Review

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Endovascular Treatment of Pelvic Venous Injuries

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ABSTRACT Pelvic vein injuries can occur with pelvic bone fractures, gunshot wound injury, iatrogenic injuries and lead to life-threatening bleeding. CT is the main diagnostic tool in differentiating arterial from venous bleeding. Open surgical repair of venous injuries can be technically difficult. Endovascular treatment is an attractive alternative strategy. Embolization is the main method to stop arterial bleeding; balloon occlusion and stent graft implantation are also used. Arterial embolization cannot help in the situation of venous bleeding. The problem of endovascular treatment of pelvic vein injuries was not given enough attention. The purpose of this review is to summarize the available reports on the use of endovascular techniques in pelvic vein trauma and show the capabilities of the methods.

Keywords: venous injury, pelvic fracture, gunshot wound injury, iatrogenic trauma, bleeding, endovascular treatment, stent-graft, embolization

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AVF, arterio-venous fistula
CT, computed tomography
FA, false aneurysm
IVC, inferior vena cava
SG, stent graft
USE, ultrasound examination

INTRODUCTION

Injury to the pelvic veins can be fatal due to haemorrhage and shock. Traditionally, in case of injury of large veins, open interventions are performed. The problem of endovascular treatment for pelvic vein injuries has received insufficient attention. There are publications on individual clinical cases or small series of cases. The **purpose** of this review is to summarize the available reports on the use of endovascular treatment for pelvic vein injuries and to show the possibilities of the methods.

Vein injuries for which endovascular treatment has been used:

1. fractures of the pelvic bones in various types of motor vehicle trauma [1–6], falls from a height [7];
2. consequences of gunshot wounds [8–12];
3. iatrogenic injuries: a) during operations on the lumbosacral spine [13–24]; b) during other types of surgical interventions [25].

Types of vein damage (influence the choice of a particular method of endovascular treatment to be used) include: dissection, perforation, rupture, a false aneurysm (FA) formation, arteriovenous fistula (AVF). The injury may be localized in the area of the inferior vena cava (IVC) lower the confluence of the iliac veins, iliac veins, a combination of damage to various veins (different anatomical zones or, for example, the extension of the rupture from the iliac vein to the IVC). There may be ruptures of large and medium diameter veins, of small veins, venous plexuses; ruptures of their various combinations are possible, as well as simultaneous injury to arteries and veins. The thickness and structure of the vein wall is different from that of the artery, and less force is required to rupture the vein.

The main diagnostic methods are multidetector spiral computed tomography (CT) and venography.

For various injuries of the pelvic vessels, different endovascular technologies are used [26–28]. M. H. Lauerman et al [26] based on USA National Trauma Data Bank showed that in the 21st century, endovascular stenting has been used in 11.3% of blunt iliac trauma associated with pelvic fractures, 6.3% of blunt trauma without pelvic fractures, and 1.8% of penetrating vascular injuries. However, the focus is on arterial injury.

The main methods of endovascular treatment for pelvic vein injury include the implantation of a stent-graft (SG) and embolization.

ENDOVASCULAR TREATMENT METHODS FOR VEIN INJURIES IN PATIENTS WITH PELVIC FRACTURES

Bleeding in all types of pelvic fractures is the main cause of mortality that remains high, especially in patients with unstable fractures and unstable hemodynamics. To date, there are few reports on the treatment of injuries associated with low pressure, high flow venous systems in complex anatomical regions such as the pelvis [4].

There are three types of bleeding in pelvic fractures [28, 29]: arterial bleeding resulting from rupture of any of the arteries in the pelvis, venous bleeding resulting from rupture of the veins and venous plexuses, and bleeding directly from the site of a cancellous bone fracture. There may be a combination of these types of bleeding.

According to *T. Suzuki et al.* [28], pelvic bleeding is similar to "black box" bleeding in terms of which source is the predominant cause of the ongoing bleeding, it remains difficult to determine the proportional contribution of arterial bleeding, venous bleeding, and cancellous bone fracture bleeding to total pelvic bleeding that should be controlled first. There is no absolutely accurate way to identify both the main and all sources of bleeding and absolutely reliable method for accurately quantifying bleeding into the retroperitoneal space. Treatment for each of these bleeding sources should be different.

In the treatment algorithms for pelvic fractures, the venous injury have not been paid due attention. Considering the structure of the walls of arteries and veins, the thickness of the walls, their characteristics, it should be expected that in fact, injury to the veins is not less common, but more often than ruptures of the arteries. Bleeding as a result of arterial injury accounts for up to 10–20% of all causes of hematoma formation. And when the arteries are ruptured as a result of a high-energy impact, it is logical to assume that such an impact also causes a rupture of the vein. When an artery ruptures, the incidence of vein rupture is likely to approach 100% [28]. According to J. Uyeda et al. [30], the isolated pelvic vein injuries account for about 20% of pelvic vascular injuries.

G. J. Motsay et al. [31] cited data from 6 patients in whom iliac vein injury was the main cause of fatal bleeding in pelvic fractures, therefore, before arterial intervention, it is necessary to make sure that the vein does not rupture. Y. Kataoka et al. [1] found extravasation in 9 of 11 patients who underwent venography. D.A. Rothenberger et al. [32] reported on a group of 12 patients with pelvic fractures, of which 11 had damage to the veins and 5 to the arteries. In the "open book" type fractures with a pubis diastasis of 5 cm, damage to the iliac vein occurred in 60% of cases, while there was no damage to the arteries (experimental study by R. Baque et al. [33] on corpses).

The main attention focuses on the bleeding from vessels with high blood flow rate (arteries), but bleeding from vessels with low blood flow rate can also be fatal.

M. R. Grimm et al. [34] experimentally studied the relationship between the pressure and volume in the intact and damaged retroperitoneal space of the small pelvis, and the importance of external fixation. In the intact retroperitoneal space, after fluid infusion of 5 liters, the pressure rapidly increased to an average of 30 mm Hg. After a fracture, it was possible to infuse up to 20 liters of fluid at a pressure not exceeding 35 mm Hg.

There is a growing consensus, based on clinical experience, that the majority of uncontrolled bleeding results from damage to the venous system that has not been controlled by either arterial embolization or pelvic

stabilization [29]. Damage to the veins, especially to large venous trunks, is no less dangerous than ruptures of the arteries.

The main diagnostic tool for suspected pelvic vascular injury is multidetector spiral CT [35–42]. Active arterial bleeding at CT is characterized by extravasation of the contrast medium (contrast blush) appearing in the arterial phase. Active venous bleeding is characterized by extravasation of contrast agent during the venous phase as well as in the delayed phase. The use of multiphase images allows a more accurate characterization of the areas of "contrast blush" in terms of identifying the localization of vascular damage and active bleeding.

Subsequent angiographic examination allows in most cases to accurately localize the source of arterial bleeding. A common treatment is embolization with various materials, as well as stenting. There are two options: a selective and non-selective embolization. Selective embolization is preferred. But this is not always possible because of 1) the anatomical features that prevent superselective catheterization of the vessel; 2) an extremely serious patient's condition, in which it is necessary to minimize the time of intervention; 3) absent extravasation due to spasm and local thrombosis, while it is necessary to focus on CT data on a possible source of bleeding. In such cases, non-selective embolization of the internal iliac arteries is performed.

But arterial embolization does not always lead to stabilization of the condition, to an increase in blood pressure. A fatal outcome is possible even without damage to the arteries of large and medium diameter.

All the attention of researchers, the vast majority of publications is devoted to arterial trauma and embolization, because there is a prevailing opinion that with venous bleeding and bleeding from a cancellous bone fracture, a self-tamponade is possible as a result of increased pressure in the bounded retroperitoneal space of the pelvis. Self-tamponade is possible with damage to veins of small and medium diameter. But it may not occur, especially with a rupture of large diameter veins (inferior vena cava and iliac veins), a blood clotting impairment. The ability to self-tamponade disappears when the pelvic fascia is ruptured, especially in injuries with significant posterior displacement, such as sacroiliac dislocations, sacral fractures, and fracture-dislocations of the sacroiliac joint (sickle-shaped fractures). Open-book pelvic fractures cause the distraction to the pelvic bed, thereby allowing bleeding into the perineum and hips [34]. In such cases, the hemorrhage is actually an escape of blood into a free space, which can potentially contain the entire volume of the victim's blood without the occurrence of tamponade.

There are only few studies on endovascular treatment methods for vein injuries. Basically, they are the descriptions of single case.

Y. Kataoka et al. [1] presented their experience in the treatment of patients with venous injuries in blunt pelvic trauma. The authors believe that the relevance of the problem is due to the fact that severe pelvic vein injuries caused by blunt trauma can be a difficult problem in diagnosis and treatment, and some patients remain unstable even after arterial embolization. The authors studied a group of 72 patients with unstable pelvic fractures in shock. Embolization was the first choice for hemorrhage control in pelvic fractures in 61 patients. Thirty-six patients recovered from shock after embolization. Eighteen of the 25 who did not recover from the shock died. Of these 25, 11 underwent transfemoral balloon catheter venography, which revealed significant venous extravasation in 9: that of common iliac vein in 5, of internal iliac vein in 3, and external iliac vein in 1. The treatment for venous injuries included laparotomy to achieve hemostasis (n = 1; survivors = 0), retroperitoneal gauze tamponade (n = 3; survivors = 1), and endovascular stent placement (n = 3; survivors = 3). According to the authors, the iliac vein injury is the main cause of hemorrhagic shock in some patients with unstable pelvic fractures after blunt trauma. Therefore, venography is useful for detecting iliac vein injuries.

V. Mosquera Rey et al. [2] presented a case of the iliac vein rupture in a victim of a motorcycle accident. A contrast-enhanced CT showed rupture of the left external iliac vein with active bleeding and retroperitoneal hematoma, complex fractures of the pelvis and left femur. A self-expanding SG of 13 × 100 mm was successfully deployed through the access to both femoral veins under duplex ultrasound guidance. Immediately after the SG placement, the patient's blood pressure returned to normal. SG patency was confirmed 12 months later.

S. R. Zieber et al. [3] reported two cases of successful SG application: one in the case of rupture due to blunt trauma; the other one in spontaneous rupture of the iliac vein.

P. Castelli et al. [4] described the treatment of a woman injured in a car overturn. Examination showed a fracture of the first lumbar vertebra, multiple fractures of the acetabulum and right femur, retroperitoneal hematoma surrounding the first lumbar vertebra. CT angiography revealed damage to the inferior vena cava at the level of the iliac-caval bifurcation, which was confirmed by cavography. The left common femoral vein was surgically exposed and 20 Fr introducer deployed SG (Excluder - W. L. Gore, Flagstaff, AZ, USA (31 × 14 × 150

mm). The contralateral part was installed through the right transfemoral access. The final venogram confirmed a complete exclusion of damage and the absence of bleeding. The duration of the procedure was 9 minutes. The patient died due to a head injury.

K. Sofue et al. [5] showed that if SG is unavailable, uncoated stents can be used. In a woman injured in a traffic accident with blunt pelvic trauma, no extravasation was found at arteriography. Examination of the venous system showed the injury to the external iliac vein with extravasation and stenosis as a result of hematoma compression. A self-expanding stent 14 x 64 mm (Wallstent, Boston Scientific, USA) was implanted into the area of rupture and proximal stenosis, an additional stent was placed, overlapping the first one over the rupture site. The extravasation disappeared immediately. Control examinations within 3 years showed good patency of the stents.

Two groups of authors [6, 7] cited cases of successful embolization (1 patient in each report) of arteriovenous fistulas formed during pelvic fractures. V. Perinjelil et al. [6] described a patient who suffered a severe pelvic injury as a result of a car accident. CT and subsequent angiography revealed a traumatic fistula, which was embolized. At an angiographic examination in a man who suffered from a fall, S. Cho et al. [7] revealed a fistula between the internal iliac artery and a vein, which was successfully treated by arterial embolization with n-butylcyanoacrylate.

ENDOVASCULAR SURGERY FOR GUNSHOT WOUNDS OF THE PELVIS, ABDOMEN, RETROPERITONEAL SPACE

The literature contains only single-case reports [8–12]; only V.A. Ivanov et al. [8] described the treatment of 4 patients, including 2 with injuries of the iliac vessels, in whom AVF occurred at the level of the iliac artery and vein as a result of a gunshot wound. The development of arteriovenous anastomosis, as well as the resulting heart failure, occurred over a fairly long time (up to 17 years [9]). SG implantation into the iliac artery made it possible to exclude fistulas from the blood flow in all cases.

THE USE OF ENDOVASCULAR METHODS OF TREATMENT FOR IATROGENIC VEIN INJURIES

A) Iatrogenic vein injuries during operations on the lumbosacral spine [13–24].

Incidence of iatrogenic vascular injuries during spinal surgery: *S. Papadoulas et al.* [13], by using the MEDLINE database, reviewed all reports published in English from 1965 to 2002 and identified 98 cases of vascular complications with an incidence of 1–5 per 10,000 intervertebral disc interventions; a retrospective analysis at their institution for the period from 1990 to 2001 showed an incidence of iatrogenic vascular injury of 4 per 10,000. *P. C. Bonasso et al.* [14] reported iliocaval complications during spinal surgery in 3 cases of 102 interventions (2.9%). Most publications report 1–2 clinical cases [15–21], and only three groups of investigators presented observation of up to 7 cases [22–24].

G.-W. Yan et al. [17] reported a clinical case of endovascular treatment of an arteriovenous fistula after lumbar discectomy. CT angiography revealed a fistula between the common iliac artery and the common iliac vein, the false aneurysm formation, and a dissection in a patient. The patient was implanted with 2 SGs (24 mm × 120 mm and 14 mm × 100 mm, ANKURA, LifeTech Scientific Corporation, China). Control CT angiography showed the anastomosis, aneurysm, dissection had disappeared.

Also, the authors [17] systematized the available literature data on iatrogenic iliac arteriovenous fistulas after lumbar discectomy operations. In 31 reports (published from 2000-2018) on using the posterior surgical approach (the anterior surgical approach was excluded), which included 44 patients, the following levels of damage were described: L3-L4 2.3%, L4-L5 40.9%; L5-S1 9.1%; L4-L5 and L5-S1 13.6% (data on the rest of the patients were unavailable). In the majority of patients (86.4%), the diagnosis was made by CT angiography and/or digital subtraction angiography. In 63.6 % of patients, signs of heart failure developed after some time. The time interval between discectomy and fistula detection was less than 24 hours in 9.1%, from 24 hours to 1 week in 6.8%, from 1 week to 1 month in 20.5%, from 1 month to 1 year in 34.1%, and more than 1 year in 29.5% of cases. As a result of surgery, injuries and fistulas of the common iliac arteries and veins (in 74% of cases), internal iliac arteries and veins (4.5%), fistulas with IVC (in 6.8%) may occur; in 6 patients, the authors did not report the fistula localization. In 36.4% of patients, FA also developed in addition to the fistula; in 1 patient an anastomosis, FA, and dissection occurred. The majority of patients (88.6%) were treated with endovascular methods: The SG placement in an artery or vein, embolization of the internal iliac artery to prevent blood flow from the contralateral artery, a combination of these approaches.

B. Liu et al. [22] presented their experience in the treatment of vascular complications and analyzed the literature data: a total of 77 patients. Among vascular injuries, the injuries of the common iliac artery and vein most often occurred (78.7%). In case of vessel ruptures, the traditional surgical repair method was most often chosen, and in the event of fistula and FA, the endovascular interventions were chosen.

L. Canaud et al [23] performed a retrospective database analysis over 13 years of treatment of 7 patients with acute (3) or subacute (4) injuries of the common iliac artery (6) or abdominal aorta (1) after surgery on the lumbar spine. Arterial ruptures occurred in 3 cases, AVF in 2, FA also in 2. These injuries were successfully repaired using the placement of SGs: Passager (3), Viabahn (1), Wallgraft (1), Zénith (1) and Advanta V12 (1). Technical success has been achieved in all cases. There were neither deaths, nor complications. When followed-up over a period of 0.3 to 13 years (average 8.7 years), all SGs were patent.

H.S. Jung et al. [24] also described the treatment of 7 patients with lumbar discectomy from the posterior approach and resulting vascular complications. Operations were performed on 4 patients, and 3 patients with AVF and FA were diagnosed with a good SG effect.

After discectomy, the occurrence of the iliac artery FA, and AVF with a massive run-off into the IVC is possible [15, 16]. After the implantation of VIABAHN SG (GORE, USA) [15], the clinical effect was obtained immediately on the operating table; further there was a regression of the right ventricular failure, a decrease in the liver size, and the disappearance of regurgitation on the tricuspid valve. Due to the difference in the diameters of the iliac arteries, it is possible to implant three SGs of different diameters and lengths to exclude FA and AVF from the bloodstream [16].

At present, SG is most often used in the occurrence of pathology, but a combination of SG implantation and embolization is possible. In a case of AVF of the iliac artery and vein, J. P.Hart et al. [20] deployed 2 SGs in the artery and the embolization of the internal iliac artery was performed, which made it possible to eliminate the pathology.

B). Iatrogenic injury to veins during other operations.

In 1995*, A. B. Zajko et al.* [25] described a patient who underwent a series of operations for prostate cancer, where the common iliac artery was damaged by a trocar; primary arterioplasty was performed, but later a fistula with IVC occurred. The authors deployed an SG made of polytetrafluoroethylene (PTFE) synthetic material attached to the Palmaz balloon-expandable stent by means of surgical sutures. This was the first report of the use of SG in such situations.

CONCLUSION

Injury to the veins of the pelvis can occur in motor vehicle trauma, falling from a height, gunshot wounds, iatrogenic injuries. The source of pelvic bleeding can be an artery, vein, or cancellous bone, or a combination of these sources. Due to anatomical features, the walls of the veins and venous plexuses are thinner and more fragile than the walls of the arteries, their rupture occurs more often than the rupture of the arteries. It is impossible to accurately determine the proportional contribution of venous and arterial bleeding to total pelvic bleeding. In pelvic fractures, bleeding is the main cause of high mortality, especially in patients with unstable fractures and unstable hemodynamics.

Accurate diagnosis of bleeding sources is of decisive importance for the tactics of subsequent treatment. Treatment should be differentiated with regard to the source of bleeding. CT angiography is an important diagnostic tool.

Endovascular treatment of pelvic vein injury is paid insufficient attention is paid to, as the main attention is focused on arterial injury. However, arterial embolization does not have effect on venous bleeding. In case of venous injury, stent grafts are more often used, and embolization is used only when arteriovenous fistula occurs. These reports show a high efficacy of stent-graft implantation and embolization of the vessels.

REFERENCES

1. Kataoka Y, Maekawa K, Nishimaki H, Yamamoto S, Soma K. Iliac vein injuries in hemodynamically unstable patients with pelvic fracture caused by blunt trauma. *J Trauma*. 2005; 58(4):704–708. PMID:15824645 https://doi.org/10.1097/01.ta.0000159346.62183.8f
2. Mosquera Rey V, Fernández C, Zanabili A, Del Castro JA, Pandavenes MG, Alonso M. Endovascular repair of iliac vein laceration associated with complex pelvic fracture. *Ann Vasc Surg*. 2019;54:336.e9–336.e12. PMID:30114500 https://doi.org/10.1016/j.avsg.2018.06.020
3. Zieber SR, Mustert BR., Knox MF, Fedeson BC. Endovascular repair of spontaneous or traumatic iliac vein rupture. *J Vasc Interv Radiol*. 2004;15(8):853–856. PMID:15297589 https://doi.org/10.1097/01.RVI.0000128811.75493.CC
4. Castelli P, Caronno R, Piffaretti G, Tozzi M. Emergency endovascular repair for traumatic injury of the inferior vena cava. *Eur J Cardiothoracic Surg.* 2005;28(6):906–908. https://doi.org/10.1016/j.ejcts.2005.09.001
5. Sofue K, Sugimoto K, Mori T, Nakayama S, Yamaguchi M, Sugimura K. Endovascular uncovered Wallstent placement for life-threatening isolated iliac vein injury caused by blunt pelvic trauma. *Jpn J Radiol*. 2012;30(8):680–683. PMID:22752416 https://doi.org/10.1007/s11604-012-0100-9
6. Perinjelil V, Maraqa T, Yenter AC, Ohaeri H, Mercer L,Bansal A, et al. Traumatic arteriovenous fistula formation secondary to crush injury. *J Surg Case Rep.* 2018;2018(9):rjy240. PMID: 30254731 https://doi.org/10.1093/jscr/rjy240
7. Cho HS, Kim Y, Lee J, Yi KS, Choi C-H. Use of N-butyl cyanoacrylate in the successful transcatheter arterial embolization of an arteriovenous fistula caused by blunt pelvic fracture: A case report and review of literature. *Medicine (Baltimore)*. 2021;100(1):e24215. PMID: 33429814 https://doi.org/10.1097/MD.0000000000024215
8. Ivanov VA, Pinchuk OV, Obrastchov AV, Ivanov AV. Surgical correction of post-traumatic arteriovenous fistula with help of stent-grafts. *Journal Diagnostic & interventional radiology*. 2015;9(2):42–47. (In Russ). https://doi.org/10.25512/DIR.2015.09.2.05
9. de Oliveira Raymundo SR, Leite RLT, Reis LF, da Silva Russeff GJ. Traumatic arteriovenous fistula with serious haemodynamic repercussions: endovascular treatment. *BMJ Case Rep*. 2020;13(4):e234220. PMID: 32345586 https://doi.org/10.1136/bcr-2019-234220
10. Queiroz AB, Mulatti GC, Aun R, Valentim LA, Puech-Leão P. Endovascular repair of a traumatic arteriovenous fistula involving the iliac bifurcation using an iliac branch device. *J Vasc Surg*. 2012;55(5):1474–1476. PMID: 22277687 https://doi.org/10.1016/j.jvs.2011.12.006
11. Biswas S, Hristov B. Endovascular management of a penetrating zone III retroperitoneal gunshot wound injury; a case report. *Bull Emerg Trauma*. 2017;5(4):303–306. PMID: 29177179 https://doi.org/10.18869/acadpub.beat.5.4.482
12. Kokhan YeP, Mitroshin GYe, Batrashov VA, Ivanov VA, Terekhin SA, Pinchuk OV, et al. Roentgenendovascular stenting (stent-graft) of the external iliac artery for elimination of post-traumatic arteriovenous anastomosis. *Angiology and Vascular Surgery*. 2005;11(2):49–52. (In Russ.) PMID: 16037803
13. Papadoulas S, Konstantinou D, Kourea HP, Kritikos N, Haftouras N, Tsolakis JA. Vascular injury complicating lumbar disc surgery. A systematic review. *Eur J Vasc Endovasc Surg*. 2002;24(3):189–195. PMID: 12217278 https://doi.org/10.1053/ejvs.2002.1682
14. Bonasso PC, Lucke-Wold BP, d'Audiffret A, Pillai L. Primary endovascular repair of ilio-caval injury encountered during anterior exposure spine surgery: evolution of the paradigm. *Ann Vasc Surg*. 2017;43:316.e1–316.e8. PMID: 28479457 https://doi.org/10.1016/j.avsg.2017.03.192
15. Sinkov MA, Murashkovsky AL, Pogorelov EA, Golovin AA, Kalinichenko NA, Khaes BL, et al. Endovascular closure of iatrogenic arteriovenous anastomosis of the iliac artery and vein. *Angiology and Vascular Surgery.* 2014;20(1):80–84. (In Russ.).
16. Generalov MI, Maystrenko DN, Panov IO, Novikov PV, Fokin AA. Endovascular treatment of iliac arteriovenous fistula occured after spinal disc surgery. *Journal Diagnostic & interventional radiology*. 2014;8(1):78–82. (in Russ.) https://doi.org/10.25512/DIR.2014.08.1.12
17. Yan GW, Li HW, Yang GQ,Bhetuwal A, Liu JP, Li Y, et al. Iatrogenic arteriovenous fistula of the iliac artery after lumbar discectomy surgery: a systematic review of the last 18 years. *Quant Imaging Med Surg*. 2019;9(6):1163–1175. PMID: 31367570 https://doi.org/10.21037/qims.2019.05.12
18. Kwinta BM, Myszka AM, Bigaj MM, Dragan MR, Kenig J, Krzyżewski RM. Iatrogenic common iliac vessel injury during routine degenerative lumbar spine surgery: Report of 2 cases and review of literature. *World Neurosurg*. 2020; 137: 111–118. PMID: 32006736 https://doi.org/10.1016/j.wneu.2020.01.168
19. Kiguchi M, O'Rourke HJ, Dasyam A, Makaroun MS, Chaer RA. Endovascular repair of 2 iliac pseudoaneurysms and arteriovenous fistula following spine surgery. *Vasc Endovascular Surg*. 2010; 44(2):126–130. PMID: 20034939 https://doi.org/10.1177/1538574409352809
20. Hart JP, Wallis F,Kenny B,O'Sullivan B,Burke PE,Grace PA. Endovascular exclusion of iliac artery to iliac vein fistula after lumbar disk surgery. *J Vasc Surg.* 2003;37(5):1091–1093. PMID: 12756359 https://doi.org/10.1067/mva.2003.180
21. Kaźmierski P, Wąsiewicz M, Chrząstek J, Pająk M. Endovascular treatment of iatrogenic arteriovenous fistula of the iliac vessel. *Adv Clin Exp Med.* 2018; 27(10): 1371–1375. PMID: 30058782 https://doi.org/10.17219/acem/69859
22. Liu B, Ye K, Gao S, Liu K, Feng H, Zhou F, et al. The summary of experience of abdominal vascular injury related to posterior lumbar surgery. *Int Orthop*. 2019;43(9):2191–2198. PMID: 30643934 https://doi.org/10.1007/s00264-018-4262-7
23. Canaud L, Hireche K, Joyeux F, D'Annoville T, Berthet J-P, Marty-Ané C, et al. Endovascular repair of aorto-iliac artery injuries after lumbar-spine surgery. *Eur J Vasc Endovasc Surg*. 2011; 42(2):16771. PMID: 21592826 https://doi.org/1–0.1016/j.ejvs.2011.04.011
24. Jung HS, Kim DJ, Kim HS, Lee HK, Choi SJN, Chung SY. Vascular complications related to posterior lumbar disc surgery. *Vasc Specialist Int*. 2017;33(4):160–165. PMID: 29354627 https://doi.org/10.5758/vsi.2017.33.4.160
25. Zajko AB, Little AF, Steed DL, Curtiss EI. Endovascular stent-graft repair of common iliac artery-to-inferior vena cava fistula. *J Vasc Interv Radiol.* 1995;6(5):803–806. PMID: 8541688 https://doi.org/10.1016/s1051-0443(95)71190-3
26. Lauerman MH, Rybin D, Doros G, Kalish J, Hamburg N, Eberhardt RT, et al. Characterization and outcomes of iliac vessel injury in the 21st century: a review of the National Trauma Data Bank. *Vasc Endovascular Surg.* 2013;47(5):325–330. PMID: 23651699 https://doi.org/10.1177/1538574413487260
27. Franco DF, Zangan SM. Interventional radiology in pelvic trauma. *Semin intervent Radiol*. 2020;37(01):044–054. https://doi.org/10.1055/s-0039-3401839
28. Suzuki T, Smith WR, Moore EE. Pelvic packing or angiography: competitive or complementary? *Injury.* 2009;40(4):343–353. PMID: 19278678 https://doi.org/10.1016/j.injury.2008.12.006
29. Dyer GSM, Vrahas MS. Review of the pathophysiology and acute management of haemorrhage in pelvic fracture. *Injury*. 2006;37(7):602–613. PMID: 16309680 https://doi.org/10.1016/j.injury.2005.09.007

30. Uyeda J, Anderson SW, Kertesz J, Soto JA. Pelvic CT angiography: application to blunt trauma using 64MDCT. *Emerg Radiol*. 2010;17(2):131–137. PMID: 19588177 https://doi.org/10.1007/s10140-009-0825-7
31. Motsay GJ, Alho A, Butler B, Perry JF, Lillehei RC. Iliac vein trauma with pelvic fracture. *Postgraduate Medicine.* 1972; 51(2):133–136. PMID: 5019711 https://doi.org/10.1080/00325481.1972.11698135
32. Rothenberger DA, Fischer RP, Perry JrJF. Major vascular injuries secondary to pelvic fractures: An unsolved clinical problem. *Am J Surg*. 1978;136(6):660–662. PMID: 717645 https://doi.org/10.1016/0002-9610(78)90331-8
33. Baqué P, Trojani C, Delotte J, Séjor E, Senni-Buratti M, de Baqué F, et al. Anatomical consequences of "open-book" pelvic ring disruption: a cadaver experimental study. *Surg Radiol Anat*. 2005;27(6):487–490. PMID:16311717 https://doi.org/10.1007/s00276-005-0027-2
34. Grimm MR, Vrahas MS, Thomas KA. Pressure-volume characteristics of the intact and disrupted pelvic retroperitoneum. *J Trauma*. 1998;44(3):454–459. PMID: 9529171 https://doi.org/10.1097/00005373-199803000-00006
35. Lazarev A, Golokhvast K, Borozda I. Review of the problems of diagnosis of endopelvic haemorrhage, its intensity, volume, and duration, and treatment methods of circulatory injuries and surgical hemostasis after pelvic fractures. *Emerg Med Int*. 2019; 2019:2514146. PMID: 30915239 https://doi.org/10.1155/2019/2514146
36. Lee MJ, Wright A, Cline M, Mazza MB, Alves T, Chong S. Pelvic fractures and associated genitourinary and vascular injuries: a multisystem review of pelvic trauma. *AJR Am J Roentgenol*. 2019; 213(6):1297–1306. PMID: 31613662 https://doi.org/10.2214/AJR.18.21050
37. Raniga SB, Mittal AK, Bernstein M, Skalski MR, Al-Hadidi AM. Multidetector CT in vascular injuries resulting from pelvic fractures: a primer for diagnostic radiologists. *Radiographics*. 2019; 39(7):2111–2129. PMID: 31697619 https://doi.org/10.1148/rg.2019190062
38. Anderson SW, Soto JA, Lucey BC, Burke PA, Hirsch EF, Rhea JT. Blunt trauma: feasibility and clinical utility of pelvic CT angiography performed with 64-detector row CT. *Radiology*. 2008; 246(2):410–419. PMID: 18227538 https://doi.org/10.1148/radiol.2462070082
39. Romano L, Pinto A, De Lutio Di Castelguidone E, Scaglione M, Giovine S, Sacco M, et al. [Spiral computed tomography in the assessment of vascular lesions of the pelvis due to blunt trauma]. *Radiol Med*. 2000; 100 (1–2):29–32. (In Italian). PMID: 11109448
40. Vu M, Anderson SW, Shah N, Soto JA, Rhea JT. CT of blunt abdominal and pelvic vascular injury. *Emerg Radiol*. 2010;17(1): 21–29. PMID: 19381700 https://doi.org/10.1007/s10140-009-0813-y
41. Kertesz JL, Anderson SW, Murakami AM, Pieroni S, Rhea JT, Soto JA. Detection of vascular injuries in patients with blunt pelvic trauma by using 64-channel multidetector CT. *Radiographics*. 2009;29(1):151–164. PMID: 19168842 https://doi.org/10.1148/rg.291085508
42. Wijffels DJ, Verbeek DO, Ponsen KJ, Goslings JC, van Delden OM. Imaging and endovascular treatment of bleeding pelvic fractures: review article. *Cardiovasc Intervent Radiol*. 2019; 42(1):10–18. PMID: 30225676 https://doi.org/10.1007/s00270-018-2071-4

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