European Spine Journal
https://doi.org/10.1007/s00586-018-5620-2

CASE REPORT

Management of aortic injury during minimally invasive lateral lumbar interbody fusion

Michael M. Safaee[1] · Devin Zarkowsky[2] · Charles M. Eichler[2] · Murat Pekmezci[3] · Aaron J. Clark[1]

Received: 25 January 2018 / Revised: 2 April 2018 / Accepted: 29 April 2018

Abstract

Purpose Minimally invasive lateral approaches to the lumbar spine allow for interbody fusion with good visualization of the disk space, minimal blood loss, and decreased length of stay. Major neurologic, vascular, and visceral complications are rare with this approach; however, the steps in management for severe vascular injuries are not well defined. We present a case report of aortic injury during lateral interbody fusion and discuss the use of endovascular repair.

Methods This study is a case report of an intraoperative aortic injury.

Results A 59-year-old male with ankylosing spondylitis suffered an acute L1 Chance fracture after mechanical fall. He was taken to the operating room for a T10–L4 posterior instrumented fusion followed by a minimally invasive L1–L2 lateral interbody fusion for anterior column support. During the discectomy, brisk arterial bleeding was encountered due to an aortic injury. The vascular surgery team expanded the incision in an attempt to control the bleeding but with limited success. The patient underwent intraoperative angiogram with placement of stent grafts at the level of the injury followed by completion of the interbody fusion. Despite the potentially catastrophic nature of this injury, the patient made a good recovery and was discharged home in stable condition with no new neurologic deficits.

Conclusions This case highlights the importance of immediate recognition and imaging of any potential vascular injury during minimally invasive lateral interbody fusion. Given the poor outcomes associated with attempted open repair, endovascular techniques provide a valuable tool for the treatment of these complex injuries with significantly less morbidity.

Keywords Vascular injury · Minimally invasive · Lateral interbody fusion · Ankylosing spondylitis

Background and importance

Minimally invasive lateral approaches to the lumbar spine are increasing in popularity due to their ability to provide an interbody fusion with good visualization of the disk space, minimal blood loss, decreased length of stay, and obviating the need for an independent access surgeon for mobilization of the great vessels [1–3]. In addition, lateral approaches allow for placement of a more lordotic cage compared to standard posterior approaches, an effect which can be augmented with the release of the anterior longitudinal ligament. The most common technique involves a retroperitoneal transpsoas approach for exposure of the spine followed by docking with a self-retaining retractor system to allow for discectomy and placement of an interbody graft. Rates of neurologic deficits range from 1 to 5% and are generally transient, mainly related to stretching of the lumbar plexus and its nerves [4–6].

Rates of non-neurologic intraoperative complications, specifically major vascular complications, are less well defined. Based on the data from large series, the rates of major vascular injury are rare, generally less than 1% [4–6]. These vary from injuries to the segmental vessels that are managed by direct hemostasis, packing, observation and blood transfusion, or injury to the great vessels including

✉ Aaron J. Clark
Aaron.Clark@ucsf.edu

1 Department of Neurological Surgery, University of California, San Francisco, 505 Parnassus Ave. Room M779, San Francisco, CA 94143, USA

2 Division of Vascular and Endovascular Surgery, Department of General Surgery, University of California, San Francisco, 400 Parnassus Ave. Suite 501, San Francisco, CA 94143, USA

3 Department of Orthopedic Surgery, University of California, San Francisco, 1500 Owens St., San Francisco, CA 94158, USA

Published online: 07 May 2018

aorta, inferior vena cava, or iliac veins, requiring surgical repair or embolization. Given the limited number of cases presented in the literature, the appropriate management of these injuries remains poorly defined.

We present the case of a 59-year-old male with ankylosing spondylitis and an L1 Chance fracture who suffered an intraoperative aortic injury during lateral interbody fusion across the fracture site. In this case, direct open repair was not possible and the patient underwent endovascular placement of an aortic cuff graft resulting in control of the hemorrhage and a good neurologic outcome.

Clinical presentation

A 59-year-old male on aspirin with history of left middle cerebral artery stroke, diabetes, and hypertension presented to our institution with pain-limited weakness 1 day after a mechanical ground-level fall. He ambulated with a cane at baseline and on presentation was noted to have bilateral lower extremity weakness (2/5 strength by Medical Research Council (MRC) scale); however, both were significantly pain-limited. Subsequent imaging revealed ankylosing spondylitis with an acute fracture of L1 involving the inferior end plate and extending into the posterior elements with an associated 4-mm anterolisthesis of L1 on L2 (Fig. 1). There was no evidence of spinal cord compression or epidural hematoma.

He was taken to the operating room for a T10–L4 posterior instrumented fusion with gentle reduction in an attempt to reduce the spondylolisthesis and fracture [7]. Postoperative imaging revealed persistent spondylolisthesis and poor fracture reduction with a large gap (Fig. 2a). The patient was taken back to the operating room for an L1–L2 lateral interbody fusion through a right-sided approach for anterior column support [7]. The minimally invasive lateral approach was performed using the standard technique as previously described [3]. The XLIF retractor system (Nuvasive, San Diego, CA) was placed under neuromonitoring and fluoroscopic guidance. The disk space had been destroyed by the fracture and was fish-mouthed open. A Cobb elevator was used to loosen the disk under fluoroscopic guidance without violating the end plates and then removed with a pituitary rongeur. While removing a piece of disk and bone fragment there was significant bleeding concerning a major vascular injury. This was controlled with packing, and the vascular surgeon immediately called into the operating room. The incision was extended, and the 12th rib was removed. Aortic bleeding was identified, which was believed to have been caused by either a bone fragment during the initial injury, or dislodgement during the removal of disk. Intraoperative fluoroscopy demonstrated that the retractor was not placed too anterior (Fig. 2b). Dissection of the infrarenal aortic injury by the vascular surgery team was difficult due to the anatomic location of the injury and perivascular inflammation of the aorta, likely related to ankylosing spondylitis. Once exposed, direct suture repair only slowed the hemorrhage.

The wound was packed, and the patient was repositioned into the supine position. Additional fluoroscopy equipment was transported into the operating room, and the right common femoral artery was catheterized. Two Preclose sutures and a flush catheter were advanced into the thoracic aorta. A subsequent angiogram demonstrated that the patient had 2 right renal arteries and a single left renal artery; the injury was 2.5 cm distal to the lowest renal artery (Fig. 2c). Two Gore 26 mm × 4 cm aortic cuffs were deployed and covered the injured vessel segment. A completion angiogram

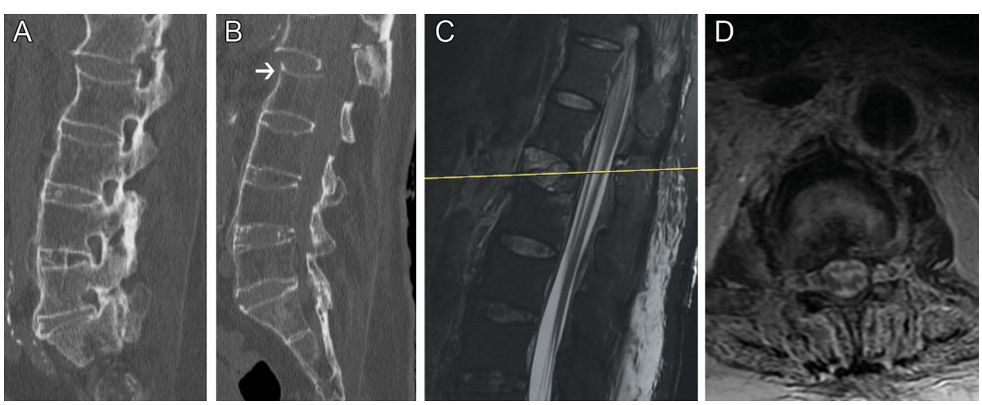

Fig. 1 Preoperative imaging of L1 Chance fracture. Sagittal CT of the lumbar spine shows evidence of ankylosing spondylitis with a fracture involving in the L1–L2 disk space and L1 pars and pedicle (**a**) with associated anterolisthesis of L1 on L2 and fractures extending through the superior end plate of L2 (white arrow) and spinous process (**b**). Sagittal T2-weighted MRI of the lumbar spine shows no canal stenosis or compression of neural elements (**c**) and demonstrates the location of the aorta with respect to the L1–L2 disk space (**d**)

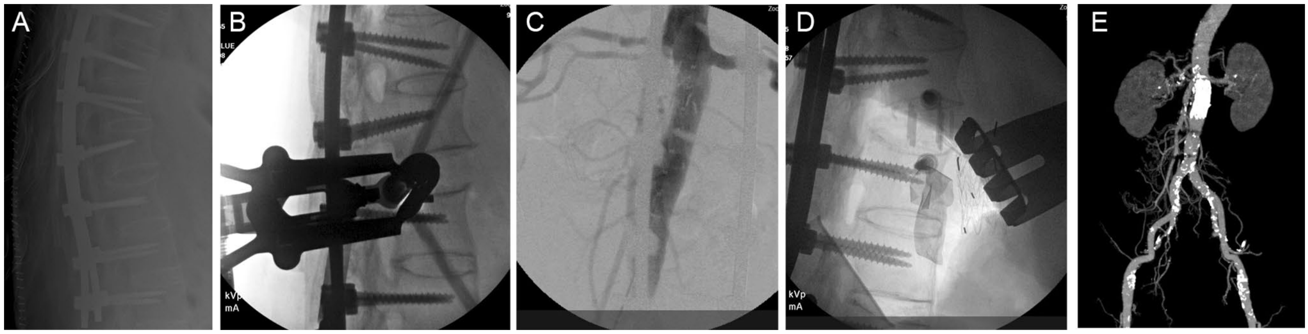

Fig. 2 Postoperative and intraoperative imaging. Postoperative lateral X-ray after T10–L4 posterior fusion shows persistent spondylolisthesis and poor fracture reduction with a large gap (**a**). Intraoperative lateral fluoroscopy shows placement of the minimally invasive retractor system at the posterior half of the L1–L2 disk space (**b**). Intraoperative angiogram showed evidence of injury 2.5 cm below the lowest renal artery (**c**). Lateral fluoroscopy shows final placement of the L1–L2 interbody cage and lateral plate with good restoration of alignment (**d**). The aortic stent graft is also visible along with a large retractor and packing sponges that were removed at the conclusion of the case. At 6-month follow-up the stent grafts were in good position with unchanged caliber and no active bleeding or complications (**e**)

demonstrated no evidence of extravasation and excellent positioning of the stent graft.

After completion of the aortic stenting the patient was returned to the lateral position. The wound was re-opened, and packing removed without significant bleeding. Lordotic spacers were introduced into the disk space, and a final intervertebral spacer packed with bone graft was inserted into the disk space. Correct position was verified by AP and lateral fluoroscopy. Integrated 20-mm screws were inserted into the L1 and L2 vertebral bodies under fluoroscopic guidance. This cage design with integrated screw provides anterior column support and additional fixation to improve the stability of the construct. The final interbody device was 18 mm which highlights the size of the gap caused by the fracture despite posterior reduction maneuvers (Fig. 2d). At 6-month follow-up the graft was in good position with no complications (Fig. 2e). All activities were approved by the Committee on Human Research, our institutional review board, and informed consent was obtained by the patient to share images from this case.

Discussion

The lateral transpsoas approach to the lumbar spine provides direct access to the disk spaces with minimal disruption of normal tissue, shorter recovery, and less blood loss compared to similar posterior approaches [5, 6]. Furthermore, the use of continuous neuromonitoring allows for the identification of a safe working corridor. The risk of nerve injury ranges from 0.7 to 5.1%, most of which result in sensory symptoms or psoas weakness and resolve spontaneously [4, 5]. Based on some reports, rates of motor deficits range from 1 to 3% with nearly all improving by 6 months [8, 9]. Vascular and visceral injuries are incredibly rare with reported rates of 0–0.1 and 0–0.08%, respectively [4–6].

Given their rarity, there is a paucity of data regarding the management of intraoperative vascular injury during lateral approaches to the lumbar spine. There are three notable reports of major vascular injury in the literature. Assina et al. reported a severe vascular injury related to lateral interbody fusion at L4–L5 resulting in lacerations of the IVC and iliac veins that ultimately resulted in a patient death [10]. That particular case was managed at 2 separate facilities; at the first institution, the lateral wound was packed with the retractor left in place and the patient kept immobilized in the left lateral position. The patient was taken to the operating room where a right femoral venogram was performed and showed occlusion of the right common iliac vein with active extravasation. The authors established balloon occlusion proximal to the extravasation, and the retroperitoneal space was accessed through a separate incision in the right lower quadrant. A large hematoma was found adjacent to the IVC, which was clamped to prevent pulmonary emboli. The retractor tip was noted to have transected the right common iliac vein and was within the lumen of the left common iliac vein. Once the retractors were removed the authors noted multiple areas of perforation along the distal IVC and a significant portion of the right common iliac vein was missing. The IVC and left common iliac defects were repaired, but the right iliac venous drainage could not be salvaged. Hemostasis was achieved, and the patient underwent bilateral lower extremity four-compartment fasciotomies. The patient had a prolonged hospital stay returning to the operating room 5 times over 4 weeks, but developed a retroperitoneal abscess and bacteremia, ultimately succumbing to multi-organ failure and septic shock.

Santillan et al. reported lumbar artery pseudoaneurysm following an L2–L3 lateral interbody fusion that was successfully embolized [11]. The patient was transferred to the author's institution 48 h after an uneventful surgery after being diagnosed with a large left retroperitoneal hematoma. Angiography revealed a pseudoaneurysm of the left L2 lumbar artery adjacent to the left lateral fixation screws consistent with a traumatic pseudoaneurysm without evidence of active extravasation. The pseudoaneurysm was successfully embolized with n-butyl cyanoacrylate (NBCA), and the patient was discharged home 2 days later.

Peiró-García et al. reported a case of delayed recognition of a vascular injury after an L3–L4 and L4–L5 lateral interbody fusion [12]. The patient presented 5 days after surgery with signs of hypovolemic shock and imaging showing a retroperitoneal hematoma. The patient underwent angiography which revealed active bleeding from a branch of the L2 segmental artery that was embolized with spheres and coils. There was a second pseudoaneurysm at the L4 segmental artery that was also embolized and occluded with fiber coils. The patient was discharged 10 days later with no neurologic complaints.

Direct injury to the adjacent vascular structures with surgical instruments is the most common mechanism of vascular injury during lateral interbody fusion; therefore, knowledge of the patient's vascular anatomy is essential during preoperative planning. Hu et al. performed an important study in which patients with non-deformed lumbar spines who underwent lateral transpsoas approach also underwent postoperative MRI [13]. The authors found that in nearly 71% of patients the vena cava would be at risk of injury using the right-sided approach, while the aorta was at risk in 29% of patients accessed from the left side. The risk of injury is obviously higher in patients with deformity, such as degenerative scoliosis, where axial rotation can shift the great vessels more posteriorly into the concave side of the deformity, or in cases of unstable fractures. The corridor used for the lateral transpsoas approach gets progressively narrower as one moves inferiorly since the great vessels move posterior and laterally, and the neural elements move anteriorly along the lateral surface of the vertebral body [14]. Using Uribe's system for identifying safe working zones for the lateral interbody fusion, the vertebral body is divided into four zones from anterior to posterior; the nerve roots are all in the most posterior quadrant at L1–L2 [15]. Based on Hu's study of postoperative MRI, when operating at L1–L2 the vena cava was only past the most anterior quadrant in 29% of cases and the aorta passed the midpoint of the pre-vertebral zone (zone A) in 2% of cases; interestingly, in our case we experienced an aortic injury despite the right-sided approach, stressing the need for careful analysis of the patient's preoperative anatomy.

A second, less reported mechanism of vascular injury during lateral interbody fusion is related to preexisting adhesions between the great vessels and spinal column, which increases the risk of injury during manipulation of the disk and bone fragments. In the present report, we believe that the patient's ankylosing spondylitis was an important risk factor given evidence of chronic inflammation along the aorta, which was visualized intraoperatively by our vascular surgery team. This inflammation may have resulted in adhesions between the aorta and the anterior longitudinal ligament (ALL) or annulus, which predisposed the patient to vascular injury. This injury was likely present prior to surgery when the patient suffered the initial fracture, but only became clinically significant once the bone or disk fragment was dislodged intraoperatively. This type of vascular injury is also theoretically possible during spinal osteotomies where the anterior column is directly or indirectly fractured and lengthened for deformity correction [16]. Identifying potential vascular injuries preoperatively is challenging, especially in complex cases; however, it suggests a role for preoperative angiograms in high-risk patients, particularly those with abnormal imaging with evidence of vascular lumen irregularities and certainly those with active extravasation. In these cases, preoperative endovascular intervention may be a viable option to prevent intraoperative vascular injury.

In contrast to the previously reviewed cases that involved segmental artery injuries, ours is a dramatic and potentially catastrophic presentation. This case represents the first report of direct aortic injury related to lateral interbody fusion and the only case of vascular injury during lateral interbody fusion for a fracture in a patient with ankylosing spondylitis. The relatively high location at L1 and the presence of an unstable fracture are unique, since all previous cases involved apparent elective surgeries for degenerative conditions. The management of this type of complex injury requires extensive coordination between the neurosurgeon, vascular surgeon, anesthesia, and operating room staff. Our case, as well as those in the literature, highlights the need for prompt recognition of the injury with immediate vascular imaging, as well as having a vascular surgery team available for emergencies during high-risk cases. Open repairs are challenging due to patient positioning and limited exposure, with no successful cases reported in the literature. We believe endovascular treatment offers the best solution for this very complex and rare entity.

In retrospect, given the potentially life-threatening injury with this case, we recommend CT angiography in all patients with ankylosing spondylitis presenting with acute traumatic three-column injuries in which an anterior or lateral approach is being considered. Another important consideration is for lateral approaches at L1–L2; a left-sided approach places the aorta closer to the surgeon and theoretically at less risk during the discectomy and end plate preparation stages. Careful attention to the preoperative imaging must be performed to determine which side approach is best. Lastly, for ankylosing spondylitis patients with traumatic three-column thoracolumbar fractures, it is important to consider the option of a posterior fusion alone, even in cases with residual fracture gap or concern for instability. In the subaxial spine it is recognized that anterior/posterior constructs provide the greatest construct stability and may increase time to fusion [17–21]. Einsiedel et al. reported failure rates of 50% without anterior/posterior constructs [22]. However, in the thoracolumbar spine, there is limited data on the role of anterior/posterior constructions; however, Rustagi et al. note that "the presence of a large anterior gap may benefit from secondary anterior column reconstruction with a structural graft or cage" [7]. In our case, we chose to perform an interbody fusion for anterior column support; however, in retrospect another reasonable option would be to follow the patient clinically for signs of pseudarthrosis, instability, or worsening deformity and only then proceed with the interbody fusion.

Given our individual experience and review of the literature, we believe that open repair of the great vessels has limited success and poses significant challenges due to the limited exposure and patient positioning. We propose that in cases of suspected major vascular injury, the critical steps are first identifying and controlling the site of hemorrhage, followed by emergent intraoperative consultation with a vascular surgeon. In cases with persistent bleeding, the wound should be packed and immediate vascular imaging obtained. In cases where the anatomy is favorable, endovascular repair should be performed. While completing the planned lateral interbody fusion after vascular injury was feasible in our case, the decision requires careful clinical deliberation and should only be attempted if the patient is hemodynamically stable and in environments where excellent support is available. Secondary anterior surgery in ankylosing spondylitis is rarely required since these patients have a propensity for bone formation and fracture healing, but the presence of a large anterior gap may benefit from anterior column reconstruction with interbody graft or cage [7]. The indications of anterior column reconstruction are not completely defined, but the patient's bone quality, fracture pattern, and location must be taken into consideration. In this particular case, the patient's poor bone quality, large anterior gap, junctional location, and relatively good preoperative neurologic function prompted us to pursue a more aggressive approach with anterior column reconstruction. We acknowledge that most ankylosing spondylitis fractures do not require such extensive reconstruction.

Conclusions

Minimally invasive lateral approaches to the lumbar spine allow for interbody fusion and good visualization of the disk space with minimal blood loss and decreased length of stay. They have a favorable risk profile with rare incidences of major neurologic, vascular, and visceral complications. In the rare event of an intraoperative vascular injury during lateral minimally invasive surgery, the important principles are to control bleeding or pack the wound and obtain immediate vascular imaging. Traditional open repairs can be challenging, and endovascular techniques provide a valuable tool for the treatment of these complex injuries with significantly less morbidity.

Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest.

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