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Systematic Review

Injuries to the Celiac Trunk: A Systematic Review of Trauma to Haller's Tripod

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Abstract

Introduction: The celiac artery is nestled deep within the abdomen and provides blood flow to the foregut. Injuries to the celiac artery are rare and carry a high mortality rate.

Methods: A systematic MEDLINE Complete literature search was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Relevant studies, specifically those focusing on diagnosis and management of traumatic celiac arterial injuries were selected, excluding pediatric and iatrogenic cases. Studies from all years were considered, given the paucity of literature on this topic. Studies included in the review were categorized according to level of evidence.

Results: The initial search yielded 5295 results. Specifiers and removing duplicates reduced this number to a final result of 226 studies. After applying exclusion criteria, there were 33 remaining studies containing a total of 175 patients. Of these, only 5 had greater than ten patients in the study, and the majority of the remaining studies were level IV and V evidence. Of the studies reporting deaths, the overall mortality was 34%.

Conclusion: Injuries to the celiac artery are very rare and occur as a result of penetrating or blunt trauma. These injuries carry a high mortality rate and early recognition requires a high index of suspicion. Diagnosis is based on CT imaging or direct visualization during an exploratory laparotomy. Treatment modalities include open repair, endovascular repair, ligation and medical management. Currently, given the lack of available studies, there is no uniform or agreed-upon treatment approach.

Keywords: Celiac Trunk, Trauma, Haller's Tripod

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Introduction

The celiac artery, also known as the Tripod of Haller, is the first anterior branch off the abdominal aorta. Swiss physiologist Albrecht Haller, for whom the tripod is named, devoted eight pages of his work to the anatomy of the celiac axis and noted the great variation of vessels supplying the upper abdominal organs.[1] Later, Adachi described 6 anatomical variants of the axis with 28 subtypes in his atlas. The late Sir Arthur Keith (1866-1955) again stressed that "variation is rampant" in the vasculature supplying the supramesocolic organs after devoting 18 years of study to this area.[1] Along with the superior mesenteric artery (SMA) and inferior mesenteric artery (IMA), the celiac artery supplies the foregut, midgut, and hindgut. Together, these 3 vessels carry roughly 20%-25% of the total cardiac output.[2] The celiac artery is short, measuring only 1.0-1.5 cm.[2,3] Its 3 main branches, the left gastric, splenic, and common hepatic arteries supply the foregut, including the distal esophagus to the second part of the duodenum, spleen, liver, gallbladder, and pancreas (Figure 1).[2,3] Damage to the celiac artery can occur at the short main trunk or along any of its 3 main branches.[4] The celiac artery has collateral flow with the SMA through the inferior pancreaticoduodenal branches and an anastomotic arcade with the transverse pancreatic artery.[2,5] These collateral sources can restore arterial blood supply and prevent malperfusion after complete occlusion of the celiac artery.[2,5] Due to its anatomical location nestled deep

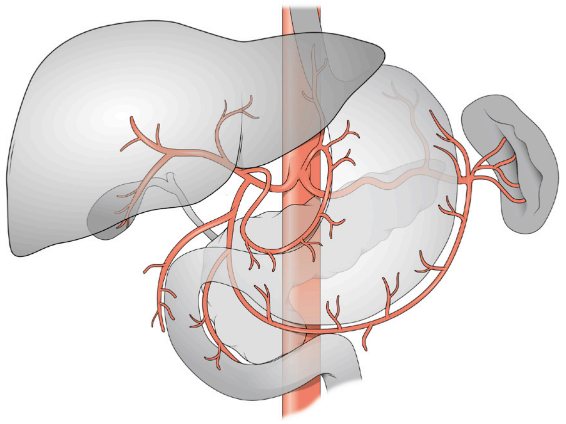

Figure 1. Haller's Tripod and the Celiac Arterial System.

in the upper abdomen, injuries to the celiac artery are rarely isolated. The small bowel, duodenum, pancreas, colon and/or stomach are commonly associated organ injuries.[6]

While penetrating trauma to the abdomen is relatively common, injuries to the celiac trunk are a rare and deadly entity. Of all mesenteric vessels, the celiac trunk is one of the least likely to be injured, accounting for only 1%-2% of all visceral vascular lesions.[7] Visceral arterial injuries, including those to the celiac artery, are some of the most lethal injuries trauma surgeons face. The reported mortality of these injuries ranges from 38% to 75%.[2,4] Death after celiac arterial injury most commonly occurs secondary to exsanguinating hemorrhage. Treatment is complicated by the difficult exposure of the injured vessel both proximally and distally.[2] Due to the rarity of this injury, a clear consensus regarding management has not been established.[7]

The majority of celiac arterial injuries occur in the setting of penetrating trauma, most commonly gunshot (GSW) or stab wounds (SW).[2,4] However, blunt abdominal trauma to the celiac branches is also a reported mechanism of injury.[4,8,9] Isolated injuries to the celiac artery in cases of blunt trauma are extremely rare, but have been reported as well. The mechanism underlying such an event has been hypothesized to include underlying celiac artery compression by the median arcuate ligament.[3,8,10–13]

Computed tomography (CT) scan is the most common imaging modality used to diagnose celiac trunk injuries.[6] Patients with celiac arterial injury require rapid assessment to determine the rate and extent of blood loss as stability and severity of the injury typically dictate the treatment choice.[7] While several different treatment interventions exist, there is no established superior method currently. This review revealed 4 approaches: observation, medical therapy with anti-platelets or anticoagulants, endovascular intervention, and open surgical repair.[9] Traditionally open repair has been the most common approach, but endovascular intervention is seeing increased use in cases of arterial trauma, including injury to the celiac trunk.[14] This review sought to thoroughly quantify and qualify the existing literature on traumatic celiac arterial injuries (Table 1). Through further experience and analysis of the literature, this collective review of celiac arterial injuries may help lead to the development of a treatment algorithm of this highly lethal injury.

Methods

Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines a systematic literature search was performed using the MEDLINE Complete database with the assistance from the Creighton University Health Science Library (Figure 2). Initially, a search for "celiac n1 (artery OR arteries OR trunk)" was performed. A specifier of "injury OR injuries" was added to the search, reducing the number of studies. A search was then run for "(MH "Celiac artery") AND (injury* OR avulsion OR rupture* OR detach*)" with a specifier of being published in English. This total was combined with those returned in a search for "celiac n3 (injury* OR avulsion OR rupture* OR detach*)". Each study was then selected based on the presence of reported cases of celiac injury and/or discussion of the diagnosis and treatment of celiac arterial injuries. Studies that discussed iatrogenic and pediatric celiac arterial injuries were excluded. Due to the underreported nature and rarity of these injuries, studies published in any year were considered and cases of celiac arterial injury without mortality data were included. Studies were then categorized according to level of evidence.[51]

Results

The initial search yielded 5295 results (Figure 2). Specifiers reduced this number to 192 studies and 38 studies respectively, yielding a combined total of 230 studies. After removing duplicates, we were left with a final result of 226 studies. After excluding review articles, literature unrelated to the injury of celiac arteries or its branches, and those regarding iatrogenic injury, we were left with 33 remaining studies containing a total of 175 patients. Of these, only 5 had greater than ten patients in the study, and the majority of the remaining studies were case reports. All studies were retrospective. There were no randomized controlled trials. Of the 175 reported celiac trunk injuries 112 reported mortality outcomes. Celiac trunk injuries were exceedingly rare; in fact, there were no instances reported in either Mattox's[16] 30-year study involving over 5 thousand patients nor Feliciano's[17] 12-month study of 456 patients with vascular and cardiac injuries. Celiac trunk injuries are typically caused by penetrating trauma. Only 15 cases of isolated celiac arterial injury due to blunt trauma have been reported in the literature.[5] Although many studies included in our review did not specify mechanism, for the cases that did include mechanism, we found a 14% mortality (2/14) for blunt injuries while penetrating injuries demonstrated a 0% mortality rate (0/18) (Table 1).

Thirty-eight deaths were recorded in the 112 cases yielding an overall mortality of 34% (Table 1). Morbidity as measured by complications associated with injuries to the celiac axis was reported in 5 of 25 cases. The reported complications included splenic infarction, gallbladder necrosis, coagulopathy, acidosis, fulminant hepatic failure, pancreatic pseudocysts, pancreatic leakage, acute kidney injury and splenic artery pseudoaneurysm. Ligation was the most common intervention utilized in this review.

Table 1. Systematic Review of Celiac Trunk Injuries

Year	Author	Level of Evidence	N	Mechanism	Non-Survivors	Mortality (%)	# Morbidities	Reported Morbidity	Morbidity (%)	Intervention
1964	Patman[15]	IV	6	–	–	–	–	–	–	–
1968	Perdue[36]	IV	7	Mixed	3	43	–	–	–	–
1971	Perry[37]	IV	8	–	–	–	–	–	–	–
1975	Mattox[38]	IV	3	–	–	–	–	–	–	Ligation, anastomosis
1978	Graham[39]	IV	8	–	–	–	–	–	–	–
1978	Graham[40]	IV	13	–	5	38.5	0	–	0%	Ligation (4), arteriorrhaphy (8), end-to-end anastomosis (1)
1979	Petersen[41]	IV	6	–	–	–	–	–	–	–
1982	Kashuk[42]	IV	6	–	0	0	0	–	0%	Ligation
1982	Stone[43]	IV	18	Mixed	–	–	–	–	–	–
1984	Feliciano[17]	IV	1	–	–	–	–	–	–	–
1985	Adkins[44]	IV	1	–	0	0	–	–	–	–
1992	Jackson[45]	IV	6	–	–	–	–	–	–	–
1998	Brown[46]	V	1	Blunt	1	100	–	–	–	Laparotomy
1998	Schreiber[18]	V	1	Blunt	0	0	1	Splenic infarction	100%	None
1999	Velmahos[47]	IV	17	Penetrating	0	0	–	–	–	Embolization
2000	Asensio[48]	IV	30	Mixed	15	50	–	–	–	Operative (ligation or primary repair)
2000	Asensio[23]	IV	10	Mixed	5	50%	–	–	–	Ligation
2001	Davis[49]	IV	6	–	–	–	–	–	–	Ligation (4), repair (1)
2001	Kavic[29]	V	1	Penetrating	0	0	1	Gallbladder necrosis	100%	Ligation
2005	Asensio[2]	IV	13	Mixed	8	61.5	–	Coagulopathy (6), acidosis (6)	–	Ligation (11), repair (1)
2006	Linuma[8]	V	1	Blunt	0	0	0	–	0%	Ligation
2007	Suchak[12]	V	1	Blunt	0	0	0	–	0%	Stent placement
2007	Kirchhoff[5]	V	1	Blunt	1	100	1	Fulminant hepatic failure	100%	None
2009	Gorra[11]	V	1	Blunt	0	0	0	–	0%	Warfarin
2010	Colonna[13]	V	1	Blunt	0	0	–	–	–	Ligation
2012	Laeseke[6]	V	1	Blunt	0	0	1	Abdominal pain, no mesenteric malperfusion	100%	Aspirin 81 mg
2012	Choi[9]	V	1	Blunt	0	0	0	–	0%	Bridging stent graft and embolization
2013	Osborne[10]	V	1	Blunt	0	0	–	–	–	Operative management
2014	Brown[3]	V	1	Blunt	0	0	–	–	–	Non-operative
2015	Rosenthal[7]	V	1	Blunt	0	0	0	–	0%	Aspirin 81 mg
2016	Ghelfi[50]	IV	1	Blunt	0	0	0	–	0%	Embolization with histoacryl glue
2016	Brenner[30]	IV	1	–	–	–	–	–	–	Stent
2016	Kronick[21]	V	1	Blunt	0	0	1	Pancreatic leak with pseudocyst, acute kidney injury, splenic artery pseudo-aneurysm	100%	Aorto-celiac bypass with Dacron graft
Total	33 studies		175		38/112	34%	5/25		20%	

Discussion

Injuries to the celiac artery are extremely rare with a reported incidence of 0.01%.[2] When these injuries do occur, they are associated with a high mortality rate. These combined factors of rarity and high mortality necessitate a comprehensive review of the literature to begin establishing a uniform approach to these deadly injuries. In our review of the literature we found 33 studies with a total of 175 cases of celiac arterial injury (Table 1). All of these were retrieved from retrospective case series and case reports found in the literature.

Mechanism of Injury

Celiac arterial injuries are more commonly due to penetrating abdominal trauma than blunt trauma.[2] Penetrating injuries to visceral blood vessels, including the celiac artery, are typically from stab or gunshot wounds.[4] Blunt trauma accounts for only 5%-10% of abdominal vascular injuries and may be the result of motor vehicle collisions, falls, direct impact, or rare accidents.[4,8,9] It is hypothesized that the median arcuate ligament (MAL) could be involved in the mechanism of isolated celiac arterial injury in cases of blunt trauma.[11,18]

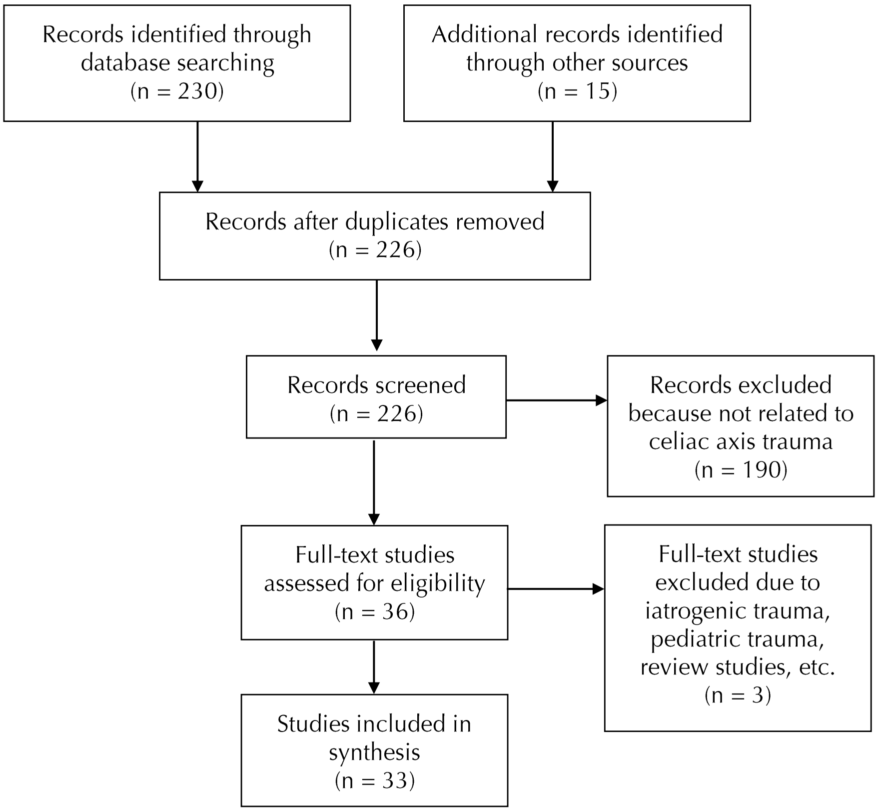

Figure 2. PRISMA-Based Approach.

The median arcuate ligament is the fibrous edge of the diaphragm, composed of fibers of the 2 crura as well as a dense celiac nerve plexus, which passes over the aorta just above the celiac artery.[11] Radiologic studies have shown that the median arcuate ligament causes compression of the celiac artery from above in up to 24% of asymptomatic patients.[19] This compression of the celiac artery by the MAL coupled with rapid deceleration and/or sudden increase in intra-abdominal pressure could cause injury to the intima of the celiac artery, leading to dissection, while leaving surrounding structures relatively unharmed.[5,7,8] The MAL may also act as a fulcrum for avulsion.[5,10] Despite this, some postulate that the MAL could actually protect the celiac artery and be part of the reason that celiac arterial injuries are so rare.[3]

Generally speaking, blunt trauma has a higher propensity to disrupt surrounding nerves, muscle, bones, and smaller vessels that would provide collateral flow, leading to ischemia, while penetrating trauma causes an isolated area of damage.[20] However, it has been suggested that patients with celiac artery disruption due to blunt trauma and penetrating trauma have similar survival outcomes.[20] Any trauma to the celiac artery, blunt or penetrating, can result in a variety of downstream effects, including arterial occlusion, intimal flap formation, dissection, pseudoaneurysm, arteriovenous fistula formation and complete avulsion.[14,21]

Clinical Presentation

Penetrating injuries from the nipples to the groin crease anteriorly and from the tip of the scapula to inferior gluteal crease posteriorly may have unseen abdominal vascular injuries.[4] Patients with celiac arterial injuries have a wide array of presentations, from asymptomatic to severe shock.[2,11] The most common presentation of celiac injury is that of abdominal pain.[22] Additional presenting signs may include nausea, vomiting, elevated liver enzymes, jaundice and liver failure.[7,8] In some cases, patients with traumatic celiac arterial injuries may be asymptomatic or present with vague symptoms initially, and then develop more severe symptoms in hours to days.[6,7] For example, a case report from Rosenthal[7] revealed the insidious nature of these injuries, detailing a patient that fell 150 feet off of a bridge into a river and upon presentation had no abdominal pain but was found to have a celiac arterial injury on CT. Celiac trunk injuries may cause free intraperitoneal bleeding resulting in profound hypotension or, alternately, result in a contained retroperitoneal hematoma leading to a hemodynamically stable patient with various degrees of responsiveness to fluid resuscitation.[4] Patients with a severe injury classically present with signs of significant hemoperitoneum, warranting an emergent exploratory laparotomy.[2] Some patients with celiac injury may present in cardiopulmonary arrest and require a lifesaving thoracotomy.[23] To complicate matters further, trauma patients often present with other distracting injuries that may make the diagnosis of celiac arterial injury more difficult to obtain.[8]

Diagnosis

The diagnosis of celiac arterial injury can be difficult and require a high index of suspicion. Some trauma patients may be obtunded, limiting the usefulness of an abdominal exam.[2,7] Focused abdominal sonography for trauma (FAST exam) can be helpful in detecting free fluid in the abdomen but does not well differentiate the celiac artery or other retroperitoneal structures.[4] To diagnose a celiac arterial injury specifically, imaging and/or an exploratory laparotomy are required.[4,7] Most commonly the diagnosis of a celiac arterial injury occurs via contrast-enhanced CT performed during the trauma work-up.[6] CT scan findings indicative of celiac arterial injury include, but are not limited to, peri-arterial stranding, a poorly defined celiac artery origin, inflammatory changes, luminal filling defects, an intimal flap, or surrounding/retroperitoneal hematoma in the supramesocolic area.[3,6,8,11] Two and 3 dimensional reconstructions in the sagittal planes can be helpful in evaluating the celiac lesion.[6] Most trauma CT scans are optimized to evaluate solid organ injury and thus are not as accurate in visualizing vascular injuries.[7] Therefore, the diagnosis of celiac arterial injury in an initially asymptomatic patient can be missed.[7] This delay in diagnosis may ultimately prove fatal.[5] A follow-up CT scan in 6-8 hours is recommended in complex clinical settings, instances of high-energy trauma, or in the case of nonspecific findings on the first CT scan.[5] This second CT scan can increase the sensitivity for detecting celiac arterial injuries. Catheter angiography may be used to confirm suspected celiac arterial injury and further delineate a known injury.[6] Angiography can also be used to evaluate collateral flow distal to the injury and determine the need for revascularization.[5,6] If the SMA is compromised, then ligation of the celiac artery is a less attractive treatment option as flow to at least one of these main aortic branches must be re-established to prevent intestinal ischemia.[22] MR angiography has also been used to diagnose celiac dissection in patients who are hemodynamically stable, or those unable to tolerate iodinated contrast.[6]

Mortality

The mortality rate of celiac arterial injuries ranges 38% to 75%.[4] The most common cause of early death in patients with celiac arterial injuries appears to be exsanguinating hemorrhage.[2] A correlation in the number of associated vascular injuries and an increase in mortality has also been reported by Asensio et al,[23] who demonstrated a 45% mortality rate with one abdominal vessel injury, 60% mortality rate with 2, 73% mortality with 3, and 100% mortality with 4 or more injuries.[23] Additionally, AAST-OIS grading has been correlated with mortality in cases of celiac trunk injuries. A 43% mortality for grade III, 50% mortality for grade IV, and 100% mortality for grade V have been reported.[2]

Associated Injuries

Due to its anatomical location, traumatic celiac arterial injuries typically occur in conjunction with other injuries. Although some cases of isolated celiac arterial injury have been documented in the literature, it is rare due to the complex tightly packed anatomy surrounding the tripod.[2,3,7,8,11,12] For this reason, celiac arterial injury is commonly associated with other injuries to the surrounding intra-abdominal structures, including the small bowel, duodenum, pancreas, colon, and stomach.[6] In Asensio's[2] review of celiac trunk injuries there was a mean of 2.54 associated injuries with a mean of 1.9 non-vascular injuries found in the analyzed cohort of injuries to Haller's tripod.[2] While individual reports have documented injuries to surrounding structures, this review revealed no studies reporting or analyzing associated injuries.

Treatment

Celiac arterial injuries require critical judgement from the treating surgeon. Options include observation, medical therapy with anti-platelets or anticoagulants, endovascular stenting, and surgical intervention.[9] Treatment is selected based on injury severity, coexisting injuries, and the patient's overall hemodynamic stability.[7] Patients with celiac arterial injuries must be quickly assessed to determine the rate and extent of blood loss as well as the best treatment course. The type of injury, for example, intimal flap versus partial tear versus complete avulsion, also dictates treatment.[21] The majority of our knowledge regarding the management of blunt traumatic celiac artery dissections comes from treating spontaneous celiac artery dissections.[7] Although etiologies obviously differ, both blunt celiac arterial injuries and spontaneous celiac dissections are exceedingly rare and have a variety of treatment options including operative, non-operative, and endovascular modalities.

Open Repair

Operative management is the most traditional approach to traumatic visceral arterial injuries.[9] In cases of serious trauma, damage control is an initial consideration.[21] Active hemorrhage from the celiac artery in an unstable patient requires emergent intervention.[6,11] An emergency department resuscitative thoracotomy with aortic cross-clamping and/or open cardiopulmonary massage may be required in some patients with refractory hypovolemic shock or cardiopulmonary arrest.[4] This procedure is for the most unstable patients and comes with many considerations such as distal ischemia, hypothermia, and further blood loss.[4]

Prior to open surgery, the patient should be prepped from the chin to the knees to prepare for autogenous saphenous vein graft or thoracotomy.[4] Once an initial incision is made from xyphoid to pubis, the celiac artery should be identified in its retroperitoneal location.[4] The location of the celiac trunk can make it difficult to obtain rapid exposure.[2] Hildreth suggested a left-sided medial visceral rotation to obtain optimal exposure which was first described by DeBakey in 1956.[13,23] This left-sided medial visceral rotation requires transection of the line of Toldt along the left colon, followed by incision of the lienosplenic ligament, and then rotation of the left colon, pancreas, spleen, and stomach medially.[23,24] The abdominal aorta passing through the aortic hiatus of the diaphragm is then visible as well as the root of the celiac artery several centimeters below.[23,24] The presence of a retroperitoneal hematoma is present in 91% of abdominal vascular injuries, including celiac arterial injuries, and can further complicate exposure of the damaged celiac trunk.[23] Establishment of proximal and distal arterial control should follow.[10] Distal control can be extremely difficult and sometimes impossible in cases of avulsion.[10] If unable to control acute hemorrhage and achieve hemostasis relatively quickly, the incidence of associated bowel ischemia and necrosis is high.[6] Proximal control can be achieved with a supraceliac aortic clamp or even digital compression with sponge sticks.

Once exposure and hemorrhage control have been established, gentle debridement of the vessel wall, with prevention of embolization of clot material and irrigation with heparinized saline should be performed.[23] After the damaged celiac artery has been exposed, the extent of damage and condition of the arterial tissue must be assessed to determine if ligation, arteriorrhaphy, surgical bypass, or end-to-end anastomosis would be most prudent.[5,10] If possible, the celiac artery should be repaired with a fine monofilament polypropylene suture or by inserting an autogenous or prosthetic graft.[4,23,25] Autogenous graft is preferable to prosthetic as there is a risk of graft infection if gastrointestinal spillage has occurred, which would not be uncommon in cases of celiac arterial injury.[26] If both the celiac artery and SMA have been injured, at least one of the 2 must be re-vascularized in order to provide sufficient flow to prevent total viscera ischemia. Kronick[21] used aortoceliac bypass to maintain adequate flow to the liver after celiac arterial injury as collateral circulation was insufficient due to baseline arterial disease. Lastly, an additional benefit of open repair is the opportunity to visualize the bowel, which has a good chance of being compromised.[27]

Ligation

Primary repair is preferable to ligation if blood loss and time are not a concern but celiac trunk injuries are often managed with ligation. As a general rule in the management of vascular injuries, ligation is reserved for arteries with adequate collateral flow, including the celiac artery and IMA.[20] Ligation of the celiac axis can be a lifesaving maneuver in some cases where brisk bleeding is occurring, or in situations where primary or endovascular repair are not possible.[2,33]

Historically, the common hepatic artery was considered an artery that should never be ligated, however Hans Kehr[28] was the first to demonstrate adequate perfusion to the liver post-ligation of the proper hepatic artery. The gastroduodenal artery and portal vein typically provide adequate blood flow to the liver parenchyma in event of hepatic artery ligation.[26] Although collateral circulation does exist, arrested flow through the celiac artery may compromise liver and/or bowel function, especially in individuals with pre-existing vascular disease.[5] The gallbladder may be more susceptible to ischemia and necrosis than other organs when the celiac artery is compromised as it is a terminal vascular organ.[29] There are also reports of ligation resulting in hepatic failure and splenic necrosis.[10] Development of bile duct strictures can also result if distal hepatic branches are ligated.[26]

Endovascular Approach

Endovascular surgery has been used with success in the elective treatment of vascular disease for decades.[14,30] Hemorrhage control via endovascular treatment was initially described in 1972 and its use in the treatment of traumatic injuries is increasing.[14,30,31] With ever-evolving and improving endovascular technologies, the indications for endovascular treatment continue to expand, including into the realm of trauma.[26,32] The tortuosity of the celiac artery and its branches can make endovascular intervention difficult, but it is possible.[26] Endovascular intervention has been found to be beneficial in multisystem trauma patients who present with serious co-morbid injuries[26] and has been used increasingly in this setting.[14] Previous studies have concluded that in cases of celiac arterial injury, endovascular treatment was best for those who are hemodynamically stable with mild injury severity.[14,32] Endovascular treatment is also ideal for cases of celiac arterial injury in patients who are high-risk for surgery and fail medical management.[7] It should be noted that with the rise in endovascular treatment there has been a decrease in mortality with traumatic vascular injuries.[30]

Large studies of endovascular therapy for celiac arterial injury are lacking. The rarity of this specific injury additionally makes clinical trials unrealistic. However, the use of endovascular intervention may prove useful in treating celiac injuries.[32] Past studies have shown endovascular repair of blunt aortic injury to be associated with decreased mortality and morbidity. Additional benefits may include shorter length of stay and improved survival when compared to open surgery.[14] It must be noted though, that if at any point during endovascular treatment the patient exhibits signs of bowel necrosis or peritoneal irritation a transition to open surgery should seriously be considered.[21,33]

Embolization and stent grafts are 2 endovascular methods that have been used in traumatic vascular injuries.[9] Stent grafts have an advantage over embolization in their ability to reestablish blood flow, but their use is not always possible.[9] Patients who receive endografts require ongoing surveillance for any complications including migration of the device and endoleaks.[14] In terms of endovascular embolization, N-butyl-2-cyanoacrylate (NBCA), microcoils, gelatin sponge particles, or a combination of those products have all been used with a 90% success rate in patients with mesenteric bleeding.[34]

The use of endovascular intervention in cases of hemorrhage has seen particularly high use in Japan, due to a paucity of trauma surgeons, and the need to treat actively hemorrhaging, in unstable patients.[30,35] In the United States, modern surgical training has begun to include the use of endovascular techniques in the setting of trauma.[30] Tsurukiri reported good results, with a 60-day mortality of 8%, when using acute vascular interventional radiology techniques to treat patients who presented with acute hemorrhage.[35] The success of endovascular therapy is largely dependent on the skill of the operator and injury severity. Endovascular intervention, while limited in dealing with celiac arterial injuries, can be a valuable tool.[30,32,35] Inevitably endovascular intervention will continue to advance and evolve, and may become more useful in the treatment of celiac trunk injuries. Authors have suggested that the combination of endovascular and laparoscopic techniques could prove useful in the future.[27] The use of endovascular therapy as a bridge to a future open procedure has also been proposed.[14,27]

Non-operative Management

Not all patients with celiac arterial injuries require operative management.[6] Medical therapy, including the use of aspirin, anticoagulation and blood pressure control, is reserved for stable patients without signs of bowel ischemia.[7] Medical therapy, when used appropriately, may decrease the risk of thrombosis and propagation of an existing thrombus, while also increasing the chance for vessel recanalization.[6,7] Unfortunately, antiplatelet agents and anticoagulants may be contraindicated in many trauma patients due to co-existing injuries.[5,7]

Conclusion

Celiac arterial injuries are potentially lethal and have a very low incidence. Celiac arterial injuries are particularly perplexing as few trauma surgeons have significant experience managing them. Despite its rarity, celiac trauma is an important topic due to its life-threatening complications and high mortality.[5] Trauma surgeons should have a high index of suspicion for the presence of a celiac arterial injury. Treatment of celiac arterial injuries is trending towards endovascular intervention. Currently, high level of evidence studies regarding celiac arterial injuries are lacking. Prospective studies evaluating management of celiac arterial injuries would certainly be helpful, but are difficult to perform given the rarity and the unpredictable nature of these injuries. Future studies should also focus on predictors of mortality and development of a unified treatment method.

Limitations

Limitations of this article are similar to all PRISMA-guided review articles: the dependence on previously published research and availability of references.

Authors' Contributions

All authors contributed equally to this study.

Conflict of Interest Disclosures

The authors declare they have no conflicts of interest.

Ethical Approval

Not applicable.

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