Trauma Monthly 2024; 29(1): 1020-

10.30491/tm.2024.411108.1629

Trauma Monthly

Research Article

Outcome of Endovascular Treatment for Traumatic Arterial Injury

Iraj Nazari [1], Seyyed Masoud Mousavi[1], Hossein Minaee[1], Mohammad Amin Zargar[1*]

[1] Department of General Surgery, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

***Corresponding Author**: Mohammad Amin Zargar; Department of General Surgery, School of Medicine, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran; Phone/Fax: 00989122198191; E-mail: zargaramin@yahoo.com.

Received 2023-08-11; **Accepted** 2024-01-21; **Online Published** 2024-02-27

Abstract

Introduction: This study aimed to assess the feasibility of endovascular treatment for trauma patients with vascular damage, providing the foundation for establishing a treatment protocol for trauma patients.

Methods: The study involved 22 patients with arterial injuries caused by blunt, penetrating, or iatrogenic trauma, who underwent endovascular intervention between September 2021 and September 2022. Patient demographics, trauma type, affected artery, mortality and morbidity, packed red blood cell (PRBC) transfusion during hospitalization, hospital stay duration, reoperation, and infection were collected. Follow-up was conducted for three months using sonography.

Results: The study cohort comprised 20 males and two females, with an average age of 31 years (ranging from 22 to 45). During hospitalization, primary and secondary success rates, infection rates, and artery pathologies were analyzed. The subclavian artery (36.36%) was the most frequently treated artery in our facility. Stab wounds (50%) were the most common cause of arterial injury requiring endovascular intervention, followed by gunshot wounds (22.72%). Pseudoaneurysm (86.38%) was the most prevalent arterial injury pathology, and endovascular intervention was effective in its management. Coil embolization (59.09%) was the most common endovascular intervention technique, followed by stent graft placement. The average hospital stay duration was 9.8 days. Reoperation was required in four patients (18.1%).

Conclusion: Endovascular intervention is a viable option for vascular trauma treatment in various body regions. Vascular specialists should have access to this technique to provide timely and effective patient care.

Keywords: Endovascular, Trauma, Arterial injury.

Introduction

Before the development of endovascular techniques, open surgery was the only option for treating injured arteries [1]. However, advances in endovascular techniques and the development of new tools and embolization materials have changed the way vascular surgeons treat vascular trauma [2]. A study of the National Trauma Data Bank showed that the use of endovascular techniques to treat vascular injuries increased from 2.4% in 1994 to 13.2% by 2010 [3]. Despite guidelines, multiple small and large studies have shown that endovascular techniques can be used successfully to treat patients with trauma [4]. Endovascular treatment includes a variety of therapeutic options, such as transcatheter embolization using coils, liquid embolic agents, glue or plugs, percutaneous thrombin injection, endovascular repair using peripheral stent grafts, and multi-model and combined approaches [5].

The aim of this study was to assess the efficacy of endovascular treatment in managing vascular injuries sustained by trauma patients, laying the foundation for establishing a treatment protocol for such patients. Given the minimally invasive nature of endovascular procedures, this study aimed to underscore the potential of endovascular methods in treating certain vascular injuries.

Methods

A retrospective review was conducted to identify patients with arterial injuries resulting from trauma (blunt, penetrating, or iatrogenic during surgery) who were treated with endovascular procedures at Ahvaz's Golestan Hospital between September 2021 and 2022.

All endovascular treatments were performed in an angiographic suite, and transfemoral approaches were used for all cases. Except for two patients with aortic injuries who underwent general anesthesia, local anesthesia (lidocaine 2%) was used for the puncture site for angiography in all other patients. The indication for endovascular treatment was determined by contrast-enhanced computed tomography (CT) angiography, which showed the presence of a pseudoaneurysm, arteriovenous fistula, transaction, or extravasation. The inclusion criteria for the study were patients with vascular damage who required surgical intervention and who were deemed to be suitable for endovascular treatment based on the aforementioned CT findings. The presence of hard signs of vascular injury (absent pulses, bruit or palpable thrill, active bleeding, expanding hematoma, or distal ischemia) did not preclude patient inclusion [6].

Following treatment plan selection, angiography was performed. Coil embolization was used for pseudoaneurysms, and stent grafting was used for other types of vascular injuries, depending on the pathology, location, size, and length of the injured artery. In addition to the location and type of injury, the size of the pseudoaneurysm neck and the collateral circulation of the affected organ were carefully evaluated to determine the most appropriate treatment. If an artery was considered sacrificial and lacked collateral circulation, afferent artery embolization was performed (Figure 1).

The following data were collected: mean age and gender distribution, type of trauma, affected artery, mortality and morbidity, packed red blood cell (PRBC) transfusion during admission, hospital stay duration, reoperation rate, and infection rate. Patients were followed up for three months with sonographic examinations. Written informed consent was obtained from the patients or their legal guardians for the publication of the report and accompanying images.

Results

The study cohort comprised twenty males and two female patients with an average age of 31 years (range: 22-45). The majority of injuries (72.7%) were caused by penetrating trauma, followed by iatrogenic trauma (18.18%) and blunt trauma (9.09%). The subclavian artery was the most frequently injured artery, followed by the arteries listed in Table 1.

The most prevalent pathology observed in the injured arteries was pseudoaneurysm (86.38%), followed by arteriovenous fistulas (9.09%). Extravasation (4.5%) and transaction (4.5%) were observed in the aorta (Table 1). Angiography intervention using coils was the most common treatment modality employed (59.09%). For subclavian artery trauma, the most common pathological condition, coiling of the pseudoaneurysm site was the treatment of choice.

Table 1: Demographics, mechanism of injury, angiography findings, length of stay, and findings at follow-up for all study patients

Variable Result	Result (N= 22)
Age, years	31
Male gender	90
Length of stay, days	9.8
Follow-up, months	3
Amputation	0
Mortality	0
Mechanism of injury	
Penetrating	16(72.7%)
Blunt	2(9.09%)
Iatrogenic	4(18.18%)
Angiography finding	
Arteriovenous fistula	2(9.09%)
Pseudoaneurysm	18(81.8%)
Extravasation	1(4.5%)
transection	1(4.5%)
Vascular injury	
Subclavian	8 (36.36%)
Common femoral	2 (9.09%)
Deep femoral	3 (13.63%)
Superficial femoral	1 (4.54%)
Aorta	2 (9.09%)
Popliteal	1 (4.54%)
Post tibialis	2 (9.09%)
Peroneal	1 (4.54%)
Internal iliac	1 (4.54%)
External iliac	1 (4.54%)
The blood transfusion amount (units)	2.2

Endovascular aneurysm repair (EVAR) was employed for the treatment of aorta artery injuries (Table 2). Acute traumatic aortic injuries are among the most life-threatening consequences of penetrating trauma and demand prompt diagnosis and management. A 44-year-old man presented to the emergency department with abdominal pain and a pulsating abdominal mass. He had undergone a laparotomy two months prior due to a gunshot wound to the abdomen, accompanied by a left nephrectomy. On examination, his vital signs were stable, and a pulsating mass was palpable in the central abdomen. Bilateral femoral artery pulses were +2. Other examinations were unremarkable, with the exception of anemia (Hb: 7.6). The patient underwent abdominal and pelvic CT scan with contrast. CT revealed a pseudoaneurysm and extravasation of the aorta at the site of the left nephrectomy (Figure 2).

Table 2: Detailed analysis of the artery injured related to the pathology of artery and kind of treatment.

Artery injured	Number of patients	Pathology of the artery (N)	Kind of treatment (No.)
Subclavian	8	pseudoaneurysm (7) pseudoaneurysm and AV fistula (1)	Angioplasty with stent graft (3) Angioplasty with coiling (5)
Common femoral	2	AV fistula (1) Pseudoaneurysm (1)	Angioplasty with stent graft (2)
Deep femoral	3	Pseudoaneurysm (3)	Angioplasty with coiling (2) Angioplasty with stent graft (1)
Superficial femoral	1	Pseudoaneurysm (1)	Angioplasty with stent graft (1)
Aorta	2	Pseudoaneurysm (1) Transection (1)	EVAR (2)
Popliteal	1	Pseudoaneurysm (1)	Angioplasty with coiling (1)
Post tibialis	2	Pseudoaneurysm (2)	Angioplasty with coiling (1)
Peroneal	1	Pseudoaneurysm (1)	Angioplasty with coiling (1)
Internal iliac	1	Pseudoaneurysm (1)	Angioplasty with coiling (1)
External iliac	1	Pseudoaneurysm (1)	Angioplasty with stent graft (1)

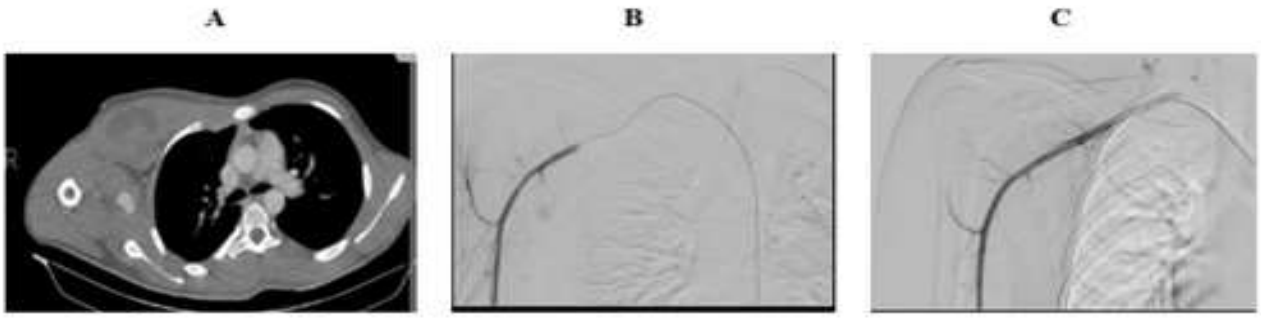

Figure 1: A 30-year-old patient with Subclavian PA following a stab wound to the right hemi thorax. (A) contrast-enhanced computed tomography (CT) demonstrates a Subclavian PA with narrow stock. (B) Angiography shows subclavian PA with active extravasation of contrast. (C) PA is filled by the coil, and normal blood flow in the Subclavian artery is observed.

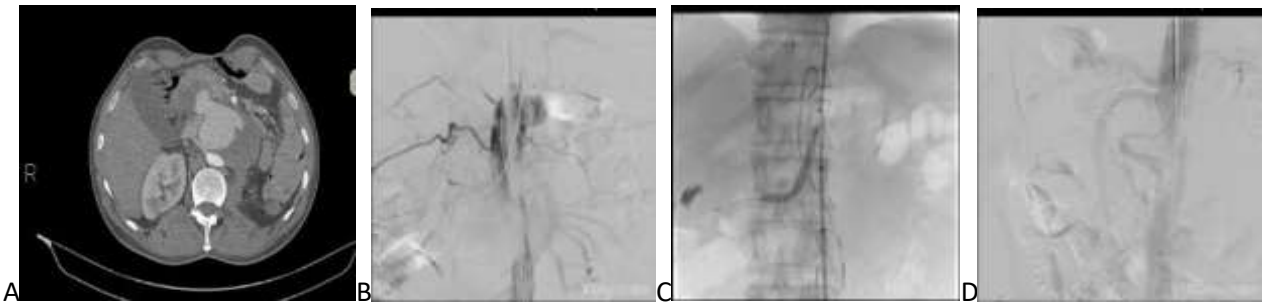

Figure 2: A 44-year-old patient with pseudoaneurysm of the aorta following nephrectomy after laparotomy due to a gunshot to the abdomen. (A) Contrast-enhanced computed tomography (CT) demonstrates abdominal aorta pseudoaneurysm. (B) Angiography shows active extravasation of contrast. (C) A 26 x 10 cm stent graft that fits the patient's aorta park in the aorta. Then, through the brachial sheet, a V12 stent graft 70 *56 mm was opened inside the renal opening and the end of the aorta stent was opened in the aorta and above the renal stent. (D). After the procedure was completed, no endoleak species were seen in the final angiography.

The challenging aspect of this case was the patient's previous laparotomy and severe adhesions, prohibiting repeat laparotomy. Additionally, placing a stent graft at the site of the left nephrectomy could potentially occlude the opening of the right renal artery, jeopardizing the patient's sole functioning kidney. After comprehensive evaluation, it was decided to utilize the chimney endovascular aortic aneurysm repair technique. Under general anesthesia, the Pictil catheter was advanced through the femoral artery following guidewire insertion, and the location of the pseudoaneurysm was determined. Subsequently, the right renal artery was cannulated via guidewire insertion through the left brachial artery. A 26 x 10 cm stent graft tailored to the patient's aortic dimensions was prepared and deployed. Subsequently, a V12 stent graft measuring 70 x 56 mm was deployed within the renal opening via the brachial sheath, and its distal end was positioned in the aorta, above the renal stent. Upon completion of the procedure, no endoleak was observed in the final angiography (Figure 3). Five days following surgery, the patient was discharged in a stable condition with normal kidney function, and subsequent follow-up revealed no significant issues.

The primary clinical success rate in our study was 85.7%, and the secondary clinical success rate was 100% for all patients. Four patients required reoperation, and three were treated successfully with coil embolization. One of these patients was a 31-year-old man who sustained a popliteal pseudoaneurysm following a gunshot wound to the popliteal artery after undergoing an open surgical femoropopliteal bypass with a saphenous vein graft. Contrast-enhanced computed tomography (CT) imaging revealed the presence of a popliteal pseudoaneurysm.

This case presented a challenging scenario as open surgical repair of the popliteal pseudoaneurysm involved proximal control of the artery and dissection in an inflamed environment, increasing the risk of thrombosis and damage to the saphenous vein of the femoropopliteal bypass. This ultimately led to limb ischemia and amputation for the patient. Angiography demonstrated the popliteal pseudoaneurysm with active extravasation of contrast. The pseudoaneurysm was successfully embolized with coils from both the proximal and distal ends, while maintaining normal blood flow in the bypass graft.

Due to the presence of a large hematoma that could not be drained through radiological intervention, open drainage was considered necessary to address the pressure exerted by the remaining hematoma (Figure 3).

Three additional patients who underwent coil embolization for arterial damage experienced recurrence during follow-up. Two of these cases were successfully treated with additional coil embolization, while one case required open surgery due to the lack of preparation for reangiography (Table 3).

It is noteworthy that no amputations or fatalities occurred among the patients treated in this study. The average blood transfusion volume (units) was 2.2, with the highest transfusion being 7 units for the patient with an aortic pseudoaneurysm.

The average length of hospital stay for vascular surgery was 9.8 days, ranging from 8 to 17 days. The longest hospital stay was 17 days for the patient who had an aortic transection.

No infections or hematomas at the operation site were reported during the three-month follow-up period. It is important to emphasize that there was no need for surgical dissection or damage to adjacent tissues. No stent graft thrombosis was observed.

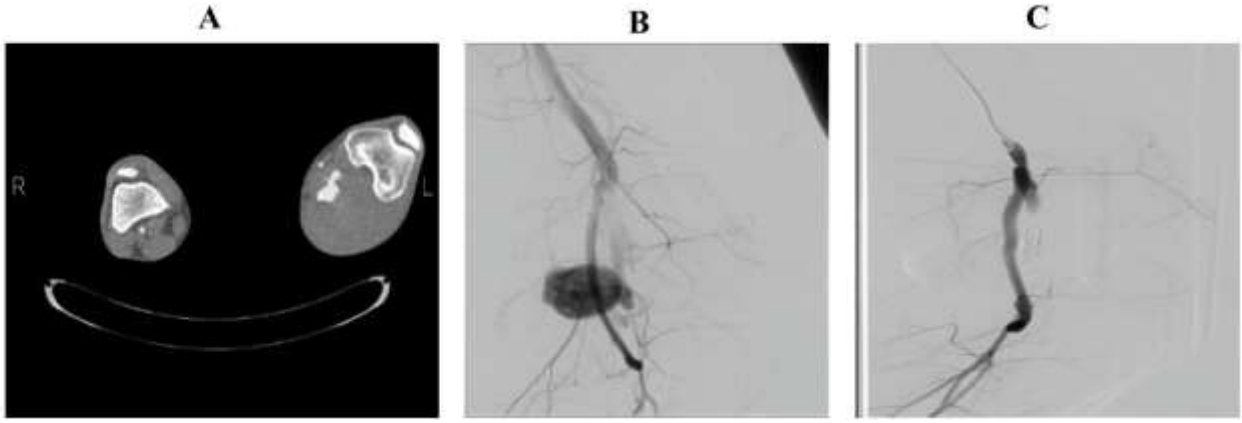

Figure 3: A 31-year-old patient with popliteal PA following gunshot to popliteal after open surgical femoropopliteal bypass with a saphenous vein. (A) Contrast-enhanced computed tomography (CT) demonstrates popliteal PA. (B) Angiography shows popliteal PA with active extravasation of contrast. (C) PA is filled by coil from the proximal and distal of the pseudoaneurysm, and normal blood flow in the bypass graft is observed. Because of a massive hematoma that cannot drain with radiologic intervention, open drainage was considered.

Table 3: Summary of patients who needed reoperation.

Type of Trauma	Pathology of artery	Primary intervention	Complications during follow up	Secondary intervention
Stab wound	Pseudoaneurysm subclavian artery	angioplasty with coiling	Hematoma in a stab wound due to pseudoaneurysm	Re-angioplasty with coiling
Iatrogenic trauma	AV fistula between the femoral artery and vein by femoral dialysis catheter	angioplasty with coiling	Thrill in the femoral vein	angioplasty with stent graft in the common femoral artery
Iatrogenic trauma	Pseudoaneurysm of internal iliac after pelvic surgery	angioplasty with coiling	rebleeding	Surgical ligation of internal iliac
Gunshot	Pseudoaneurysm of the popliteal artery after surgical bypass	angioplasty with coiling	Massive hematoma in the popliteal fossa	Surgical drainage

Discussion

Our study has demonstrated that angiography interventions are a viable treatment option for vascular trauma. Our research findings at our center indicate that endovascular therapy is most commonly employed in vascular injuries that result in pseudoaneurysm or arteriovenous fistula. However, in two cases, surgical bleeding could not be controlled. Consequently, packing was performed, and bleeding was successfully managed following angiography and coiling of the artery.

Given the location and nature of the vascular injuries in the patients involved in this study, open surgery would necessitate extensive tissue exploration and dissection, potentially leading to damage to surrounding tissues and wound infection. Notably, subclavian artery injuries comprised the majority of cases in the study, emphasizing the high morbidity and mortality rates associated with vascular trauma in the thoracic outlet. The consensus among experts is that endovascular treatment is the preferred management approach for vascular trauma.[7]

Pseudoaneurysm was the most prevalent vascular injury pathology to undergo endovascular treatment in this study, although based on Asensio's study on Traumatic penetrating arteriovenous fistulas: a collective review, arteriovenous fistula was expected to have fewer cases. Asensio's study, which reviewed articles from 1829-2019 on arteriovenous fistula in arterial trauma, identified only 291 patients for review[8].

One of the primary treatment methods for pseudoaneurysms is coil embolization. However, it has been reported that the risk of coil emboli increases with decreasing sac size and neck length, and increasing neck width. The risk of distal embolization can be minimized by employing slow injection and avoiding aneurysms with short wide necks. Similar findings were reported in a study by Sarioglu on interventional treatment options in pseudoaneurysms. [9,10]

Our study demonstrated primary clinical success rates of 85.7% and 100% secondary clinical success rates for all patients.

In our study, three patients experienced recurrence following a successful endovascular intervention. Potential causes for recurrence include recanalization of embolized arteries, incomplete embolization, collateral arterial supply, disseminated intravascular coagulation, arterial vasospasm, and vasodilatation.[11] Our research demonstrates that endovascular intervention is a procedure with high success rates and low complication rates. The artery has remained patent for 3 months after the the operation. In addition, the amount of blood transfusion required for endovascular intervention is significantly lower than in other surgical procedures.[12]

A study by Paul et al. (2007) compared the outcomes of surgical and endovascular treatment for acute traumatic thoracic aortic injuries. They concluded that endovascular repair of blunt aortic injuries using thoracic or abdominal stent grafts is a technically feasible and effective modality that is at least equivalent to open therapy in the short term and is associated with lower intraoperative mortality. Endovascular therapy also offers advantages in terms of operative time, operative blood loss, and the need for intraoperative blood transfusions.[13]

Damage to the aortic wall caused by penetrating trauma can lead to pseudoaneurysms. Due to the absence of true arterial walls and the presence of hematoma, these pseudoaneurysms are more prone to rupture. Over time, if left untreated, they will eventually tear. Traumatic aortic pseudoaneurysms are best treated with endovascular thoracic aortic repair using stent-graft grafting. Endovascular treatment offers significantly lower rates of complications and mortality compared with open repair, and the reported complications are primarily associated with endovascular prosthetic grafts.[14]

Conclusion

There is no clear-cut distinction between traumatic vascular injuries that should be treated with open surgery and those that are more amenable to endovascular procedures. Endovascular surgery has become increasingly preferred for vascular injuries that are located in deep anatomical regions or where open exposure would pose significant challenges and potential complications for the patient. Vascular specialists should consider this approach whenever possible, and this necessitates the establishment of a dedicated department for endovascular procedures with the necessary facilities and expertise.

Acknowledgments

The authors of this article are grateful for the financial support of Ahvaz Jundishapur University of Medical Sciences and the cooperation of the patients participating in the study.

Conflict of Interest Disclosures

There is no conflict of interest.

Funding Sources

This research received no specific grant from any

funding agency in the public, commercial, or not-for-profit sectors.

Authors' Contributions

Article preparation (MAZ)
Study design (IN, SMM, and MAZ)
Intervention (IN, MAZ)
Intervention follow-up (MAZ, HM)

Ethical Statement

The current study was approved by the Ahvaz Jundishapur University of Medical Sciences Ethics Committee (Ethical Approval No. IR.AJUMS.HGOLESTAN.REC.1400.071). Written informed consent was obtained from the patients for the interventions and publishing of the reports and images.

References

1. Marone EM, Mascia D, Kahlberg A, Brioschi C, Tshomba Y, Chiesa R. Is open repair still the gold standard in visceral artery aneurysm management? Ann Vasc Surg 2011; 25: 936-945.

2. Tulsyan N, Kashyap VS, Greenberg RK, Sarac TP, Clair DG, Pierce G, Ouriel K. The endovascular management of visceral artery aneurysms and pseudo aneurysms. J Vasc Surg 2007;45: 276-287.

3. Branco BC, Dubose JJ, Zhan LX, Hughes JD, Goshima KR, Rhee P, Mills Sr JL. Trends and outcomes of endovascular therapy in the management of civilian vascular injuries. J Vasc Surg 2014; 60: 1297-1310.

4. Glaser JD, Kalapatapu VR. Endovascular therapy of vascular trauma—current options and review of the literature. Vasc Endovasc Surg 2019; 53:477-790.

5. Venturini M, Marra P, Colombo M, Panzeri M, Gusmini S, Sallemi C, Salvioni M, Lanza C, Agostini G, Balzano G, Tshomba Y. Endovascular repair of 40 visceral artery aneurysms and pseudoaneurysms with the Viabahn stent-graft: technical aspects, clinical outcome, and mid-term patency. Cardiovasc Intervent Radiol 2018;41: 385-395.

6. Feliciano DV, Moore FA, Moore EE, West MA, Davis JW, Cocanour CS, Kozar RA. Evaluation and management of peripheral vascular injury. Part 1. Western Trauma Association/critical decisions in trauma. J Trauma 2011; 70: 1551-1560.

7. Jigarkumar A, Rasmussen T. Vascular Trauma—Open or Endovascular. Curr. Trauma Rep. 2019; 5:137-145.

8. Asensio A, Dabestani J, Miljkovic S, Wenzl A, Kessler J, Kalamchi D, Kotaru R, Agrawal K. Traumatic penetrating arteriovenous fistulas: a collective review. Eur J Trauma Emerg Surg. 2022; 48:775-789.

9. Saydam O, Serefli D, Engin AY, Atay M. Ultrasound-guided thrombin injection for treatment of iatrogenic femoral artery pseudoaneurysms compared with open surgery: first experiences from a single institution. Ann Surg Treat Res 2020; 98: 270-280.

10. Sarioglu o, Ergin Capar A, Belet u.Interventional treatment options in pseudoaneurysms: different techniques in different localizations. Pol J Radiol 2019; 84:319-327.

11. Wu CQ, Nayeemuddin M, Rattray D. Uterine artery pseudoaneurysm with an anastomotic feeding vessel requiring repeat embolisation. Case Rep 2018; 2018: bcr-2018-224656 doi:10.1136/bcr-2018-224656.

12. Shreve L, Jarmakani M, Javan H, Babin I, Nelson K, Katrivesis J, Lekawa M, Kuncir E, Fernando D, Abi-Jaoudeh N. Endovascular management of traumatic pseudoaneurysms. CVIR endovascular 2020; 3:75-80.

13. Paul J, Riesenman J, MSaMark A, Farber MD. Outcomes of surgical and endovascular treatment of acute traumatic thoracic aortic injury. J Vasc Surg 2007; 46(5): 934-940.

14. Manetta F, Newman J, Mattia A. Indications for thoracic endovascular aortic repair (TEVAR): a brief review. Int J Angiol 2018;27(04):177-184.