Iatrogenic arteriovenous fistula of the iliac artery after lumbar discectomy surgery: a systematic review of the last 18 years

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Abstract: Patients with iatrogenic iliac arteriovenous fistulas (IAVFs) after lumbar discectomy surgeries (LDSs) from our hospital and the published literature were reviewed in order to better understand this clinical phenomenon. Literature from databases about iatrogenic IAVFs after LDSs were retrieved and a patient from our hospital was reviewed with emphasis placed upon the patient's clinical data. From 31 publications and studies of 44 individuals' data, the study revealed L4–L5 and/or L5–S1 intervertebral space levels were mostly involved (62.0%). Most of the patients underwent computed tomography angiography (CTA) and/or digital subtraction angiography (DSA) examinations to confirm the potential diagnosis and rule out other differential diagnosis (86.4%). Most of the patients (63.6%) developed features of high output heart failure months to years after the LDSs, and the majority of them (88.6%) were treated with endovascular repairs. An iatrogenic IAVF after an LDS is a rare occurrence; however, more attention should be paid to it for the purpose of obtaining accurate diagnosis and proper treatment.

Keywords: Iatrogenic vessel injury; arteriovenous fistula; iliac artery; endovascular treatment; lumbar disc surgery

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Introduction

An abnormal connection between an artery and a vein is defined as an arteriovenous fistula (AVF) (1). Accordingly, an iliac arteriovenous fistula (IAVF) is formed when there is an abnormal connection between an iliac artery [for instance, a common iliac artery (CIA), an internal iliac artery (IIA), or an external iliac artery (EIA)] and a vein [for instance, a common iliac vein (CIV), an internal iliac vein (IVI), an external iliac vein (EIV), or an inferior vena cava (IVC)] (2). Depending on the pathogenesis, IAVFs can be divided into two types: congenital and acquired types. A congenital IAVF is mainly caused by the congenital dysplasia of an iliac artery and a vein with subsequent formation of an IAVF (3). Meanwhile, an acquired IAVF is mainly caused by trauma, especially an iatrogenic injury (1,2).

An IAVF after a lumbar discectomy surgery (LDS) is a rare occurrence. The aim of this study was to retrospectively analyze the clinical data of a patient with IAVF after an LDS, performed in our hospital, dating between the years 2000 to 2018. In addition to that data, literature from the databases about IAVFs after LDSs were also retrieved with emphasis placed upon the patients' clinical data.

The institutional review board of our hospital agreed to this present study. This being a retrospective study, any the informed consent requirement from the patient was waived.
Material and methods

Case presentation

A 47-year-old woman was admitted with symptoms of exertional dyspnea, bilateral lower extremity edema, abdominal distention, and anorexia for more than nine months. She was diagnosed with primary pulmonary hypertension (PPH) at two other hospitals. Cardiac and pulmonary catheterizations were performed revealing increased pressure in her right heart and pulmonary arteries. Echocardiography showed an enlarged right atrium and ventricle, severe tricuspid insufficiency, and increased right ventricular systolic pressure (Figure 1A,B). After symptomatic treatments were completed, her conditions improved.

Nevertheless, the patient's symptoms deteriorated, and this prompted her to visit our hospital. Physical examination findings included raised jugular venous pulse (JVP), positive hepatojugular reflux, bilateral lower extremities edema, grade III–VI ejection systolic murmur, pulsatile mass with thrill, and a continuous bruit over her left lower abdominal quadrant. Medical history revealed an L4–L5 level LDS 9 months previous (Figure 2A,B). With a provisional diagnosis of iatrogenic vascular injury, we performed computed tomography angiography (CTA) of the thoracic aorta (TA) and abdominal aorta (AA) (Figure 3A,B,C,D) which showed AVF and pseudoaneurysm formation between the left CIA and CIV (A, red arrow), with dissection of the left CIA (A, red arrow), opacification of veins during venous phase (B,C, blue arrow), and absence of dilated vessels. CTA with volume rendering (VR) post-processing technology and digital subtraction angiography (DSA) (Figures 5,6) of the TA and AA before and after the surgery showed findings identical to those seen on Figures 3 and 4, respectively. She was discharged 1 week after the surgery with the advice of a monthly follow-up. During her 2-year period of follow-up, she was found to be doing well without any discomfort.

Literature search

Two reviewers comprehensively searched every potential publication in English on PUBMED, EMBASE, OVID, EBSCO, and Google Scholar, along with publications in Chinese on the China National Knowledge Infrastructure (CNKI), Chinese Biomedical (CBM), WanFang, and Baidu Scholar databases (Figure 7). Publication dates were restricted from January 2000 to October 2018, and papers employing posterior surgical approaches were included while anterior surgical approaches were excluded. If there was any disagreement, it was settled through discussion and consensus.
Figure 2  Sagittal fat saturated T2-weighted MR image (A) and axial T2-weighted MR image (B) of the lumbar spine showing lumbar disc herniation at the level of L4–L5 (A and B, white arrow). An incidental sacral canal cyst (A, black arrow) is also noted.

Figure 3  CTA done 3 days before the endovascular repair shows AVF and pseudoaneurysm of left CIA and CIV (A, red arrow) along with left CIA dissection (B, yellow arrow). Arterial phase opacification of veins and dilated vessels (B,C,D, blue arrow) were also noted. CTA, computed tomography angiography; AVF, arteriovenous fistula; CIA, common iliac artery; CIV, common iliac vein.
Figure 4 AA CTA 6 days after the endovascular repair reveals complete resolution of the AVF, pseudoaneurysm, and dissection (A, red arrow). Opacification of veins during the venous phase rather than the arterial one (B, C, blue arrow) and absence of dilated veins are also noted. CTA, computed tomography angiograph; AVF, arteriovenous fistula.

Figure 5 CTA with VR (A) and DSA (B) before endovascular repair showing AVF and pseudoaneurysm of the left CIA and CIV. Also seen are the arterial phase opacification of veins and dilated vessels (including pelvic and subcutaneous veins of anterior-inferior abdominal wall; A, blue arrow). CTA, computed tomography angiograph; DSA, digital subtraction angiography; AVF, arteriovenous fistula; AA, abdominal aorta; IVC, inferior vena cava; CIA, common iliac artery; CIV, common iliac vein.

The following literature retrieval strategy was used separately or in combination with the PUBMED database:

(I) (“Disc” OR “Lumbar disc” OR “Lumbar intervertebral disc” OR “Disc herniation” OR “Lumbar disc herniation” OR “Lumbar intervertebral disc herniation” OR “Disc prolapse” OR “Lumbar disc prolapse” OR “Lumbar intervertebral disc prolapse” OR “Disc surgery” OR “Lumbar disc surgery” OR “Disc herniation surgery” OR “Lumbar disc herniation surgery” OR “Lumbar intervertebral disc surgery” OR “Disc prolapse surgery” OR “Lumbar discectomy” OR “Surgery” OR “Discectomy”);

(II) (“Iatrogenic” OR “Iatrogenic trauma” OR “Iatrogenic injury” OR “Vascular injury” OR “Vascular trauma” OR “Iatrogenic vascular trauma” OR “Iatrogenic vascular injury” OR “Perforation” OR “Laceration” OR “Fistula” OR “Arteriovenous fistula” OR “Pseudoaneurysm” OR “Dissection” OR “Trauma” OR “Injury”);

(III) (“Lumbar” OR “Spine” OR “Spinal”);

(IV) (I) AND (II) AND (III).

The reference list from the retrieved papers was also crosschecked for overlooked articles. Language of the publications was not restricted, but the publication date was restricted to between January 2000 and October 2018.
Figure 6 CTA with VR (A) and DSA (B) after endovascular repair showing 2 stents (24 mm × 120 mm and 14 mm × 100 mm, respectively; XJZDF-24120 and XJZDZ-24040, ANKURA, LifeTech Scientific Corporation, Shenzhen City, Guangdong, China) placed at right and left CIA and extending up to the AA below the origin of renal arteries. Complete resolution of AVF, pseudoaneurysm, and dissection with absence of dilated veins can be noted in the images. CTA, computed tomography angiograph; DSA, digital subtraction angiography; AA, abdominal aorta; CIA, common iliac artery; SG, stent grafts.

Figure 7 Flowchart and outcomes of the literature retrieval.

Choice of this time window was based on the following two reasons: (I) there was a review on this topic published in 2002 by Papadoulas et al. (1). In that paper, the authors gave a general review of vascular injury complications of LDS (including laceration, AVF, and pseudoaneurysm), but the complication of IAVF after an LDS was not comprehensively or specifically treated. Thus, the authors of this present study wanted to update that 2002 article with emphasis placed upon the complication of IAVF only; (II) the increasing application of endovascular repair technology for the treatment of IAVF after an LDS had begun only since 1995 in which only a few cases with IAVFs after LDSs were included in the paper by Papadoulas (1).
Data extraction

For each included study, the following clinical data were collected: first author, year of publication, gender and age of the patient, level of disc space involved, time interval, clinical presentations, diagnostic tool, pathology, site of the AVF, method of repair, device chosen, IIA embolization, results after the repair, complications after the repair, and period of follow-up.

Statistical analysis

Because not all of the clinical data mentioned above might be collected from each publication included in this study, percentage representation (%) was calculated from all the collected clinical data.

Results

Publication description

Thirty-one publications were ultimately (4-20) included in this study (21-34). Twenty-nine were published in English while 2 were published in Chinese (9,20). There were 44 patients enrolled; 26 (59.1%) were men and 17 (38.6%) were women. However, Bingol et al. did not report the patient's gender in their study (6). The mean age of the patients were 42 years old, with a range of 17 to 75 years old.

Level of disc space involved

The levels of disc space involved are as following: involvement of only L3–L4 disc space occurred in 1 patient (2.3%), L4–L5 in 18 patients (40.9%), and L5–S1 in 4 patients (9.1%), while both L4–L5 and L5–S1 disc spaces were involved in 6 patients (13.6%). However, the remaining 15 patients' disc space involvements were not reported (4,5,10,17,22,25,33).

Time interval

The time interval between the LDS and recognition of the IAVF in the patients are as follows: less than 24 hours in 4 patients (9.1%), from 24 hours to 1 week in 3 patients (6.8%), from 1 week to 1 month in 9 patients (20.5%), from 1 month to 1 year in 15 patients (34.1%), and more than 1 year for 13 patients (29.5%), while the longest time interval among all the patients was 17 years (2.3%) (15).

Clinical presentation

The common clinical findings were abdominal bruits (24 patients, 60.0%), dyspnea (10 patients, 25.0%), tachycardia (9 patients, 22.5%), edema of the bilateral lower extremities (8 patients, 20.0%), cardiac murmur (8 patients, 20.0%), abdominal thrill (7 patients, 17.5%), jugular venous distension (6 patients, 15.0%), left leg edema (6 patients, 15.0%), and decreased hemoglobin level (6 patients, 15.0%). Characteristics and clinical presentations of the included 44 patients are summarized in Table S1 and Table 1 respectively.

Diagnostic tool

Diagnostic tools used for the diagnosis of iliac AVFs complicating LDSs include color duplex ultrasonography (CDUS), CTA, magnetic resonance angiography (MRA), and DSA examinations. Among the diagnostic tools listed above, both CTA and DSA were used in 22 patients (50.0%); DSA was used in only 8 patients (18.2%); CTA, MRA, and DSA were used in 2 patients (4.5%); both MRA and DSA were used in 1 patient (2.3%); CDUS, CTA, and DSA were used in 2 patients (4.5%); both CDUS and CTA were used in 1 patient (2.3%); both CDUS and DSA were used in 1 patient (2.3%); and CTA alone was used in 8 patients (2.3%). However, diagnostic tools for 6 patients were not reported by their authors (13.6%) (33).

Pathology

Twenty-six patients were diagnosed as iliac AVFs only (59.1%), 16 as iliac AVFs with pseudo aneurysms (36.4%), 1 patient as iliac AVF with pseudo aneurysm and thrombus formation (2.3%), and 1 patient as iliac AVF with pseudoaneurysm and traumatic dissection of the left CIA (2.3%).

Sites of the AVFs

Vessels involved included the CIA, CIV, IVC, IIA, and IIV. Among the arteries and veins listed above, right CIA-right CIV AVFs occurred in 19 patients (43.2%), right CIA-left CIV AVFs occurred in 7 patients (15.9%), left CIA-left CIV AVFs occurred in 7 patients (15.9%), right IIA-right IIV AVFs occurred in 2 patients (4.5%), right CIA-IVC AVFs occurred in 2 patients (4.5%), and left CIA-IVC AVF occurred in only 1 patient (2.3%). However, the sites of AVF in 6 patients were not reported by their authors (13.6%) (33).
Methods and devices

Four patients with AVFs were treated with traditional open surgical repair method (9.3%) (5,6,28) while 39 patients underwent endovascular repair (90.7%). However, Mihmanli et al. (10) did not report the method of repair for the patients in their study. Sixty-two percent of the authors (n=24) reported the specific devices used for repair of AVF that varied from manufacturer to manufacturer. Details of the methods and devices are listed in Table S1.

Results and follow-ups

During the period of the follow-ups, most of the patients (97.7%) had benefited from the endovascular repair method achieving good resolutions or significant improvements without any significant complications. As for the duration of follow-up, the shortest was 3 weeks (n=1) (7), and the longest was 15 years (n=1) (33). Most of the patients were followed up for months to years (n=36).

Discussion

Prevalence

Iatrogenic vascular injury complications (including laceration, AVF, and pseudo aneurysm) after LDS may potentially be source of medical dispute between doctors and patients. This makes it difficult for it to be comprehensively reported in the literature. Furthermore, some patients suffering from vascular complications might not have any symptoms or symptoms may be present after a long time. As a result, the prevalence of iatrogenic vascular injury complications (including laceration, AVF, and pseudo aneurysm) after LDS is not clear. Nevertheless, Anda et al. (35) reported that it might vary between 1 and 5 per 10,000 LDSs. However, after retrospectively analyzing the clinical data in their institution, during the period from 1990 to 2001, Papadoulas et al. (1) stated that the prevalence of an iatrogenic vascular injury complicating with an LDS was 4 per 10,000. The prevalence of iatrogenic AVF of the iliac artery after an LDS is not clear either. In the same study by Papadoulas et al. (1), after reviewing the publications retrieved from the MEDLINE database, during the period from 1965 to 2001, they only found 66 cases reported.

This present study reports a case of iatrogenic AVF of the iliac artery after an LDS from China, which can be added to the world literature. Also, the authors of this study performed a comprehensive literature retrieval in the databases (e.g., PUBMED, EMBASE, OVID, et al.), and found a few published cases of iatrogenic AVFs of the iliac arteries complicating with LDSs. However, in contrast to the cases published in the databases mentioned above, the

### Table 1 Clinical presentations of the 40 included with IAVF

<table>
<thead>
<tr>
<th>Clinical presentation</th>
<th>N=40*</th>
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<tbody>
<tr>
<td>Abdominal bruit</td>
<td>24 (60.0)</td>
</tr>
<tr>
<td>Dyspnea</td>
<td>10 (25.0)</td>
</tr>
<tr>
<td>Tachycardia</td>
<td>9 (22.5)</td>
</tr>
<tr>
<td>Bilateral lower limb swelling</td>
<td>8 (20.0)</td>
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<tr>
<td>Murmur over the precordium</td>
<td>8 (20.0)</td>
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<tr>
<td>Thrill</td>
<td>7 (17.5)</td>
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<tr>
<td>Jugular venous distension</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td>Left leg edema</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td>Hemoglobin level decreased</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td>Right leg edema</td>
<td>6 (15.0)</td>
</tr>
<tr>
<td>Abdominal distention</td>
<td>5 (12.5)</td>
</tr>
<tr>
<td>Exertional dyspnea</td>
<td>5 (12.5)</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>4 (10.0)</td>
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<tr>
<td>Hepatomegaly</td>
<td>4 (10.0)</td>
</tr>
<tr>
<td>Hypotension</td>
<td>4 (10.0)</td>
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<tr>
<td>Lower limb pain</td>
<td>4 (10.0)</td>
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<tr>
<td>Lung rales</td>
<td>4 (10.0)</td>
</tr>
<tr>
<td>Orthopnea</td>
<td>4 (10.0)</td>
</tr>
<tr>
<td>Ascites</td>
<td>3 (7.5)</td>
</tr>
<tr>
<td>Palpitation</td>
<td>2 (5.0)</td>
</tr>
<tr>
<td>Varicose veins</td>
<td>2 (5.0)</td>
</tr>
<tr>
<td>Dizziness</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Abdominal discomfort</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Right heart failure</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Facial edema</td>
<td>1 (2.5)</td>
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<tr>
<td>Irregular heart rate</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Pain in the right iliac area</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Prominent right femoral pulse</td>
<td>1 (2.5)</td>
</tr>
<tr>
<td>Paroxysmal nocturnal dyspnea</td>
<td>1 (2.5)</td>
</tr>
</tbody>
</table>

* clinical presentations for four patients were not reported (5). IAVF, iliac arteriovenous fistula.
patient concerned in this present study suffered from AVF, pseudo aneurysm, and traumatic dissection of the left CIA at the same time, which to the author's knowledge, is much more complex than the other published cases. As a result, it was not reported until now.

Risk factors
An iatrogenic vascular injury complication after an LDS is rare, but when it does occur, it can lead to life-threatening results. Therefore, it is important to identify the potential risk factors carefully before an LDS. The main risk factors are summarized as follows: (I) previous history of abdominal or lumbar intervertebral disc surgery which can cause adhesions between the lumbar vertebral bodies and the retroperitoneal vessels (36); (II) chronic disc diseases, for example, degeneration or disruption of the peridiscal fibrosis, anterior longitudinal ligament, or anterior annulus fibrosus (37); (III) inappropriate operation; especially inappropriate deep intrusion of the pituitary rongeur (38); (IV) inappropriate posture of patients (39); (V) pillows placed under the abdomen in the prone position while performing the procedure, which may decrease the distance between the operated disc and the retroperitoneal vessels lying in front of the disc (40); and (VI) anomalies of a lumbar vertebral body, such as a hypertrophic spur which may compress retroperitoneal vessels during the procedure (41). The patient reported from our hospital seems to not have any potential risk factors as listed above.

Clinical presentations and its pathogenesis
Anatomy plays an important role in the occurrence of IAVF after an LDS. The AA and IVC usually course along the left and right side of the spine respectively. At the middle level of the 4th lumbar vertebra, or occasionally at its inferior border, the AA branches off to the left and right CIA, which continues off the left and right internal and external iliac arteries. The common iliac veins at that level combine to form the IVC. Therefore, there is a wide vascular bed in front of the lumbar spine that is separated from each other by the anterior longitudinal ligament only. As a result, IAVFs may occur as complications of LDSs when the anterior longitudinal ligaments and the adjacent arteries and veins are perforated by instruments of the disc space, usually by a pituitary rongeur and a screw.

Vascular injury complications during LDSs are usually thought to be related with the level of lumbar intervertebral disc space. Generally, injury of the AA and IVC occur at the level of the L3–L4 intervertebral disc spaces, while the iliac arteries and veins may occur at the level of the L4–L5 and L5–S1 intervertebral disc spaces. Other vessels injured at this level, such as the internal iliac vessels (16,27), superior mesenteric artery (42), inferior mesenteric artery (32,42), superior rectal artery (43), median sacral artery (44), and L4 lumbar artery (32,42), have also been reported. The vessels affected the most during LDSs appeared to be the right common iliac arteries (1,42).

In the 44 patients with IAVFs, the top 3 most common IAVFs were right CIA-right CIV (43.2%), right CIA-left CIV (15.9%), and left CIA-left CIV (15.9%) AVFs. The patient in our study was operated at the level of the L4–L5 intervertebral disc space, causing injury to the left CIA-CIV and leading to the formation of an AVF between them along with a pseudoaneurysm and dissection of the left CIA.

When AVFs are formed between the iliac arteries and adjacent veins, abnormal channels of left to right shunts are built locally. Blood flow occurs from high-pressure vessels, e.g., iliac arteries, to vessels with low-pressure, e.g., other veins, resulting in increased blood volume in the IVC, right atrium, and ventricle. Long-term volume overload in the right heart may result in pulmonary hypertension and subsequently right ventricular hypertrophy, right heart failure, and systemic venous congestion. After that, symptoms and signs of high output heart failure, for example, enlargement of the jugular veins, hepatomegaly, enlargement of the visceral veins (e.g., superior and IVC, hepatic, pelvic floor veins, etc.), ascites, bilateral lower extremities edema, dyspnea on exertion, and cardiac murmur can occur. Also, some patients may present with abdominal masses with or without thrill on palpation, and continuous vascular bruits over the abdomen on auscultation (1,2).

The main clinical manifestations of this series of patients were bruits over the abdomen (60.0%), dyspnea (25.0%), tachycardia (22.5%), edema of the bilateral lower extremities (20.0%), cardiac murmur (20.0%), abdominal thrill (17.5%), distension of the jugular veins (15.0%), and edema of the left leg (15.0%).

Diagnosis and differential diagnosis
After exclusion of any heart, lung, and vascular disorders in a patient with history of an LDS and features of high output heart failure, abdominal mass with or without thrill on palpation, and continuous vascular bruit over the abdomen
on auscultation, iatrogenic IAVF should be kept in mind.

Medical imaging examinations, such as CDUS, CTA, MRA, and DSA each plays an important role in the diagnosis, differential diagnosis, and follow-up of an iatrogenic IAVF. As were shown in the 44 patients included in this paper, CTA and/or DSA combined with or without other investigations (CDUS and MRA) were the first choices for IAVF. CTA can demonstrate the site, size, anatomical relationship between the artery and vein of an AVF accurately. Any secondary changes (e.g., thrombus formation) and/or presence of other types of vascular lesions (e.g., pseudo aneurysm or dissection) can also potentially be detected through CTA. Post-processing technologies of CTA examinations, for example, multiple plane reconstruction (MPR), curve plane reconstruction (CPR), maximum intensity projection (MIP), or volume rendering (VR), are also added benefits of CTA (45). As a result, more information and details can be provided by CTA examinations, which is why clinicians can utilize CTA to plan surgeries and evaluate the potential risks. On the other hand, although being an invasive procedure, DSA examinations are still considered a gold standard for the diagnosis of AVFs, while importantly rendering treatment at the same time. However, comparative advantage MRA possesses over CTA and DSA are that it is non-ionizing radiation, non-invasive, and has low risks of contrast-related complications in evaluating patients with AVFs (46-48). Thus, MRA is particularly helpful to patients with chronic renal disease, young or pregnant subjects, and those who require frequent examinations (without contra-indications and non-compatible stent-grafts) (46-48).

When it comes to the differential diagnosis, deep vein thrombosis, pulmonary embolism, non-high output heart failure, primary pulmonary hypertension, and some other common diseases that may originate from the heart, lung, and vascular regions, should be taken into consideration (1,2,49). Overall, a careful inquiry of the medical history, comprehensively performed physical examination, and the reasonably selected above-mentioned imaging modalities, are helpful in the formulation of diagnosis and ruling out other differential diagnoses.

The patient in this present study was finally confirmed as an iatrogenic IAVF after an LDS which was based on the following facts: (I) clinical manifestations of high output heart failure; (II) clear medical history of LDS; (III) CTA and DSA examinations confirming the diagnosis and ruling out other differential diagnoses; (IV) the patient doing well after the endovascular stent-graft placement surgery, even during the two-year period of follow-up; and (V) a few case reports in the literature with conditions similar to the patient in this study.

Treatment

Treatment choice may mainly focus on the traditional open surgical repair and relatively new endovascular repair technologies, which may depend on the type of the injury and some other clinical situations (1,2,49,50). Traditional open surgical repairs may include excision with end-to-end anastomosis, interposition grafting, suturing from within the vessel, endovascular embolization, ligation, patch angioplasty, and primary suturing (1,2,49,50).

Generally, traditional open surgical repairs may have the disadvantages of greater trauma, increased bleeding, prolonged operation duration, a much higher incidence of complications and mortality when compared with endovascular repairs (1,2,49,50). Thus, only a small number of patients with IAVFs underwent traditional open surgical repairs (1,2,49,50). The patient in our study did not experience any procedure related morbidity or mortality; however, reported operative mortality rates range from 5% to 10% (5). On the contrary, there are more surgeons and patients willing to select endovascular repairs as the treatment method. Since it was first introduced to treat a case of a common iliac artery-to-inferior vena cava fistula successfully by Zajko et al. in 1995 (51), endovascular repair has been widely used in the treatment of an IAVF after an LDS (1,2,49,50).

There were 4 patients who were treated with traditional open surgeries (9.3%) (5,6,28), and thirty-nine patients who were treated with endovascular repair methods (90.7%). IIA embolization may also be needed to prevent the circulation from contralateral IIA or other collateral pathways in the case of involved internal iliac artery (type II endoleak) (47,52-54). However, there were only three patients who were treated with IIA embolization (right IIA) in combination with endovascular repair for AVFs (7.7%, 3/39) (4,18,31). Hence, broadly speaking, the endovascular methods that may be performed during the repair may include placement of a covered-stent graft at the arterial or venous site, embolization of the affected vessel, a or combination of these approaches (7,55). As for the outcomes, although duration of the follow-ups between the publications were not consistent with each other, most patients had achieved resolution or significant improvements, and there were no significant complications.
that were reported which indicated that endovascular repair technology can be an ideal treatment of choice for selected patients with IAVFs after LDSs.

**Iatrogenic IAVF vs. AVF occurrence in other positions**

Except for the iatrogenic IAVFs associated with LDS, there are some other iatrogenic AVFs, which may be encountered when medical activities are performed. The medical activities may include transradial and transfemoral artery coronary angiography surgeries (radial and femoral AVFs), total ankle and knee arthroplasty surgeries (ankle and knee AVFs), left atrial appendage surgeries (renal AVFs), pacemaker implantation surgeries (axillary AVFs), breast core-biopsies (axillary AVFs), coronary artery bypass grafting surgeries (aortocoronary AVFs), and others (Table S2) (56-66), even though they have different clinical backgrounds. This present study reports a case of iatrogenic AVF of the iliac artery after an LDS, indicating it is another source of iatrogenic AVF in the clinical practice. Thus, it can be added to the world literature.

Among the iatrogenic AVFs listed above (Table S2) (56-66), the radial and femoral AVFs each has a relatively higher prevalence. According to the documents, patients who underwent cardiac catheterization may suffer from femoral AVFs at a rate of 0.0–0.08% (67,68), whereas radial AVFs have a rate of 0.0–0.03% (69,70). This is why the transradial approach to percutaneous coronary angiography and coronary intervention has gained its popularity among the interventional cardiologists (71). When compared with iatrogenic IAVFs complicated with LDSs, iatrogenic radial and femoral AVFs have the following clinical characteristics: (I) iatrogenic radial and femoral AVFs locate at the body surface, which makes symptoms of pulsatile masses and murmurs on the intervention site be relatively more easy to detect than IAVFs (64); (II) diagnosis of iatrogenic radial and femoral AVFs is mostly performed with CDUS, and DSA is used for definitive diagnosis (64); and (III) as for the treatments, traditional open surgical repair technologies are mostly used for symptomatic iatrogenic radial and femoral AVFs, while conservative treatments can be used for the asymptomatic ones (72-74).

**Conclusions**

An iatrogenic IAVF after an LDS is a rare occurrence; however, more attention should be paid to it for the purpose of obtaining accurate diagnosis and proper treatment.

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**Footnote**

**Conflicts of Interest:** The authors have no conflicts of interest to declare.

**References**


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<th>Author</th>
<th>Reference</th>
<th>Year</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Clinical presentations</th>
<th>Diagnostic tool</th>
<th>Pathology</th>
<th>Site</th>
<th>Treatment</th>
<th>Device</th>
<th>Result</th>
<th>Complications</th>
<th>Follow-up</th>
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<tbody>
<tr>
<td>Cai et al. (2021)</td>
<td>51</td>
<td>Female</td>
<td>38</td>
<td>3 months</td>
<td>Lower abdominal pain</td>
<td>CTA; DSA</td>
<td>Right CIA-right CIV</td>
<td>SG</td>
<td>A covered stent (Diameter of 10 mm × 30 mm, 10 mm × 50 mm, respectively; Boston Scientific, Galway, Ireland)</td>
<td>Resolution</td>
<td>None</td>
<td>6 months</td>
<td></td>
</tr>
<tr>
<td>Cai et al. (2021)</td>
<td>52</td>
<td>Female</td>
<td>43</td>
<td>2 days</td>
<td>Pain in the right iliac area</td>
<td>CTA; DSA</td>
<td>Right CIA-right CIV</td>
<td>SG</td>
<td>A covered stent (Diameter of 10 mm × 30 mm, 10 mm × 50 mm, respectively; Boston Scientific, Galway, Ireland)</td>
<td>Resolution</td>
<td>None</td>
<td>6 months</td>
<td></td>
</tr>
<tr>
<td>Cai et al. (2021)</td>
<td>53</td>
<td>Female</td>
<td>50</td>
<td>6 months</td>
<td>Shortness of breath and tachycardia</td>
<td>CTA; DSA</td>
<td>Right CIA-right CIV</td>
<td>SG</td>
<td>A covered stent (Diameter of 10 mm × 30 mm, 10 mm × 50 mm, respectively; Boston Scientific, Galway, Ireland)</td>
<td>Resolution</td>
<td>None</td>
<td>6 months</td>
<td></td>
</tr>
</tbody>
</table>

*OSR, open surgical repair; NA, not available.*
<table>
<thead>
<tr>
<th>Author</th>
<th>References</th>
<th>Year</th>
<th>Gender</th>
<th>Age (years)</th>
<th>Clinical presentations</th>
<th>History</th>
<th>Diagnostic tool</th>
<th>Pathology</th>
<th>Site</th>
<th>Treatment</th>
<th>Result</th>
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</thead>
<tbody>
<tr>
<td>Moorthy</td>
<td>(56)</td>
<td>2017</td>
<td>Female</td>
<td>62</td>
<td>Asymptomatic</td>
<td>Myocardial infarction</td>
<td>US, DSA</td>
<td>AVF</td>
<td>Right radial artery and vein</td>
<td>No intervention</td>
<td>Resolution</td>
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<tr>
<td>Wooster</td>
<td>(57)</td>
<td>2017</td>
<td>Male</td>
<td>62</td>
<td>Swelling and a pulsatile mass</td>
<td>Total ankle arthroplasty</td>
<td>US</td>
<td>AVF</td>
<td>Posterior tibial artery and anterior vein</td>
<td>OP</td>
<td>Resolution</td>
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<tr>
<td>Koleilat</td>
<td>(58)</td>
<td>2017</td>
<td>Male</td>
<td>78</td>
<td>Hemarthrosis</td>
<td>Total knee arthroplasty</td>
<td>US, CTA, DSA</td>
<td>AVF</td>
<td>The above-knee popliteal artery, anterior tibial artery and their relevant veins</td>
<td>Embolization</td>
<td>Resolution</td>
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<tr>
<td>Rama-Merchan</td>
<td>(59)</td>
<td>2017</td>
<td>Female</td>
<td>86</td>
<td>NA</td>
<td>Left atrial appendage</td>
<td>DSA</td>
<td>AVF</td>
<td>The right superficial femoral artery and femoral vein</td>
<td>SG</td>
<td>Resolution</td>
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<tr>
<td>Kuklik</td>
<td>(60)</td>
<td>2018</td>
<td>Female</td>
<td>64</td>
<td>Lumbar pain and micro-hematuria</td>
<td>Clear cell renal carcinoma</td>
<td>US, CTA</td>
<td>Pseudo, AVF</td>
<td>Right renal artery</td>
<td>Embolization</td>
<td>Resolution</td>
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<tr>
<td>Gupta</td>
<td>(61)</td>
<td>2018</td>
<td>Male</td>
<td>76</td>
<td>Swelling of the left upper limb</td>
<td>Pseudocyst, palpable mass</td>
<td>DSA</td>
<td>AVF</td>
<td>Left axillary artery and vein</td>
<td>SG</td>
<td>Resolution</td>
</tr>
<tr>
<td>Blanker</td>
<td>(62)</td>
<td>2018</td>
<td>Female</td>
<td>36</td>
<td>Lump with thrill and bruit</td>
<td>Fibroadenoma in the right breast</td>
<td>US, MRA</td>
<td>AVF</td>
<td>Right axillary artery and vein</td>
<td>OP</td>
<td>Resolution</td>
</tr>
<tr>
<td>Ffrench-Constant</td>
<td>(63)</td>
<td>2018</td>
<td>Male</td>
<td>70</td>
<td>High output cardiac failure and deteriorating renal function</td>
<td>Renal transplant</td>
<td>US, CTA, DSA</td>
<td>AVF</td>
<td>The main transplant artery and veins</td>
<td>Embolization</td>
<td>Resolution</td>
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<tr>
<td>Işık</td>
<td>(64)</td>
<td>2018</td>
<td>Male</td>
<td>59</td>
<td>Edema and murmur</td>
<td>Coronary angiography</td>
<td>US, DSA</td>
<td>AVF</td>
<td>The superficial femoral artery and vein</td>
<td>OP</td>
<td>Resolution</td>
</tr>
<tr>
<td>Akbal</td>
<td>(65)</td>
<td>2018</td>
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<td>41</td>
<td>Signs of high output right heart failure</td>
<td>Coronary angiography</td>
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<td>AVF</td>
<td>The left common iliac artery and vein</td>
<td>SG</td>
<td>Resolution</td>
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<tr>
<td>Saleh</td>
<td>(66)</td>
<td>2019</td>
<td>Female</td>
<td>35</td>
<td>Exertional angina</td>
<td>Coronary artery bypass grafting</td>
<td>DSA</td>
<td>AVF</td>
<td>Left internal mammary artery graft to the great cardiac vein</td>
<td>No intervention</td>
<td>Resolution</td>
</tr>
</tbody>
</table>

AVF, arteriovenous fistula; Pseudo, pseudoaneurysm; US, ultrasonography; CTA, computed tomography angiography; MRA, magnetic resonance angiography; DSA, digital subtraction angiography; SG, stent graft; OP, operation; NA, not available.