

ABSITE CORNER

Vascular injury during spinal surgery

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GENERAL INFORMATION

Key points: (a) Iatrogenic vascular injury is a rare but well-recognized complication of spinal surgery; (b) The most serious injuries involve the aorta and its major branches; (c) Vascular injuries following spinal surgery can present early or late; (d) Early presentation usually involves intraoperative hemorrhage and may be associated with hemodynamic instability; (e) Injuries that present late include pseudoaneurysms and arteriovenous fistulae; (f) Arteriography – traditional, CT or MRI angiography – should be used to diagnose the injury and define relevant vascular anatomy; (g) Therapy may require surgery or interventional techniques.

ABSITE CORNER is a section of OPUS 12 Scientist dedicated to brief topic reviews geared toward resident preparation for the American Board of Surgery In-Training Examination. Each bi-monthly edition of OPUS 12 Scientist will contain one or two condensed overviews, accompanied by a list of selected references. Resident contributions via regular article submission process are welcome, subject to Editorial Board and Section Editor approval.

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BACKGROUND

Iatrogenic vascular injury is a rare but well-recognized complication of spinal surgical procedures. Injury to the aorta and its major branches has been reported following cervical, thoracic, lumbar, and sacral spinal instrumentation procedures.

Vascular injuries resulting from instrumentation during spinal surgery can be divided into *early* and *late* types. Early injuries occur intraoperatively or shortly after surgery, and usually involve bleeding that requires immediate intervention. Late injuries may present days, months, or even years later. Pseudoaneurysms and arteriovenous fistulae constitute most of the lesions in this group.

Whenever major vascular injury is suspected, clinical considerations should begin with assurance of adequate vascular control and hemodynamic stability. It is important to remember that mortality associated with vessel rupture can be as high as 80%, and mortality associated with vascular injury without vessel rupture can reach 10%.

In the setting of suspected vascular injury, traditional angiography, computed tomographic (CT) angiography, or magnetic resonance (MRI) angiography may be employed in order to confirm the diagnosis and help plan interventional and/or operative vascular repair. The choice of diagnostic imaging should be based on the overall index of clinical suspicion and patient stability. It is important to obtain follow-up imaging after endovascular intervention or operative repair of vascular injuries in order to document adequacy of the repair or any signs of post-procedural failure. An overview of vascular lesions based on the anatomic region (cervical, thoracic, lumbar and sacral) will now follow.

CERVICAL SPINE

Iatrogenic injury to the carotid artery by a transarticular screw is a rare but very serious complication of surgery on cervical spine. Although bleeding and pseudoaneurysm formation may be the most common clinical manifestations, there are also reports of delayed clinical presentation characterized by repetitive cerebral infarctions following unrecognized operative carotid injury.

Pseudoaneurysms and other injuries of the vertebral arteries have been reported following cervical spinal fusion, with an incidence of approximately 0.5%. In a study by Kast *et al*, transpedicular screw fixation in the cervical spine was associated with 21% incidence of screw misplacement and greater than 25% narrowing of the vertebral canal in 4 of 16 cases. Although no vascular injury was seen in that study, the potential for one clearly existed. In the same study, the only statistically significant risk factor for screw misplacement was the surgical level, with all ‘critical’ breaches seen from C3 to C5.

Traditional arteriography or CT/MRI angiography should be obtained whenever vascular injury following surgery on cervical spine is suspected. Ultrasonographic techniques may also be helpful in this setting. Treatment may involve operative repair or endovascular intervention in selected cases. Endovascular techniques (i.e., stenting, embolization, coil occlusion) have been used in cases of both carotid and vertebral arterial injuries. Follow-up angiography is important after repair of any vascular injuries, regardless of whether operative or interventional treatment was undertaken.

THORACIC SPINE

Despite the potentially high morbidity, few reports of iatrogenic vascular injury associated with thoracic spine procedures exist in the literature. Proper placement of thoracic spinal pedicle screws can be technically challenging even to experienced spinal surgeons. The proximity of the aorta to the thoracic spine may

contribute to potentially life-threatening complications during screw placement. Anatomic anomalies, such as scoliosis, can further increase this risk. Surgery may be required to correct screw placement and repair any associated aortic injury.

In one study of thoracic pedicle screw placement in human cadavers by experienced spinal surgeons, 37 of 90 screws penetrated the pedicle cortex, and 16 of those penetrated the lateral cortex. The frequency of screw misplacement in live patients has been reported to be between 4% and 25%. The aorta is at most risk during screw placement in the fifth through twelfth thoracic vertebrae. Abutment of the screw tip against the aorta has been reported to occur in 2% to 12% of cases, and the complete natural history of such abutment is not known. The position of the aorta relative to the thoracic spine in scoliosis may increase the risk during pedicle screw placement in this group of patients.

Aortic injury can manifest in an acute or delayed fashion. Hemodynamic instability may occur in acute aortic perforation and is usually associated with brisk bleeding. Acute ruptures may occur during surgery, but have been reported up to five months postoperatively. Aortic pseudoaneurysms are typically a late finding occurring anywhere between 11 months and 20 years postoperatively, and may become infected. Delayed rupture of a calcified descending thoracic aorta at the site of intraoperative retraction has also been reported.

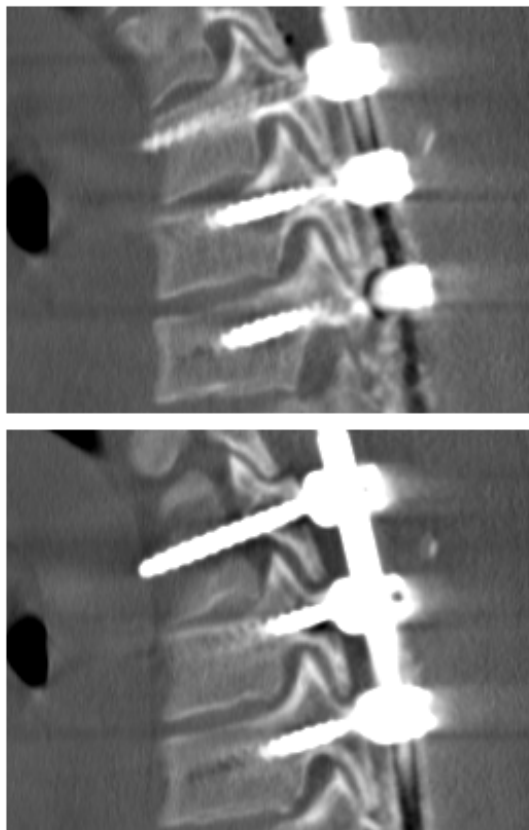


Figure 1. Example of a fixation screw in direct contact with the thoracic aorta. The screw was subsequently re-adjusted, as shown in **Figure 2**.

Treatment of aortic injury following pedicle screw placement has been described using a variety of techniques. Both the vascular injury and screw malposition must be evaluated and addressed. Good outcomes have been reported for vascular injury repair using endovascular graft, patch angioplasty, and open tube graft. Screw malposition can be rectified by screw repositioning or removal (**Figure 1** and **Figure 2**).

LUMBAR SPINE

Surgical instrumentation of the lumbar spine has been associated with a variety of vascular injuries and potentially devastating sequelae of such injuries. The reported incidence of vascular injury in this setting varies from 0.05% to 4%. The high mortality rate (up to 40%) is attributed to a combination of rapid blood loss and the failure to promptly recognize the cause of the patient's clinical deterioration. Early diagnosis and treatment are essential. Treatment has traditionally consisted of open vascular surgical repair. However, the evolution of modern imaging and endovascular techniques now allow the clinicians to utilize minimally invasive endovascular treatment as first line therapy in patients who are hemodynamically stable.

Venous injury is considerably more common than arterial injury in the lumbar anatomic region, with reported incidence between 5% and 15% after procedures on the lumbar spine. Most venous injuries occur at the L5/S1 surgical level. They can be usually repaired by direct suture repair and rarely result in any appreciable short- or long-term sequelae.

In a study by Szolar *et al*, intraoperative vascular complications included lacerations of the abdominal aorta and median sacral artery. One case of an arteriovenous fistula between the left common iliac artery and vein was detected 19 days following discectomy. In another case, a partially thrombosed aortic aneurysm with an arteriovenous fistula between the aneurysm and the inferior vena cava was found 11 months after spinal surgery.



Figure 2. Axial images of fixation screw before (left) and after (right) prompt repositioning. Computed tomographic aortogram (right) shows no injury to the aorta.

Anterior exposure of the lower lumbar spine (L4-S1) requires mobilization of the left common iliac vessels as they course obliquely across the anterior portion of the L5 vertebral body and portions of the L4-L5 and L5-S1 disc spaces. The left common iliac vein, because of its dorsal location, is the most likely vascular structure to be injured during anterior lumbar spinal surgery. Iliac artery injury with arterial occlusion and/or thrombosis can occur as well, and may require thrombectomy, arterial repair, and/or arterial bypass procedure. Rhabdomyolysis associated with significant morbidity and even mortality has been reported in this setting if the injury is not recognized promptly.

A study by Fantini *et al*, identified risk factors for vascular injury during anterior spinal surgery. Active or previous osteomyelitis, discogenic infection, osteophyte formation, previous anterior spinal surgery, transitional lumbosacral vertebra and anterior migration of interbody device all seem to be associated with increased risk of vascular injury during anterior spinal surgery. Careful intraoperative handling of the vascular structures and liberal use of hemostatic agents may be helpful in hemorrhage control and preservation of vascular patency. Postoperative surveillance for proximal deep venous thrombosis should be performed after venorrhaphy – traditional, computed tomographic, or magnetic resonance venography may be performed. Ultrasonography may also be considered in this setting.

Arteriovenous fistulae constitute some of the more commonly reported vascular injuries following lumbar spine surgery. Large arteriovenous fistulae usually present with some evidence of congestive heart failure (left ventricular hypertrophy, left ventricular diastolic overload, pulmonary hypertension, dyspnea) and characteristic bruit on auscultation. Clinical signs and symptoms associated with large arteriovenous fistulae tend to resolve following definitive repair of these lesions.

While open surgical exploration and repair continues to be the definitive treatment of vascular injuries detected intraoperatively and accompanied by hemodynamic instability, significant advances in endovascular techniques are changing the treatment of vascular injuries associated with lumbar spinal procedures in hemodynamically stable patients. Endovascular stenting with or without coil embolization has been highly successful for delayed vascular lesions – arteriovenous fistulae and pseudoaneurysms. There are even reports of emergent endovascular coil occlusion of actively bleeding vessels in the setting of early postoperative hemodynamic instability.

SACRAL REGION

There is a significant risk of injury to neurovascular structures during placement of sacral screws. In a cadaveric study by Ergur *et al*, 17% of sacral screws were in direct contact with the middle sacral artery and 10% were in direct contact or proximity with the middle sacral vein. In addition, the authors identified cases where

the lateral sacral vein was ‘disrupted’ by the screws. The diagnostic and treatment approach to vascular injuries resulting from procedures performed on the sacral spine is similar to that for other spinal regions. The choice of procedural intervention should be guided mainly by the presence of bleeding and patient physiology.

CONCLUSIONS

Iatrogenic vascular injury is a rare but well-recognized complication of spinal surgical procedures. Vascular injuries resulting from instrumentation during spinal surgery can be divided into *early* and *late* types. Early injuries become clinically apparent intraoperatively or shortly after surgery, and usually involve bleeding that requires immediate intervention. Late injuries may present days, months, or even years later. Pseudoaneurysms and arteriovenous fistulae constitute most of the lesions in this group. In the setting of suspected vascular injury, traditional angiography, computed tomographic (CT) angiography, or magnetic resonance (MRI) angiography may be employed in order to confirm the diagnosis and help plan interventional and/or operative vascular repair. It is important to obtain follow-up imaging after endovascular intervention or operative repair of vascular injuries in order to document adequacy of the repair or any signs of post-procedural failure. The risk of both arterial and venous injuries should be clearly communicated with the patient as a part of the preoperative consent process.

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