic bypasses or iliac artery transpositions (which are more complicated) should be considered (Fig. 10). This becomes more complex in the face of multiple injuries and hemorrhagic shock. Similarly, it is almost impossible to find an autogenous vein of the appropriate size for a vessel this size [1, 2, 25–41].



Fig. 10 Partial resection of the sigmoid colon secondary to a destructive injury. The distal segment was left as a Hartmann's pouch and the proximal segment was matured as a left end colostomy

Blunt arterial injuries caused by compression of the iliac vessels between the pelvic girdle and or the vertebral column during blunt trauma. Motor vehicle collision and direct application of blunt forces to the pelvic girdle are often at fault. The result is usually an intimal disruption with thrombus formation. Surgical repair demands resection and debridement of the injured section of artery. Repair with interposition grafting, usually with PTFE, will suffice [1, 2, 25–34].

Repairs of venous injuries are dependent on several factors, such as location, exposure and size of disruption, and patient stability. The best results are obtained with primary repairs with 4-0 or 5-0 Prolene vascular sutures, taking great care not to restrict or narrow the vessel lumen. A saphenous vein patch can rarely be attempted with a segment of vein that is harvested and sutured in place with 4-0 or 5-0 Prolene sutures [1, 2, 25, 31]. If destruction of the vessel is severe and primary repair is not feasible, ligation is warranted due to the reported poor patency rates of PTFE in vein injury (Fig. 11). Several more time-consuming and technically difficult variations exist; jugular vein interposition and panel grafting from saphenous vein have been anecdotically reported but are not recommended [16]. Again; in the unstable patient with multiple injuries, ligation may be the lifesaving option [1, 2, 25–34] (see Table 3).

Although biological patches such as bovine pericardium or other antibiotic impregnated grafts may be available, experienced trauma surgeons such as Asensio [25, 31], Burch [41], Mattox [23], Bongard [24], and Feliciano [26] do not recommend them in their respective series (especially Asensio and Burch [31, 41], who have reported the largest series in the world's literature). Similarly, Mattox and Feliciano [23] have described the resistance of PTFE to infection (Fig. 12).

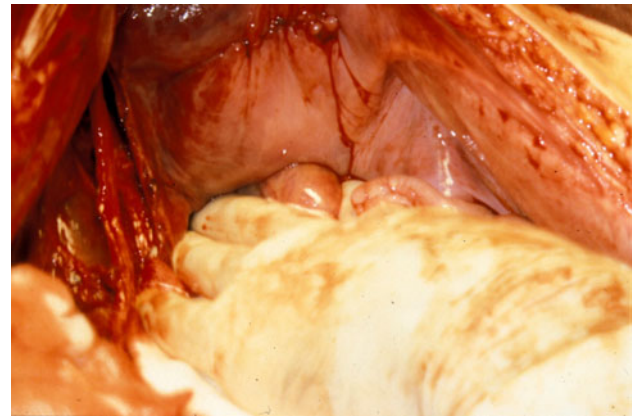


Fig. 11 Primary repair of the bladder

Options for endovascular treatment are very limited, as the vast majority of these patients have sustained penetrating injuries and arrive in shock, as described in Asensio's [31] series; they are thus hemodynamically unstable, preventing their transportation to an angiographic suite. Coil embolization is not a suitable option, as vessels of this size cannot be completely occluded without ischemic consequences. Blunt injuries to the iliac arteries are very rare, result in immediate ischemia, and the extent of their thrombosis is significant, thus precluding stent grafts. Supporting statements can be found in Asensio's series [31], which reported eight blunt iliac artery injuries, all of which required interposition grafting. Although these eight patients were reported within the group of 185 iliac vessel injuries, to our knowledge this is the largest group of blunt iliac vessel injuries in the literature. Most other series report one or two [23, 24, 26, 41].

Anticoagulation is not warranted in high-flow, larger diameter vessels, and is thus not warranted in iliac repairs. When the accompanying vein of an arterial injury is ligated, fasciotomies of the extremity should be considered to avoid postoperative compartment syndrome [1, 2, 25–34].

Morbidity and mortality

In 1997, Carrillo [36] evaluated their institutional results for iliac vessel injuries and found a mortality of 23 %, consistent with the present literature. Several key points included the use of damage control and poststabilization extra-anatomic bypass to maintain extremity survival, fasciotomies and DVT prophylaxis for limb preservation after vein ligation, and the use of PTFE grafts in the face of bowel contamination [1, 2, 25–35]. Haan [35] described his institutional experience and found a mortality of 25 % with a bypassed single-vessel injury versus 83 % mortality with both injured vessels. They concluded shock was the most significant prognostic factor for mortality [35].

Table 3 Management of iliac vessel injuries

Author		Total number of iliac vessel injuries	Arteriography	Ligation	Surgical technique				
					Ligation and EAB ^a	End-to-end	PTFE	Other	None
Wilson [33]	Artery	–	–	–	–	–	–	–	–
	Vein	49	18 (36.7 %)	31 (63.3 %)	–	–	–	–	–
Cushman [34]	Artery	36	7 (19.4 %)	12 (33.3 %)	1 (2.8 %)	7 (19.4 %)	3 (8.3 %)	2 (5.6 %)	5 (13.9 %)
	Vein	56	17 (30.3 %)	33 (58.9 %)	–	–	–	–	5 (8.9 %)
Davis [26]	Artery	72	29 (40.3 %)	25 (34.7 %)	–	–	–	10 (13.9 %)	8 (11.1 %)
	Vein	100	35 (35 %)	59 (59 %)	–	–	–	–	6 (6 %)
Asensio [31]	Artery	72	57 (79.2 %)	1 (1.4 %)	–	–	14 (19.4 %)	–	–
	Vein	113	12 (10.6 %)	101 (89.4 %)	–	–	–	–	–
Haan [35]	Artery	48	17 (35.4 %)	17 (35.4 %)	10 (20.9 %)	–	–	4 (8.3 %)	–
	Vein	49	19 (38.8 %)	27 (55.1 %)	–	–	–	3 (6.1)	–
Clouse [29]	Artery	9	2 (22.2 %)	1 (11.2 %)	–	–	2 (22.2%)	4 (44.4 %)	–
	Vein	5	3 (60 %)	–	–	–	–	2 (40 %)	–

^a Extra-anatomic bypass



Fig. 12 Shows the completion angiogram and the distal anastomosis at the level of the common femoral artery

Lee and Bongard [37] reported a mortality ranging between 24 and 40 %, with iliac vessel injuries accounting for 10 % of all abdominal vascular injuries and 2 % of all vascular injuries at their center. In 2010, Paul [28] evaluated their previous work on abdominal vascular injuries and compared it with their most recent experience. Their original series for the time period 1970–1981 included 112 patients who sustained abdominal vascular injuries, among which 17 had iliac artery and 14 iliac vein injuries; the overall mortality was 32 %. When compared with data from their January 1996 through June 2007 period, 242 patients were identified as having abdominal vascular injuries, including 24 iliac artery and 32 iliac vein injuries, with an overall mortality of 28 %. The most common injured arteries were the iliac artery, aorta, and superior

mesenteric artery, with the most common injured veins being the inferior vena cava, iliac, and portal vein. They showed that despite improvements in pre-hospital care, EMS training, and better-staffed level-one trauma centers, there was no real improvement in the mortality from intra-abdominal vascular injuries of all types.

Despite the advances made in vascular repair, the utilization of damage control and improvements in critical care, iliac vessel morbidity and mortality have not changed much over the years. The most common quoted mortality rates range from 24 % to upwards of 40 %, with morbidity ranging from 8 to 15 % [1, 2, 25–37]. For patients arriving in cardiopulmonary arrest and requiring an emergency department thoracotomy (EDT), mortality approaches 100 %. In a series of 185 iliac vessel injuries reported over an eight-year period, Asensio [31] reported a 57 % survival for arteries and 55 % for veins, and an overall survival of 51 %. In this series, the mean Injury Severity Score (ISS) was 20, with 95 % of injuries resulting from penetrating injuries and 5 % from blunt traumas. Paul [28] found that despite great improvements in emergency medical systems (EMS) and the increased presence of well-staffed level-one trauma centers, the morbidity and mortality from abdominal vascular injuries remained 28 % overall, with iliac artery mortality at 28 % and iliac vein at 22 % [25–42] (see Table 4).

Conclusions

Injuries to an iliac vessel remain daunting, even after great advances in anatomic injury grading and damage control, as well as advances in surgical techniques and critical care.

Table 4 Survival from injuries to the iliac artery and vein

Author	Year	Iliac artery			Iliac vein		
		No. patients	No. survivors	Survival (%)	No. patients	No. survivors	Survival (%)
Millikan [38]	1981	19 (6) ^a	9 (5) ^a	47.4 (83.3) ^a	16 (8) ^b	11 (8) ^b	68.8 (100.0) ^b
Ryan [39]	1982	66 (17) ^a	41 (15) ^a	62.1 (88.2) ^a	97 (48) ^b	71 (45) ^b	73.2 (93.8) ^b
Sirinek [40]	1983	21	15	71.4	28	23	82.1
Burch [41]	1990	130 (34)	80 (26) ^a	61.5 (76.5) ^a	214 (81) ^b	153 (70) ^b	71.5 (86.4) ^b
Wilson [33]	1990	—	—	—	49	24	48.9
Davis [26]	2001	55	35	63.6	76	58	76.3
Tybuski [27]	2001	70	37	52.9	73	40	54.8
Asensio [25]	2001	—	—	—	37 (22) ^b	23 (18) ^b	62.2 (81.8) ^b
Jasmeet [42]	2009	39	11	71.8	36	8	77.8
White [30]	2011	19	—	—	17	—	—
Overall		361 (57) ^a	217 (46) ^a	60.1 (80.7) ^a	590 (159) ^b	403 (141) ^b	68.3 (88.7) ^b

^a Isolated injury to iliac artery^b Isolated injury to iliac vein

The establishment of EMS and rapid transportation has not drastically changed the overall morbidity and mortality of iliac vessel injuries. Advances in vascular grafts and surgical equipment have made the repair of these injuries easier and faster, but the rapid deterioration of these patients and the large number of associated injuries have lead to the incorporation of damage-control practices into the majority of abdominal vascular injuries. Established level-one trauma centers with fellowship-trained trauma surgeons and well-equipped staff have fared no better over several decades of emergency vascular treatment. As before, a high suspicion for the presence of iliac vessel injuries and rapid transport together with rapid surgical control of hemorrhage and contamination remain the mainstay of their treatment. When damage control is initiated, shunted vessels should be accompanied by fasciotomies of the associated lower extremity and adequate DVT prophylaxis. Despite all the advances in treatment and appropriate management strategies, the morbidity and mortality from iliac vessel injuries remain high, demonstrating the complex challenge that their treatment presents to even the modern-day trauma surgeon [25, 31].

Conflict of interest None.

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