Iatrogenic Lumbar Artery Injury in Spine Surgery: A Literature Review

Liehua Liu[1,4], Nan Li[5], Qian Wang[6], Haoming Wang[5], Yuexiang Wu[2], Weidong Jin[3], Qiang Zhou[4], Zili Wang[3]

Key words
- Iatrogenic injury
- Lumbar artery
- Lumbar artery pseudoaneurysm
- Spine surgery

Abbreviations and Acronyms
CT: Computed tomography
ILAI: Iatrogenic lumbar artery injury
LA: Lumbar artery
PKP: Percutaneous kyphoplasty
PVP: Percutaneous vertebroplasty
TAE: Transarterial embolization

From the [1]Graduate School, [2]Outpatient Department, General Hospital, and [3]Department of Spinal Surgery, General Hospital, Ningxia Medical University, Yinchuan, Ningxia Hui Autonomous Region, China; [4]Department of Spine Surgery, The Third Affiliated Hospital of Chongqing Medical University (General Hospital), Chongqing, China; [5]Department of Orthopedics, Three Gorges Central Hospital, Chongqing, China; and [6]Hillsborough Community College, Tampa, Florida, USA

To whom correspondence should be addressed: Zili Wang, M.D. [E-mail: wangzlnx@126.com]

Liehua Liu and Nan Li contributed equally to this research.

Citation: World Neurosurg. (2019) 122:266-271. https://doi.org/10.1016/j.wneu.2018.10.219

Journal homepage: www.WORLDNEUROSURGERY.org

Available online: www.sciencedirect.com

BACKGROUND: **We reviewed the reported data related to iatrogenic lumbar artery injury (ILAI) in spine surgery with a focus on which iatrogenic procedure might cause lumbar artery injury.**

METHODS: **We conducted a comprehensive search in the Web of Science, PubMed, EMBASE, and Chinese biomedical databases in July 2018.**

RESULTS: **A total of 20 reports on ILAI were selected for the present study. Most of these were case reports, with a total of 26 cases. The causes of ILAI were as follows: puncture injury in 9 cases, transforaminal endoscopic operation in 5 cases, pedicle screw injury in 3 cases, intervertebral foramen decompression in 2 cases, disc rongeur injury during discectomy in 2 cases, lumbar artery tear caused by transverse process fracture in 1 case, vertebral fracture restoration in 1 case, retractor injury in 1 case, cage insertion or pedicle screw injury in 1 case, and drainage tube stimulation in 1 case. The treatment methods included transarterial embolization in 20 cases, percutaneous embolization in 2 cases, surgical ligation in 1 case, and steroid and cyclophosphamide treatment in 1 case. All patients were treated successfully. One patient died during antishock therapy, and another patient died because her family refused any further intervention.**

CONCLUSIONS: **Attention should be given to the surgical procedures that are likely to cause ILAI, such as percutaneous vertebroplasty/percutaneous kyphoplasty, vertebral biopsy, pedicle screw implantation, discectomy, transforaminal endoscopic operation, and intervertebral foramen decompression. Once a diagnosis of ILAI has been confirmed, selective endovascular transarterial embolization is the preferred treatment.**

INTRODUCTION

The lumbar arteries (LAs) are small blood vessels originating from the abdominal aorta that are mostly distributed in L1-L4 in pairs and, rarely, in L5.[1] They traverse the posterolateral side of the vertebral body and are divided into 3 branches in front of the intervertebral foramen (anterior branch, posterior branch, and middle branch).[2] However, the origin, distribution, and branches could have some variations.[3,4] Some studies have reported that bleeding and/or a pseudoaneurysm can occur in the LA from trauma,[5,6] vascular disease,[7,8] and iatrogenic injury.[9-27] These cases are uncommon in clinical practice and easy to ignore; however, a belated diagnosis can lead to serious consequences, such as massive bleeding, shock, and, even, death.[25]

The present study reviewed the reported data related to iatrogenic LA injury (ILAI) during spine surgery, with a focus on which iatrogenic operation caused the LA injury. We also analyzed its causes, diagnosis, and treatment with the aim of alerting spine surgeons to pay attention to ILAIs.

METHODS

The present study did not require ethical review because all analyses were of data from previous reports. We conducted a comprehensive search in the Web of Science, PubMed, EMBASE, and Chinese biomedical databases in July 2018. The searched titles or keywords were lumbar artery, lumbar artery hemorrhage, lumbar artery injury, lumbar artery aneurysm, lumbar artery pseudoaneurysm, segmental artery, segmental artery injury, segmental artery aneurysm, and segmental artery pseudoaneurysm. The inclusion criteria were the receipt of spine surgery for spine disease, LA bleeding, and/or a pseudoaneurysm confirmed during or after surgery; detailed diagnosis and treatment information available; and report of the reason for analysis of the ILAI. The exclusion criteria were trauma and arterial vasculopathy leading to LA bleeding and/or a pseudoaneurysm.

RESULTS

A total of 102 reports were found and included, 42 of which involved an LA injury associated with spine surgery. Thus, 22 non-ILAI reports were excluded, and 20

Table 1. Details of the Studies of Iatrogenic Lumbar Artery Injury

Investigator	State	Patient	Sex	Age (years)	Primary Disease	Operation	Other Indications	Symptom of ILAI	Diagnostic Point	Diagnostic Method	Affected LA	Cause of ILAI	Treatment	Outcome
Smith et al.,[9] 1991	USA	1	M	62	LSS (L3-L4, L4-L5)	Spinal canal decompression	Atherosclerosis	Right lower limb neural symptom, acute hypotension	POD 2	CT	Right 4	Intervertebral foramen decompression	Ligation	Cured
Stevens et al.,[10] 1997	UK	2	M	80	Lymphoma	Needle biopsy (L4)		Paravertebral mass	POD 180	CT	Right 4	Puncture	Conservative treatment (steroid + CP)	Cured
Biafora et al.,[11] 2006	USA	3	F	84	OVCF (L5)	PKP (L5)	Anticoagulant agents	Incision bleeding	POD 10	Angiography	Right 4	Puncture	TAE	Cured
Dausse et al.,[12] 2006	FRA	4	F	66	Infection (L2-L3)	Needle biopsy	Lymphoma	Left lower abdominal pain	POD 11	Enhanced CT	Left 2	Puncture	TAE	Cured
	FRA	5	?	81	Paravertebral abscess	Drainage	Septicemia	No (repeat CT examination)	POD 15	Enhanced CT	Left 3	Drainage tube	TAE	Cured
Kulkarni et al.,[13] 2007	UK	6	M	79	Infection (L1-L2)	Needle biopsy		Low back pain	POD 20	Enhanced MRI	?	Puncture	Percutaneous embolization	Cured
Domenicucci et al.,[14] 2008	ITA	7	?	23	Fracture (T12-L1), SCI	Reduction + PS		Incision hematoma, hyperpyrexia, anemia	POD 7	CT	Left 1	Fracture restoration	TAE	Cured
Nijenhuis et al.,[15] 2009	NED	8	M	69	LSS (L4—S1)	PLIF + PS		Low back pain, lower limb neural symptom	POD 90	MRI	Right 4	Intervertebral foramen decompression	TAE	Cured
Karaikovic et al.,[16] 2010	USA	9	F	48	LDH (L4-L5)	Discectomy		Surgical field bleeding	During surgery	Angiography	Right 3	Disc rongeur	TAE	Cured
Santillan et al.,[17] 2010	USA	10	M	55	LDD (L2-L3)	XLIF		Shock, retroperitoneal hematoma	POD 2	CT	Left 2	Retractor	TAE	Cured
Heo et al.,[18] 2011	KOR	11	F	73	OVCF (L2)	PVP		Backache, left lower limb neural symptom, acute hypotension	POD 1	Enhanced MRI	Left 2	Puncture	TAE	Cured
Puri et al.,[19] 2011	USA	12	F	67	OVCF (L3, L4)	PVP (L3, L4)		Backache, psoas hematoma	POD 42	CTA	Left 3	Puncture	TAE	Cured
	USA	13	F	81	OVCF	PVP		Anemia	POD 9	CTA	Right 3	Puncture	TAE	Cured
Ikeda et al.,[20] 2012	JPN	14	M	56	Infection (L2-L3)	Needle biopsy	AML	Low back pain	POD 4	CTA	Left 2	Puncture	Percutaneous embolization	Cured
Oh et al.,[21] 2013	KOR	15	F	55	LSS (L3-L4)	PLF + PS	Anticoagulant agents	Stomach ache, acute hypotension, anemia	POD 9	Enhanced CT	Right 2	Transverse process fracture	Embolization	Cured
Sugimoto et al.,[22] 2013	JPN	16	M	65	Burst fracture (L1), CES	Reduction + PS		Anemia	POD 2	Enhanced CT	Right 2	PS	TAE	Cured

ILAI, iatrogenic lumbar artery injury; LA, lumbar artery; M, male; LSS, lumbar spinal stenosis; POD, postoperative day; CT, computed tomography; CP, cyclophosphamide; F, female; ?, unclear; OVCF, osteoporotic vertebral compression fracture; PKP, percutaneous kyphoplasty; TAE, transarterial embolization; FRA, France; MRI, magnetic resonance imaging; ITA, Italy; XLIF, extreme lateral interbody fusion; SCI, spinal cord injury; PS, pedicle screw; NED, the Netherlands; PLIF, posterior lumbar interbody fusion; LDH, lumbar disc herniation; LDD, lumbar degenerative disease; KOR, Korea; PVP, percutaneous vertebroplasty; CTA, computed tomography angiography; JPN, Japan; CES, cauda equina syndrome; DLS, degenerative lumbar spondylolisthesis; AML, acute myeloid leukemia; PLF, posterolateral lumbar fusion; mCa, metastatic carcinoma; ESP, Spain; CHN, China; GRE, Greece; PTED, percutaneous transforaminal endoscopic discectomy.

Continues

Table 1. Continued

Investigator	State	Patient	Sex	Age (years)	Primary Disease	Operation	Other Indications	Symptom of ILAI	Diagnostic Point	Diagnostic Method	Affected LA	Cause of ILAI	Treatment	Outcome
		17	M	82	DLS (L4-L5)	PLIF + PS	Anticoagulants	Psoas hematoma	POD 7	Enhanced CT	Left 4	PS	TAE	Cured
Giordano et al.,[23] 2017	ITA	18	M	73	mCa (L2)	PVP + cryoablation (L2)	Kidney cancer	Stomach ache	POD 2	Enhanced CT	Left 2	Puncture	TAE	Cured
Álvarez et al.,[24] 2017	ESP	19	F	77	LSS (L3-L4, L4-L5)	Decompression+ PS		Surgical field bleeding	During surgery	Angiography	Right 5	PS	TAE	Cured
Ventura et al.,[25] 2017	ITA	20	F	38	LDH (L5-S1)	Discectomy		Acute hypotension	During surgery	Autopsy	Right 4	Disc rongeur	Antishock therapy	Death
Chen et al.,[26] 2017	CHN	21—24	2 M + 2 F	67 (65—71)	LDH	PTED		Surgical field bleeding	During surgery	Angiography	Right 3	Transforminal endoscope	TAE	Cured
					LDH (L3-L4)	PTED		Surgical field bleeding	During surgery	Angiography	Left 3	Transforminal endoscope	TAE	Cured
					LDH	PTED		Surgical field bleeding	During surgery	Angiography	?	Transforminal endoscope	TAE	Cured
					LDH	PTED		Stomachache, groin pain	POD 1	CT	Left 4	Transforminal endoscope	TAE	Cured
Ntourantonis et al.,[27] 2018	GRE	25	F	76	OVCF + canal encroachment	Corpectomy (L1)	Colon cancer, ovarian cancer, anticoagulant agents	Dizzy, anemia	POD 7	CTA	Left 3	Cage insertion or PS	Her family denied any further intervention	Death
Wang et al.,[28] 2018	CHN	26	F	64	LDH (L3-L4)	PTED		Surgical field bleeding	During surgery	Angiography	Right 3	Transforminal endoscope	TAE	Cured

ILAI, iatrogenic lumbar artery injury; LA, lumbar artery; M, male; LSS, lumbar spinal stenosis; POD, postoperative day; CT, computed tomography; CP, cyclophosphamide; F, female; ?, unclear; OVCF, osteoporotic vertebral compression fracture; PKP, percutaneous kyphoplasty; TAE, transarterial embolization; FRA, France; MRI, magnetic resonance imaging; ITA, Italy; XLIF, extreme lateral interbody fusion; SCI, spinal cord injury; PS, pedicle screw; NED, the Netherlands; PLIF, posterior lumbar interbody fusion; LDH, lumbar disc herniation; LDD, lumbar degenerative disease; KOR, Korea; PVP, percutaneous vertebroplasty; CTA, computed tomography angiography; JPN, Japan; CES, cauda equina syndrome; DLS, degenerative lumbar spondylolisthesis; AML, acute myeloid leukemia; PLF, posterolateral lumbar fusion; mCa, metastatic carcinoma; ESP, Spain; CHN, China; GRE, Greece; PTED, percutaneous transforaminal endoscopic discectomy.

reports on ILAI were selected for inclusion in the present study[9-27] (Table 1). Most of these were case reports, with a total of 26 patients. These reports came from 10 countries and had been published from 1991 to 2018, including 5 from the United States, 3 from Italy, 2 each from the United Kingdom, Japan, Korea and China, and 1 each from the Netherlands, Spain, France, and Greece.

Of the 26 patients, 11 were men, 13 were women, and 2 did not report their sex. Their age was 66.23 ± 14.21 years (range, 23—84). The age of the men was 68.64 ± 9.18 years (range, 55—82), and the age of the women was 70.00 ± 8.60 years (range, 55—84).

The primary disease was lumbar vertebra degeneration in 13 patients, including 7 with lumbar disc herniation, 4 with lumbar spinal stenosis, 1 with degenerative lumbar spondylolisthesis, and 1 with a rough diagnosis of lumbar degeneration. The primary disease was lumbar vertebra fracture in 7 patients, including 5 with osteoporotic vertebral compressive fracture and 2 with lumbar vertebra fractures in young and middle-age patients with neurological symptoms. In addition, 4 patients had lumbar vertebra infection and 2 patients had lumbar tumors. Other predisposing factors included 4 case-times of anticoagulant therapy, 5 case-times of a malignant tumor, 1 case-time of atherosclerosis, and 1 case-time of sepsis.

The performed operations were as follows: percutaneous vertebroplasty (PVP) and percutaneous kyphoplasty (PKP) in 5 patients, percutaneous transforaminal endoscopic discectomy in 5 patients, needle biopsy in 4, posterior lumbar interbody fusion and pedicle screw fixation in 3, fracture reduction and pedicle screw fixation in 2, discectomy in 2 patients, and vertebral subtotal resection and pedicle screw fixation, posterior decompression of the spinal canal and pedicle screw fixation, posterior decompression of the spinal canal, extreme lateral interbody fusion, and drainage of an abscess in 1 patient each.

Intraoperative LA bleeding was found in 7 patients, of whom 6 presented with surgical field bleeding and 1 showed acute hypotension. During the postoperative period, from 1 day to 6 months, an ILAI was diagnosed in 19 patients, including

12 with a LA pseudoaneurysm. The symptoms were 10 case-times of pain exacerbation (back pain, lower back pain, abdominal pain, and groin pain), 6 case-times of anemia, 4 case-times of hypotension, 3 case-times of lower limb neural symptoms, 2 case-times of incision bleeding and hematoma, 1 case-time of shock and retroperitoneal hematoma, 1 case-time of hyperpyrexia, 1 case-time of a paravertebral mass, 1 case-time of a psoas hematoma, 1 case-time of dizziness, and 1 asymptomatic case that was diagnosed by repeat computed tomography (CT) examination.

The diagnostic methods included CT and/or contrast-enhanced CT in 11 patients, selective angiography in 7 patients, CT angiography in 4 patients, magnetic resonance imaging in 3 patients, and autopsy in 1 patient. The causes of ILAI were as follows: puncture injury in 9 patients, transforaminal endoscopic operation in 5 patients, pedicle screw injury in 3 patients, intervertebral foramen decompression in 2 patients, disc rongeur injury during discectomy in 2 patients, LA tear caused by a transverse process fracture in 1 patient, vertebral fracture restoration in 1 patient, retractor injury in 1 patient, cage insertion or pedicle screw injury in 1 patient, and drainage tube stimulation in 1 patient.

The left affected LA was included 12 patients, including the second LA in 5, the third LA in 4, the fourth LA in 2, and the first LA in 1 patient. The right affected LA was included 12 patients, including the fourth LA in 5, the third LA in 4, the second LA in 2, and the fifth LA in 1 patient. In addition, the right or left LA was not confirmed in 2 patients.

The treatment methods included transarterial embolization (TAE) in 20 patients, percutaneous embolization in 2, surgical ligation in 1, and steroid and cyclophosphamide treatment in 1 patient, all of whom were treated successfully. One patient died during antishock therapy, and another patient died because her family refused any further intervention.

DISCUSSION

During PVP/PKP and vertebral biopsy, both transpedicular and extrapedicular puncture can damage the LA. During transpedicular puncture, attention should be given to whether the front of the puncture needle breaks through the vertebral cortex.[19] The extrapedicular puncture technique carries a greater risk of LA injury owing to the LA distribution in the lateral sides of the vertebral body and the intersegmental branches coming from the upper LA on the lateral side of the basal pedicle[11,18,29] (**Figure 1A** and **B**). Heo and Cho[18] reported an extrapedicular PVP for a patient in L2 who complained of postoperative radiation pain, numbness, and tingling in the left leg. A CT scan showed a large retroperitoneal hematoma, and angiography confirmed that the left second LA was bleeding, which was successfully embolized. Biafora et al.[11] reported an extrapedicular PKP in L5 for treatment of a compressive fracture and hemorrhaging from the incision on postoperative day 10. Selective angiography confirmed the existence of an intersegmental branch from the right fourth LA, and the hemorrhage was successfully controlled by embolization. During transpedicular puncture, the

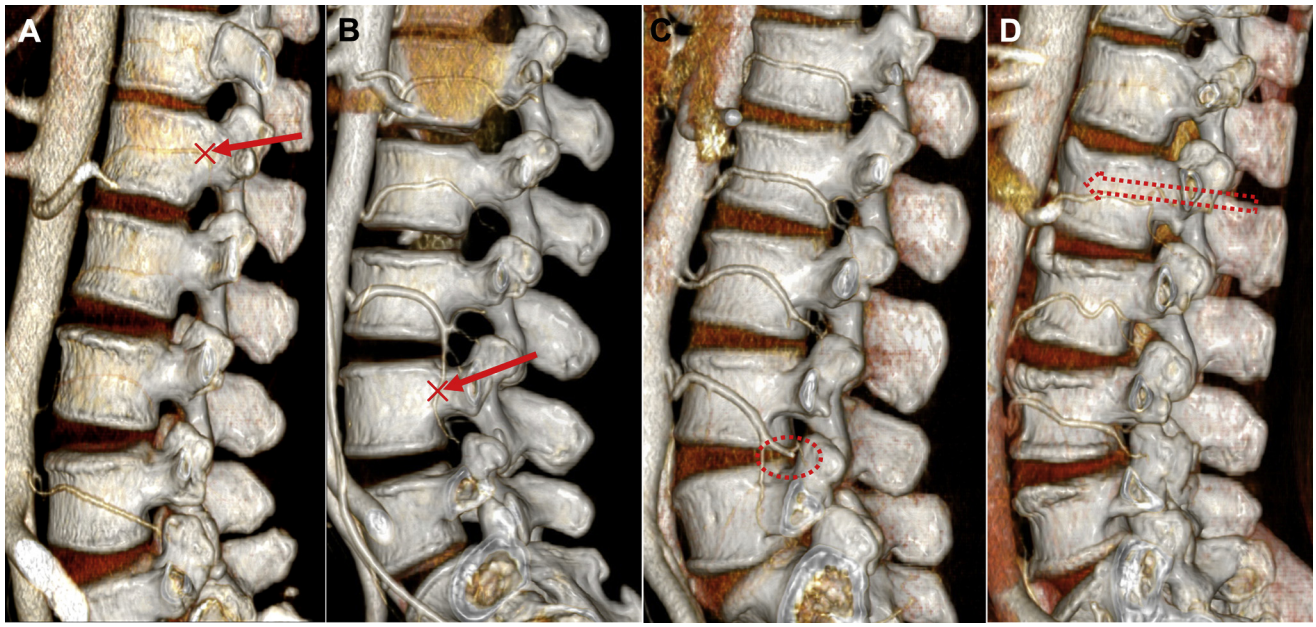

Figure 1. Illustrative drawings of iatrogenic lumbar artery injury caused by an extrapedicular puncture, transforaminal endoscopic surgery, and a pedicle screw. (**A**) A lumbar artery (LA) located at the extrapedicular puncture approach in L1. *Red arrow* indicates extrapedicular puncture path; *red* ×, the puncture point of the vertebral body. (**B**) An intersegmental branch from the third LA located at the extrapedicular puncture approach in L4. *Red arrow* indicates extrapedicular puncture path; *red* ×, the puncture point of the vertebral body. (**C**) An LA and its branches distributed in L4-L5 intervertebral foramen region. *Dotted line* indicates transforaminal endoscopic region. (**D**) An LA distributed in the lateral wall of the pedicle in L2. *Dotted line* indicates a pedicle screw outside the pedicle.

position of the puncture needle should be confirmed by fluoroscopy, especially for patients with vertebral destruction, severe osteoporosis, and/or vertebral cortical fracture. During extrapedicular puncture, determining whether the LA is distributed on the puncture path could also be necessary before surgery.

The branches of the LA can be damaged by spinal canal decompression, including central spinal canal decompression (discectomy) and nerve root canal decompression, and transforaminal endoscopic surgery. Nojiri et al.[30] studied the vertical branch of the LA in the lateral side of the intervertebral disc and found that the vertical branch of the LA across the middle one third of the intervertebral disc accounted for 3% and that across the back one third of the intervertebral disc accounted for 30%. This scenario can explain why percutaneous transforaminal endoscopic discectomy (**Figure 1C**) decompression procedures in the intervertebral foramen region, basal fracture of the transverse process, and a pedicle screw outside the pedicle can easily damage these branches. During discectomy, a disc rongeur breaking through the front of the vertebral body can damage, not only the prevertebral great vessels[31,32] but also the LA. Two cases of LA injuries were found in that study. In particular, the case reported by Ventura et al.[25] should be highly valued by every spine surgeon. They reported a patient with a lumbar disc herniation in L5-S1, who had undergone left L4-L5 half-laminectomy owing to false positioning. During the "grabbing" process in the L4-L5 intervertebral space, the right fourth LA was torn, resulting in massive retroperitoneal bleeding, shock, and the patient's death. Autopsy confirmed that the massive bleeding had been caused by iatrogenic injury of the right fourth LA. Therefore, we should emphasize that we must first ensure that the surgical site is absolutely correct. If any doubt is present, a radiograph should be taken at any point. Second, the possibility that the instrument could break through the annulus fibrosus and the anterior longitudinal ligament during the discectomy must be strictly prohibited.

A pedicle screw can damage a prevertebral vessel, such as the abdominal aorta.[33,34] In the present study, 3 cases of LA injury resulted from pedicle screws. Their commonality was that the pedicle screw was placed outside the pedicle, which damaged the branches of the LA (**Figure 1D**). Sugimoto et al.[22] reported 1 case in which pedicle screws were placed manually. On the second postoperative day, a right psoas hematoma was found on CT examination, and bleeding of the right second LA was successfully embolized. Extreme lateral interbody fusion requires the device to establish a channel; thus, the retractor could damage the adjacent LA and/or the vertical branches of the LA.[17,30] For lumbar fractures, an LA can be affected.[6] With fracture restoration, a contused LA can be torn. For patients receiving anticoagulant therapy and those with a malignant tumor, an infection, or atherosclerosis, the risk of ILAI could be increased, which might be related to abnormal blood coagulation and inflammatory changes in the vessel wall.[35,36] During implantation of a pedicle screw, the sagittal and transverse section angles and depth should be confirmed correctly using fluoroscopic guidance.

Discovering an ILAI in a timely manner is very important to guide timely treatment. If unexplained blood loss or a blood pressure decrease occurs during surgery, the surgical field should be checked carefully to ensure that the bleeding has been completely stopped. If the cause of bleeding is not found by the naked eye, the interventional department should be informed in a timely manner for selective angiography. After spine surgery, radiographic reexamination often fails to detect a psoas hematoma and retroperitoneal hemorrhage. For patients with postoperative aggravating back pain, abdominal pain, nerve symptoms of the lower limbs, anemia, hypotension, or incision bleeding, angiography should be performed as soon as possible. In the present study, the left second and the right fourth LAs were affected in 5 patients, respectively. The fourth LA was prone to injury and bleeding because of its larger diameter[37]; however, the cause of ILAI at the second LA was unclear.

For patients identified with ILAI, timely treatment is very important. TAE is a well-recognized, safe, effective, and minimally invasive treatment for LA bleeding.[7,38] In the present study, 20 patients had been successfully treated by TAE. During the surgery, ligating the affected LA was the most direct method. However, owing to the deep location of the LA, this method often does not succeed. In such cases, the surgeon must temporarily close the incision and maintain the patient in the supine position for femoral artery catheterization.[24] For patients with less bleeding, stable systemic conditions, or an unsuccessful TAE, percutaneous embolization or drug therapy were the therapeutic options.[17,20] The present study included typical cases of ILAI. Some reports related to LA injury as a surgical complication were briefly mentioned without detailed data and were not included in the present study.[39,40]

CONCLUSIONS

During spine surgery, ILAI is uncommon but can cause serious life-threatening consequences if it occurs. As surgeons, having a detailed operation plan before surgery, understanding the anatomical position of the LA, and having contingency plans to control LA bleeding are very important. Attention should be given to those surgical operations that easily cause ILAI, such as PVP/PKP, vertebral biopsy, pedicle screw implantation, discectomy, transforaminal endoscopic operation, and intervertebral foramen decompression. The position of the implant should be monitored using 3-dimensional navigation devices to ensure correct positioning. Postoperative observation should be enhanced to eliminate LA bleeding as soon as possible. Once the diagnosis of ILAI has been confirmed, selective endovascular TAE is the preferred treatment.

REFERENCES

1. Iwamoto S, Takao S, Harada M. Visualization of lumbar artery variations by contrast-enhanced multi-detector row computed tomography. *J Med Invest*. 2016;63:45-48.

2. Cho SM, Nam YS, Cho BM, Lee SY, Oh SM, Kim MK. Unilateral extrapedicular vertebroplasty and kyphoplasty in lumbar compression fractures: technique, anatomy and preliminary results. *J Korean Neurosurg Soc*. 2011;49:273-277.

3. Thomas R, Rosenthal MH, Ghouri M, Steigner ML. Infundibulum of the common origin of fourth lumbar arteries and median sacral artery [e-pub ahead of print]. *J Med Imaging Radiat Oncol*. https://doi.org/10.1111/1754-9485.12724, accessed July 30, 2018.

4. Koakutsu T, Aizawa T, Yuzawa H, Itoi E, Kushimoto S. Lumbar artery injury from which the Adamkiewicz artery originated associated with lumbar spine injury: successfully treated by transcatheter arterial embolization. *Eur Spine J*. 2016;25(suppl 1):124-128.

5. Aoki M, Tokue H, Shibuya K, Murata M, Hagiwara S, Oshima K. Transcatheter arterial embolization of a lumbar artery injury with traumatic aortic dissection. *Ann Vasc Surg*. 2017;45, 262.e11-262.e14.

6. Eun JP, Oh YM. Traumatic lumbar artery rupture after lumbar spinal fracture dislocation causing hypovolemic shock: an endovascular treatment. *Br J Neurosurg*. 2015;29:742-744.

7. Ishigaki T, Kawasaki R, Matsuda H, Mukohara N. Endovascular treatment for a ruptured lumbar artery aneurysm in a patient with von Recklinghausen disease. *EJVES Short Rep*. 2017;38:1-3.

8. Tomescot A, Dallaudiere B, Zurlinden O, Manelfe J. Lumbar artery pseudoaneurysm as a late complication of osteomyelitis with vertebral body destruction. *J Vasc Surg*. 2013;58:1084-1087.

9. Smith DW, Lawrence BD. Vascular complications of lumbar decompression laminectomy and foraminotomy: a unique case and review of the literature. *Spine (Phila Pa 1976)*. 1991;16:387-390.

10. Stevens KJ, Gregson RH, Kerslake RW. False aneurysm of a lumbar artery following vertebral biopsy. *Eur Spine J*. 1997;6:205-207.

11. Biafora SJ, Mardjetko SM, Butler JP, McCarthy PL, Gleason TF. Arterial injury following percutaneous vertebral augmentation: a case report. *Spine (Phila Pa 1976)*. 2006;31:E84-E87.

12. Dausse F, Chevallier P, Motamedi JP, Amoretti N, Cua E, Bruneton JN. Lumbar false aneurysms following image-guided interventive procedures for spondylodiskitic abscesses. *Skeletal Radiol*. 2006;35:949-952.

13. Kulkarni K, Matravers P, Mehta A, Mitchell A. Pseudoaneurysm following vertebral biopsy and treatment with percutaneous thrombin injection. *Skeletal Radiol*. 2007;36:1195-1198.

14. Domenicucci M, Ramieri A, Lenzi J, Fontana E, Martini S. Pseudo-aneurysm of a lumbar artery after flexion-distraction injury of the thoracolumbar spine and surgical realignment: rupture treated by endovascular embolization. *Spine (Phila Pa 1976)*. 2008;33:E81-E84.

15. Nijenhuis RJ, Sluzewski M, van Rooij WJ. Iatrogenic lumbar pseudoaneurysm causing dural sac compression after spine surgery. *J Neurosurg Spine*. 2009;10:585-586.

16. Karaikovic EE, Rattner Z, Bilimoria MM, Sener SF, McGee JP, Metrick LB, et al. Coil embolization of a lumbar artery to control vascular injury during intradiscal surgery. *Spine (Phila Pa 1976)*. 2010;35:E163-E166.

17. Santillan A, Patsalides A, Gobin YP. Endovascular embolization of iatrogenic lumbar artery pseudoaneurysm following extreme lateral interbody fusion (XLIF). *Vasc Endovascular Surg*. 2010;44:601-603.

18. Heo DH, Cho YJ. Segmental artery injury following percutaneous vertebroplasty using extrapedicular approach. *J Korean Neurosurg Soc*. 2011;49:131-133.

19. Puri AS, Colen RR, Reddy AS, Groff MW, DiNobile D, Killoran T, et al. Lumbar artery pseudoaneurysm after percutaneous vertebroplasty: a unique vascular complication. *J Neurosurg Spine*. 2011;14:296-299.

20. Ikeda O, Kawanaka K, Nakasone Y, Tamura Y, Yamashita Y. Direct percutaneous embolization of an iatrogenic lumbar artery pseudoaneurysm following unsuccessful coil embolization. *Acta Radiol*. 2012;53:541-544.

21. Oh YM, Choi HY, Eun JP. Delayed retroperitoneal hemorrhage due to lumbar artery pseudoaneurysm after lumbar posterolateral fusion. *J Korean Neurosurg Soc*. 2013;54:344-346.

22. Sugimoto Y, Tanaka M, Gobara H, Misawa H, Kunisada T, Ozaki T. Management of lumbar artery injury related to pedicle screw insertion. *Acta Med Okayama*. 2013;67:113-116.

23. Giordano AV, Arrigoni F, Bruno F, Carducci S, Varrassi M, Zugaro L, et al. Interventional radiology management of a ruptured lumbar artery pseudoaneurysm after cryoablation and vertebroplasty of a lumbar metastasis. *Cardiovasc Intervent Radiol*. 2017;40:776-779.

24. Álvarez Postigo M, Pizones Arce J, Izquierdo Núñez E. Lumbar segmental artery pseudoaneurysm after L5 pedicle screw placement: a rare vascular complication. *Rev Esp Cir Ortop Traumatol*. 2017;61:436-440.

25. Ventura F, Barranco R, Bernabei C, Castelletti L, Castellan L. A fatal and unusual iatrogenic fourth right lumbar artery injury complicating wrong-level hemilaminectomy: a case report and literature review. *Br J Neurosurg*. 2017;7:1-3.

26. Chen SB, Yu XX. Lumbar artery embolization for the treatment of massive hemorrhage caused by percutaneous transforaminal endoscopic discectomy: preliminary experience in 4 patients. *J Intervent Radiol*. 2017;26:1033-1037.

27. Ntourantonis D, Tsekouras V, Korovessis P. Delayed fatal lumbar artery bleeding following less invasive posterolateral decompression and fusion. *Spine (Phila Pa 1976)*. 2018;43:E976-E979.

28. Wang Y, Ai P, Zhan G, Shen B. Lumbar artery injury during transforaminal percutaneous endoscopic lumbar discectomy: successful treatment by emergent transcatheter arterial embolization. *Ann Vasc Surg*. 2018;53:267.e11-267.e14.

29. Liu L, Cheng S, Lu R, Zhou Q. Extrapedicular infiltration anesthesia as an improved method of local anesthesia for unipedicular percutaneous vertebroplasty or percutaneous kyphoplasty. *Biomed Res Int*. 2016;2016:5086414.

30. Nojiri H, Miyagawa K, Banno S, Sakamoto I, Koike M, Sawa M, et al. Lumbar artery branches coursing vertically over the intervertebral discs of the lower lumbar spine: an anatomic study. *Eur Spine J*. 2016;25:4195-4198.

31. Kim DH, Kim TW, Kim MK, Park KH. Iatrogenic vascular injury occurring during discectomy in a spondylodiscitis patient. *Korean J Neurotrauma*. 2016;12:171-174.

32. Busardò FP, Frati P, Carbone I, Pugnetti P, Fineschi V. Iatrogenic left common iliac artery and vein perforation during lumbar discectomy: a fatal case. *Forensic Sci Int*. 2015;246:e7-e11.

33. Blocher M, Mayer M, Resch H, Ortmaier R. Leriche-like syndrome as a delayed complication following posterior instrumentation of a traumatic L1 fracture: a case report and literature review. *Spine (Phila Pa 1976)*. 2015;40:E1195-E1197.

34. Mirza AK, Alvi MA, Naylor RM, Kerezoudis P, Krauss WE, Clarke MJ, et al. Management of major vascular injury during pedicle screw instrumentation of thoracolumbar spine. *Clin Neurol Neurosurg*. 2017;163:53-59.

35. Tulamo R, Frösen J, Hernesniemi J, Niemelä M. Inflammatory changes in the aneurysm wall: a review. *J Neurointerv Surg*. 2018;10(suppl 1):i58-i67.

36. Nishihara M, Aoki H, Ohno S, Furusho A, Hirakata S, Nishida N, et al. The role of IL-6 in pathogenesis of abdominal aortic aneurysm in mice. *PLoS One*. 2017;12:e0185923.

37. Beveridge TS, Power A, Johnson M, Power NE, Allman BL. The lumbar arteries and veins: quantification of variable anatomical positioning with application to retroperitoneal surgery. *Clin Anat*. 2015;28:649-660.

38. Ito T, Ishikawa E, Ito M. Lumbar artery injury following renal biopsy. *Clin Exp Nephrol*. 2016;20:145-146.

39. Abe K, Orita S, Mannoji C, Motegi H, Aramomi M, Ishikawa T, et al. Perioperative complications in 155 patients who underwent oblique lateral interbody fusion surgery: perspectives and indications from a retrospective, multicenter survey. *Spine (Phila Pa 1976)*. 2017;42:55-62.

40. Sato J, Ohtori S, Orita S, Yamauchi K, Eguchi Y, Ochiai N, et al. Radiographic evaluation of indirect decompression of mini-open anterior retroperitoneal lumbar interbody fusion: oblique lateral interbody fusion for degenerated lumbar spondylolisthesis. *Eur Spine J*. 2017;26:671-678.

Conflict of interest statement: The authors declare that the article content was composed in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Received 9 September 2018; accepted 29 October 2018

Citation: World Neurosurg. (2019) 122:266-271.
https://doi.org/10.1016/j.wneu.2018.10.219

Journal homepage: ***www.WORLDNEUROSURGERY.org***

Available online: ***www.sciencedirect.com***