Iatrogenic Lumbar Artery Injury in Spine Surgery: A Literature Review

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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

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

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, transfemoral 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, transfemoral endoscopic operation, and intervertebral foramen decompression. Once a diagnosis of ILAI has been confirmed, selective endovascular transarterial embolization is the preferred treatment.
<table>
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<tr>
<th>Investigator State</th>
<th>Patient Sex</th>
<th>Age (years)</th>
<th>Primary Disease</th>
<th>Operation</th>
<th>Other Indications</th>
<th>Symptom of ILAI</th>
<th>Diagnostic Point</th>
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<td>Smith et al., 1991</td>
<td>USA M 62</td>
<td>1</td>
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<td>Atherosclerosis</td>
<td>Right lower limb neural symptom, acute hypotension</td>
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<td>Conservative treatment (steroid + CP)</td>
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<td>3</td>
<td>OVCF (L5)</td>
<td>PKP (L5)</td>
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<td>Needle biopsy</td>
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<td>UK M 79</td>
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<td>Reduction + PS</td>
<td>Incision hematoma, hyperpyrexia, anemia</td>
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<td>Fracture restoration</td>
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<td>NED M 69</td>
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<td>LSS (L4–S1)</td>
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<td>Shock, retroperitoneal hematoma</td>
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<td>Retractor</td>
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<td>11</td>
<td>OVCF (L2)</td>
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<td>Backache, left lower limb neural symptom, acute hypotension</td>
<td>POD 1</td>
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<td>Left 2</td>
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<td>USA F 67</td>
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<td>PVP (L3, L4)</td>
<td>Backache, psoas hematoma</td>
<td>POD 42</td>
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<td>Anemia</td>
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<td>Ikeda et al., 2012</td>
<td>JPN M 56</td>
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<td>Infection (L2-L3)</td>
<td>Needle biopsy</td>
<td>AML</td>
<td>Low back pain</td>
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<td>Left 2</td>
<td>Puncture</td>
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<td>KOR F 55</td>
<td>15</td>
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<td>PLF + PS</td>
<td>Anticoagulant agents</td>
<td>Stomach ache, acute hypotension, anemia</td>
<td>POD 9</td>
<td>Enhanced CT</td>
<td>Right 2</td>
<td>Transverse process fracture</td>
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<td>Burst fracture (L1), CES</td>
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<td>Enhanced CT</td>
<td>Right 2</td>
<td>PS</td>
<td>TAE</td>
<td>Cured</td>
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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 transfemoral endoscopic discectomy.
<table>
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<tr>
<th>Investigator</th>
<th>State</th>
<th>Patient</th>
<th>Sex</th>
<th>Age (years)</th>
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<th>Operation</th>
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<th>Symptom of ILAI</th>
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<th>Affected LA</th>
<th>Cause of ILAI</th>
<th>Treatment</th>
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<td>ITA</td>
<td>17 M</td>
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<td>DLS (L4-L5)</td>
<td>PLIF + PS</td>
<td>Anticoagulants</td>
<td>Psoas hematoma</td>
<td>POD 7</td>
<td>Enhanced CT</td>
<td>Left 4</td>
<td>PS</td>
<td>TAE</td>
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<td>Álvarez et al.2017</td>
<td>ESP</td>
<td>19 F</td>
<td>77</td>
<td>LSS (L3-L4, L4-L5)</td>
<td>Decompression + PS</td>
<td>Kidney cancer</td>
<td>Stomach ache</td>
<td>POD 2</td>
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<td>Left 2</td>
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<td>Acute hypotension</td>
<td>POD 2</td>
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<td>PS</td>
<td>TAE</td>
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<td>CHN</td>
<td>21-24</td>
<td>2 M + 2 F</td>
<td>LDH</td>
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<td>Surgical field bleeding</td>
<td>POD 2</td>
<td>Enhanced CT</td>
<td>Right 3</td>
<td>Transforaminial endoscopy</td>
<td>TAE</td>
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<td>Transforaminial endoscopy</td>
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<td>Ntouantonis et al.27</td>
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<td>25 F</td>
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<td>Dizzy, anemia</td>
<td>POD 7</td>
<td>CTA</td>
<td>Left 3</td>
<td>Cage insertion or PS</td>
<td>Her family denied any further intervention</td>
<td>Death</td>
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<td>Wang et al.28</td>
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<td>26 F</td>
<td>84</td>
<td>LDH (L3-L4)</td>
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<td>Surgical field bleeding</td>
<td>POD 1</td>
<td>CT</td>
<td>Left 4</td>
<td>Transformional endoscopy</td>
<td>TAE</td>
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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 in 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 in 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. 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 (Figure 1A and B). Heo and Cho 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 the existence of an intersegmental branch from the right fourth LA, and the hemorrhage was successfully controlled by embolization. During transpedicular puncture, the
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 vessels33,34 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.37,38 For lumbar fractures, an LA can be affected.5 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 diameter37; 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.39,40 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, transfemoral 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


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.

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