A retrospective analysis of pedicle screws in contact with the great vessels

Clinical article

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Object. Pedicle screws placed in the thoracic, lumbar, and sacral spine occasionally come in contact with the aorta, vena cava, or iliac vessels. When such screws are seen on postoperative imaging in an asymptomatic patient, the surgeon must decide whether it is riskier to revise the screw or to observe it. The authors hypothesized that the incidence of screw placement causing perioperative vessel injury is low and, further, that screws placed in contact with major vessels do not always result in vessel injury.

Methods. A retrospective review of the operative records of 182 consecutive patients undergoing thoracic, lumbar, and lumbosacral pedicle screw fusion was performed to determine the frequency of intraoperative vessel injury. Postoperative imaging for 107 patients was available to determine the incidence of screws in contact with major vessels. Charts were examined to determine if any adverse sequelae had resulted from malpositioned screws. Patient outcomes were documented.

Results. There were no intraoperative vessel injuries or deaths in 182 consecutive operations. One hundred seven patients with available postoperative films had 680 pedicle screws placed between T-3 and the sacrum during 115 operations. No patient had arterial screw penetration or deformation on postoperative imaging. Thirty-three of the 680 inserted screws were in contact with a major vessel on routine postoperative imaging. The contacted vessels included the aorta (4 cases), the iliac artery (7 cases), and the iliac veins (22 cases). Patients were followed up until death or November 2009, for a mean follow-up of 44 months (median 44 months, range 5–109 months). None of the patients with vessel contact was noted to suffer symptoms or sequelae as a result of vessel contact. Radiographic follow-up as long as 50 months after surgery revealed no detectable vessel abnormality at the contacted site.

Conclusions. Placing pedicle screws in contact with major vessels is a known risk of spinal surgery. The risk of repositioning a screw in contact with a major vessel but causing no symptoms must be weighed against the relative risk of leaving it in place. (DOI: 10.3171/2010.3.SPINE09657)

Key Words • aorta • complication • iliac artery • pedicle screw • retrospective study • spinal fusion

The placement of pedicle screws into vertebral bodies using anatomical markers to augment spinal fusion is not without risk to adjacent neurological and vascular structures. Intraoperative fluoroscopy is particularly useful in determining the cranial-caudal plane in the lumbar spine but often unhelpful in the thoracic spine except in unusually thin patients. Smaller pedicles in the thoracic spine also increase the risk of pedicle breach.

Neurophysiological monitoring can be beneficial in detecting either medial screw deviation resulting in impingement on the thecal sac or inferior deviation in the lumbar spine resulting in nerve root compromise. Lateral deviation is primarily detectable by intraoperative tactile exploration of the Lenke probe–generated tract using a pedicle sounding probe. Unfortunately, even if the lateral breach is detected and a new tract is generated with a Lenke probe, the screw may still be inadvertently placed down the original lateral tract. The use of intraoperative stereotactic navigation systems reduces the risk of errant screw placement; however, such systems are expensive, possibly increase operative time, and may require substantial operating room space.

Despite the known difficulties confounding the accurate placement of pedicle screws, there are relatively few reports of complications caused by inappropriate screw placement resulting in either immediate or delayed major vessel injury. The paucity of such reports may arise from the natural reluctance of surgeons to publish a complication, but can also reflect the relative infrequency of vessel injury.

When pedicle screws are shown to contact vessels on postoperative imaging in an asymptomatic patient,
the surgeon must decide whether it is riskier to revise the screw or to observe it. This question is further confounded by an incidental discovery at a delayed time point, after the patient has already recovered from surgery. This paper is the first to document outcomes after observing pedicle screws in contact with major vessels.

Methods

Institutional review board approval for this retrospective study was obtained prior to initiating research (#00975 on 9/25/2008).

We reviewed the operating room log for between July 1, 2000, and June 1, 2009, at the VA New York Harbor Healthcare Hospital to identify all patients who underwent thoracic, lumbar, or sacral fusions with pedicle screws. Operative reports, postoperative radiographs, and hospital records were examined to determine the number of screws that had been placed between T-3 and the sacrum. Only patients who had postoperative imaging available in the computerized hospital database were included in the subsequent analysis of pedicle screw placement.

Thirty-five neurosurgery residents and 8 attending physicians were listed in the operative reports as being responsible for these surgeries. While the operative reports did not specify the individuals placing each screw, surgeons within their first 7 years of postgraduate experience inserted the majority of the screws. Postgraduate Year 6 or 7 surgeons placed at least one-half of the screws.

The surgical technique for screw placement was performed via a standard midline incision with exposure of the posterior aspects of the spine bilaterally to the tips of the transverse processes. Screws were inserted using a freehand technique based on anatomical landmarks. All of the lumbar and sacral pedicle screws were placed under fluoroscopic guidance.

Postoperative CT scans were used to evaluate screw placement in 99 of the 107 patients. In 8 patients we were able to exclude vessel wall contact on the basis of postoperative MR imaging. We eliminated 4 patients from the study in whom it was impossible to rule out vessel contact on the basis of MR imaging alone, which was inadequate to visualize the anatomy fully. A single independent radiologist (R.C.K.) retrospectively reviewed postoperative scans to determine whether any of the screws were in direct contact with the aorta, vena cava, or iliac vessels. Both axial and sagittal images were reviewed, and screws were identified as contacting a major vessel if there was not a measurable distance between the screw and the vessel radiographically. Records from the time of surgery until the present were examined to determine whether patients had experienced adverse sequelae from screws in contact with major vessels.

This study was designed and approved by the institutional review board as a retrospective chart and film analysis. For this reason, patients were not contacted and asked to undergo CT angiography if vessels were in contact with screws. Presumably if there had been arterial deformation by a screw, the surgeons caring for the patient at that time would have requested CT angiography follow-up as indicated.

Results

One hundred eighty-two consecutive patients underwent fusion involving pedicle screws between T-3 and the sacrum over a 9-year period at a single hospital. Operative notes and hospital records for these patients revealed that there were no intraoperative vessel injuries during pedicle screw placement and no intra- or perioperative deaths. No emergent intraoperative vascular or thoracic surgery consultations were requested.

Postoperative imaging was performed in all patients who underwent surgery after 2005. One hundred seven of the 182 patients had postoperative imaging studies available after 115 operations; 680 pedicle screws were placed between T-3 and the sacrum in these patients. The number of operations with available postoperative imaging studies was as follows (by year): 2000, 0; 2001, 0; 2002, 1; 2003, 9; 2004, 11; 2005, 19; 2006, 19; 2007, 13; 2008, 21; 2009 (through June), 10.

Thirty-three of the 680 placed screws were in contact with a major vessel on routine postoperative imaging. Contacted vessels included the aorta (4 cases), the iliac artery (7 cases), and the iliac veins (22 cases). No vessel demonstrated deformation by a screw (Table 1 and Figs. 1–4). As of November 2009, 8 of the 9 patients with screws contacting major vessels were alive, with a mean clinical follow-up of 25 months after surgery (range 5–51 months) (Table 1). One patient died of amyotrophic lateral sclerosis 16 months after surgery.

Eight of 9 patients were evaluated in a VA hospital for various medical problems unrelated to their spine surgery between January and November 2009. Relevant ongoing medical problems are listed in Table 1. In 7 of the patients, follow-up imaging of the screw in contact with the vessel was obtained at a mean of 16 months (median 11 months, range 2–50 months) after screw placement (Figs. 1–4). None of the official radiology reports on these follow-up studies indicated that there was a vessel abnormality associated with screw contact.

Discussion

This is the first study to document the incidence of peri- and postoperative major vessel injury due to pedicle screw placement in a series of patients who underwent surgery by multiple, relatively junior surgeons. Despite the involvement of 35 residents and 8 attending surgeons, the perioperative death rate due to vessel injury in 182 consecutive patients in the study was 0, suggesting that the overall incidence of such events is relatively low. There was no evidence to suggest that any vessel had been penetrated or deformed perioperatively. Further, we detected no cases of delayed vessel injury despite finding 11 (1.6%) of 680 screws in contact with arterial vessels on postoperative imaging.

The main impetus for this study was to provide evidence for the hypothesis that screws contacting, but not penetrating or deforming, major vessels can be safely observed. Some surgeons have elected to revise asymptomatic screws with a lateral pedicle breach to prevent possible future screw erosion into prevertebral structures. The first incentive for these revisions was the appearance
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of case reports documenting delayed erosion of screws through vessels occurring between 6 days and 1 year after screw placement. The second motivation for screw revision was the data from animal studies demonstrating histological changes in sheep vessel walls after prolonged friction from contacting screws.

We show that in 9 patients with screws in contact with either the aorta or the iliac artery, there were no clinically relevant sequelae such as aneurysm formation or vessel erosion. Patients underwent imaging studies as long as 50 months after surgery (Table 1 and Figs. 1–4).

Our data suggest that the risks of reexploration and revision of a screw must be weighed against the risk of leaving it in place and take into account the overall life expectancy of the patient. We speculate that advances in the nature of the hardware itself may render the actual risks of vessel injury different from when such hardware was first developed.

Although the Manhattan VA hospital is a teaching institution and we routinely obtain postoperative CT scans in all of our fusion patients to determine the accuracy of hardware placement, our study questions the necessity of such scans. If the patient is neurologically asymptomatic and hemodynamically stable after surgery, it is possible that a scan showing malpositioned hardware would not necessarily alter the patient’s care.

**Table 1: Summary of characteristics in patients with aortic or iliac artery pedicle screw contact**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Fusion Performed</th>
<th>Level, Artery Contacted</th>
<th>Months FU†</th>
<th>Medical Problems</th>
<th>FU Imaging (mos postop)‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>L5–S1</td>
<td>rt S-1, iliac</td>
<td>26</td>
<td>pulmonary embolism, liver hemangiomas</td>
<td>CT, no vessel changes (14)</td>
</tr>
<tr>
<td>2</td>
<td>T10–L3</td>
<td>lt T-10, aorta</td>
<td>23</td>
<td>hepatitis, COPD, HTN, colon polyps</td>
<td>chest CT, no vessel changes (23)</td>
</tr>
<tr>
<td>3</td>
<td>L3–S1</td>
<td>rt S-1, iliac</td>
<td>23</td>
<td>Parkinson, PUD, skin cancer</td>
<td>lumbar spine MRI, no vessel changes (10)</td>
</tr>
<tr>
<td>4</td>
<td>L3–S1</td>
<td>lt L-5, iliac</td>
<td>51</td>
<td>HTN, CAD, CHF</td>
<td>lumbar spine CT, no vessel changes (50)</td>
</tr>
<tr>
<td>5</td>
<td>L5–S1</td>
<td>bilat S-1, iliac</td>
<td>20</td>
<td>depression, migraines, osteoarthritis</td>
<td>lumbar spine MRI, no vessel changes (11)</td>
</tr>
<tr>
<td>6</td>
<td>L2–5</td>
<td>rt S-1, iliac</td>
<td>16</td>
<td>amyotrophic lat sclerosis</td>
<td>immediate postop imaging only</td>
</tr>
<tr>
<td>7</td>
<td>T5–10</td>
<td>lt T-5, aorta</td>
<td>10</td>
<td>HTN, prostate cancer</td>
<td>thoracic spine MRI (7), thoracic spine CT (4)</td>
</tr>
<tr>
<td>8</td>
<td>T9–12</td>
<td>lt T-10 &amp; T-12, aorta</td>
<td>5</td>
<td>anemia, HTN, diabetes, prostate cancer</td>
<td>immediate postop imaging only</td>
</tr>
<tr>
<td>9</td>
<td>L3–S1</td>
<td>rt S-1, iliac</td>
<td>51</td>
<td>anemia, hepatitis C, BPH</td>
<td>lumbar spine MRI (2)</td>
</tr>
</tbody>
</table>

*BPH = benign prostatic hypertrophy; CAD = coronary artery disease; CHF = congestive heart failure; COPD = chronic obstructive pulmonary disease; FU = follow-up; HTN = hypertension; PUD = peptic ulcer disease.
†Describes the interval between surgery and when the patient was last seen in the VA hospital.
‡Refers to the most recent film on which vessel abnormalities could conceivably have been seen.

![Fig. 1. Case 2. Axial CT scan revealing a left T-10 pedicle screw abutting the aorta 6 months after placement.](image1)

![Fig. 2. Case 7. Axial CT scan demonstrating a left T-5 pedicle screw abutting the aorta 4 months after placement.](image2)
Major limitations of this study are its retrospective nature and relatively small sample size. And ideally we would have been able to obtain an autopsy specimen from the 1 patient who died of amyotrophic lateral sclerosis as well as angiography studies of the vessels in contact with screws. Nonetheless, we believe that this study has some merit, as it is the first to document stable clinical outcomes despite the placement of screws in contact with major vessels. We are unaware of a single published paper describing the long-term observation of screws in contact with major vessels in humans.

Conclusions

This study demonstrates that the risk of perioperative vessel injury due to pedicle screw placement is relatively low. It further shows that patients with pedicle screws in contact with major vessels may not necessarily suffer adverse sequelae. The risk of leaving a misplaced asymptomatic pedicle screw must be weighed against the risk of reexploration and replacement, particularly in patients in whom the screw is discovered long after surgery and in those with limited prognoses.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

The opinions and assertions contained herein are the private views of the authors and are not to be construed as official or reflecting the views of the US Air Force, the US Army, the Department of Defense, or the Department of Veterans Affairs.

Author contributions to the study and manuscript preparation include the following. Conception and design: Samadani. Acquisition of data: Samadani, Foxx, Latzman. Analysis and interpretation of data: Samadani, Foxx, Kwak. Drafting the article: Samadani, Foxx, Kwak. Critically revising the article: Samadani, Kwak. Reviewed final version of the manuscript and approved it for submission: all authors.

References


Fig. 3. Case 8. Axial CT scan showing a left T-10 pedicle screw abutting the aorta.

Fig. 4. Case 8. Axial CT scan revealing a left T-12 pedicle screw abutting the aorta.