

## Esophageal perforation caused by a thoracic pedicle screw

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### Abstract



This grand round raises the risk of a rare complication that can be avoided with the knowledge of the particular anatomy of scoliosis vertebra. Transpedicular screws have been reported to enhance the operative correction in scoliosis surgery. The narrow and inconsistent shape of the thoracic pedicles makes the placement of pedicle screws technically challenging. Furthermore, in thoracic curves, the close proximity of the spinal cord and major soft tissue structures also adds a greater risk to the procedure. The esophagus lies close to the upper thoracic vertebrae and, an anterior cortical perforation can cause esophageal injury. We report a case of anterior cortical perforation by a T4 pedicle screw complicated by an esophageal perforation in a 15-year-old girl with convulsive encephalopathy. She was operated for a severe neurological scoliosis (Rett syndrome). Her neurological condition deteriorated 3 years after the posterior spinal surgery, requiring a percutaneous gastrostomy. An intra-esophageal screw was discovered incidentally during an endoscopy. We decided not to remove this screw, because the patient's health status presented a surgical contraindication. The patient showed no apparent discomfort at the 10-year follow-up examination after spinal arthrodesis. Esophageal perforation caused by a posterior pedicle screw is very rare. We highlight the risk of injury to esophagus from pedicle screws in upper thoracic vertebra. The systematic removal of a malpositioned screw must be discussed, on a case-to-case benefit–risk basis, especially if the patient has numerous comorbidities, given the long-term tolerance of a number of these improperly positioned implants.

**Keywords** Posterior spinal surgery · Thoracic pedicle screw · Scoliosis · Esophageal injury · Free-hand technique

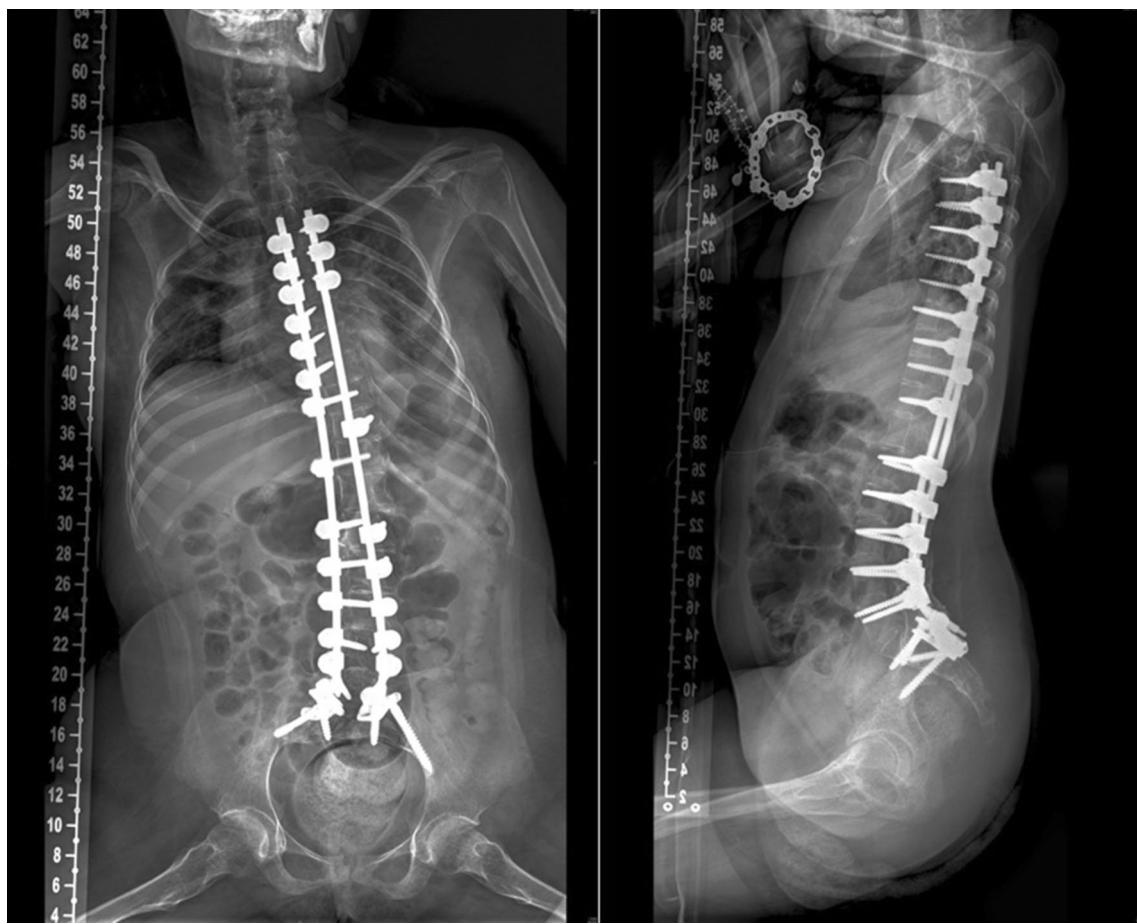
### Case presentation

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We report a case of a patient with esophageal perforation by posterior pedicle screw for which it was decided not to remove the intra-esophageal screw. A 5-year-old girl with an epileptic encephalopathy (Rett syndrome), presented with severe gastroesophageal reflux, that required a Nissen fundoplication. When she was 12 years old, she underwent posterior spinal instrumentation and fusion from T3 to

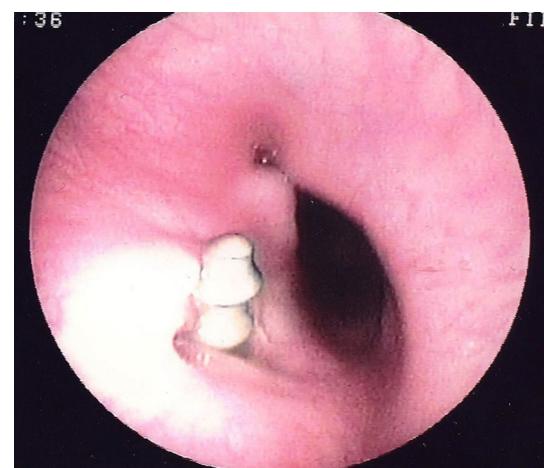


**Fig. 1** AP and lateral X-ray of the spine when the patient presented to our department. Only postoperative AP radiograph of the spine was performed. Unfortunately, no lateral X-ray was done postoperatively

the sacrum for a neurological scoliosis in another hospital (Fig. 1). Surgery was performed in ventral position on a Wilson frame. Pedicle screws insertion was performed with a free-hand technique with posterior approach. Pedicle entry point was determined by anatomic landmarks. The path was checked with pedicle probe. Anterior cortex of the vertebral body was palpated with the probe. Colorado 2® posterior spinal system by Medtronics was used with titan rod. Bone quality was poor and some screws could not be positioned. Pedicle screws were not checked with fluoroscopy. No problem was observed during the surgery and during the initial postoperative follow-up. Only postoperative AP radiograph of the spine was performed. Unfortunately, no lateral X-ray was done postoperatively. Parenteral alimentation was started postoperatively and was quickly weaned by nasogastric tube initially and by oral nutrition which was well tolerated. It was discussed with family to consider gastrostomy in the future. There was no complaint in the follow-up visits.

Neurological supra-tentorial symptoms due to the Rett syndrome increased 3 years after the posterior spinal surgery, requiring an endoscopic percutaneous gastrostomy.

During a control endoscopy, a metallic foreign body (the screw) was seen 20 cm below the dental arch level, which perforated the esophagus (Fig. 2). No leakage was observed.



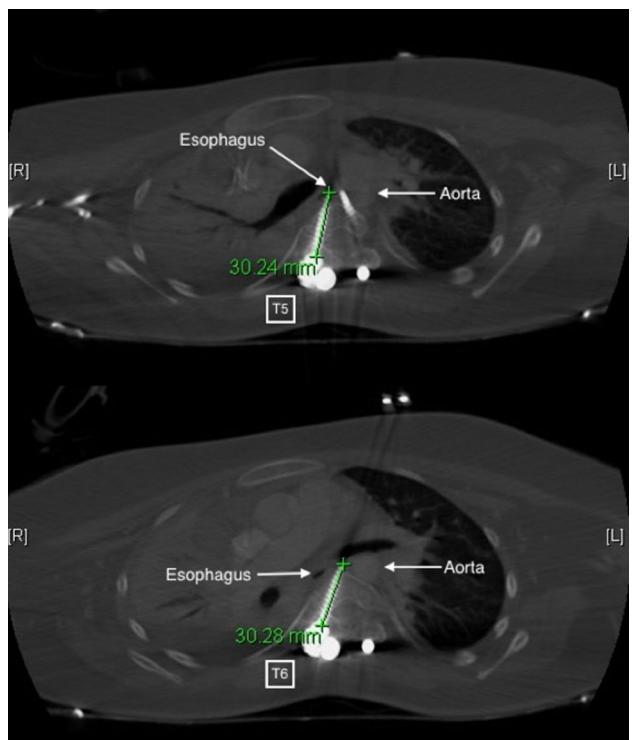
**Fig. 2** Endoscopic view with the pedicle screw protruding into the esophagus

The patient presented to our department with the endoscopy report. Initially, only antibiotic prophylaxis was done. A thoracic CT scan revealed several anterior cortical perforations: T3–T8 levels. The right T4 screw had penetrated the anterior cortex and perforated the esophagus (Fig. 3). The CT scan also showed the close relations with the aorta of T5 and T6 pedicle screw (Fig. 4). Discussion was conducted with medical staff (vascular, orthopaedics and digestive surgeons, and anaesthetist) and family: we decided against removing the screw as the patient's health status contraindicated invasive surgery.

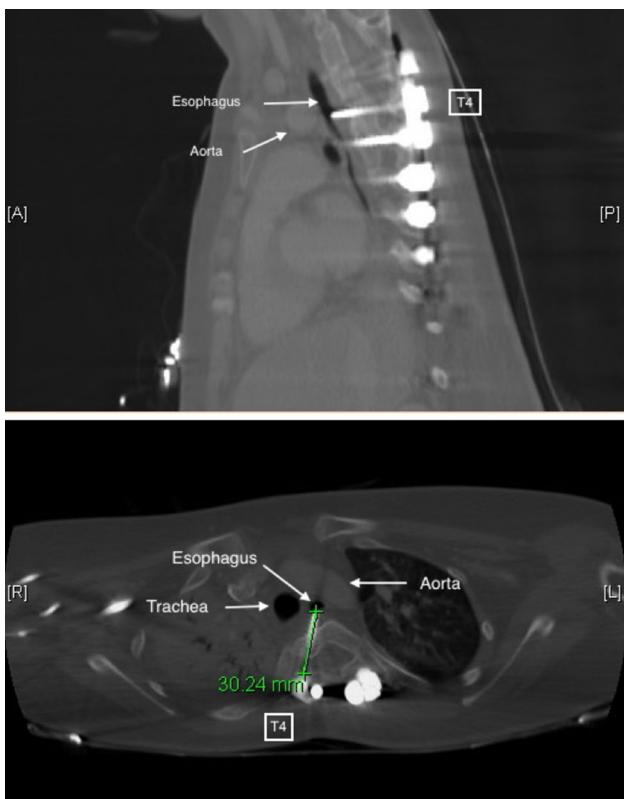
## Diagnostic imaging

### Historical review, diagnosis, and complications

Transpedicular screws have been reported to enhance the operative correction in scoliosis surgery [1, 2]. However, the use of thoracic screws in scoliosis remains controversial because of the technical difficulties and the risk of complications [3, 4]. Despite the use of adjunctive techniques, the narrow and inconsistent shape of the thoracic pedicles makes the placement of pedicle screws technically challenging



**Fig. 4** Axial computed tomography scan of upper thoracic spine, with overpenetration of T5 and T6 pedicle screws. Note the close relation with aorta and esophagus



**Fig. 3** Lateral and axial computed tomography scan of upper thoracic spine, with overpenetration of T4 right pedicle screw

[5, 6]. In the CT-based study, in the group of idiopathic deformed spine, the percentage of malpositioned thoracic pedicle screws using the free-hand method was about 30% [4, 5]. Furthermore, in thoracic curves, the close proximity of the spinal cord and major soft tissue structures including the aorta, azygos vein, esophagus, and parietal pleura also adds a greater risk to the procedure [7]. In a systematic review, Hicks et al. [3] retrieved 21 studies with a total of 14,570 pedicle screws: 4.2% screws were reported as malpositioned and 15.7% when postoperative computed tomography (CT) scans were done systematically. Only 8% of malpositioned screws had anterior vertebral cortex perforation [3]. There was no esophageal perforation in this review. Di Silvestre et al. [4] only reported one symptomatic patient out of 13 patients with malpositioned screws, demonstrating that many malpositioned screws remain asymptomatic. Kwan et al. [8] found recently on 2020 screws checked with CT, 6.4% of anterior perforation in thoracic region. Rao classification was used [9]: 1.4% of grade 2 (4–6 mm) and 0.8% of grade 3 (> 6 mm). Six anterior perforations abutting the right lung, four anterior perforations abutting the aorta, two anterior perforations abutting the esophagus, and one abutting the trachea were noted without real complication. Several cases of esophageal perforation resulting from the use of anterior instrumentation in the cervical spine region

have been reported in adults [10, 11]. Only two cases of esophageal injury by anterior cortical perforation with thoracic pedicle screw have been reported [12, 13]. Screws were removed in these two cases.

The clinical presentation of esophageal perforation can range from asymptomatic presentation to local infection to mediastinitis and death and is, therefore, considered a severe complication [10, 11, 13]. The most common presenting symptom is dysphagia followed by neck swelling and/or discharge [10]. In our case, as the patient was fed mainly via gastrostomy and a little by oral nutrition, it is difficult to know if she had dysphagia. During the postoperative 3 years without gastrostomy, there was no obvious change in her behaviour during meals. The patients swallowing disorder was more likely related to worsening encephalopathy than to the screw injury. At the 10-year follow-up after spinal arthrodesis, our patient had no complaints. As the patient is unable to communicate verbally, it is hard to determine whether any discomfort was caused by the screw, but her carers did not identify any signs of pain.

Esophageal complications after anterior cervical plates for fractures, spondylotic myelopathy or stenosis, and disc herniation include anatomic (perforation, fistula, stricture, and diverticula) and functional injuries [10]. O'Brien et al. [12] reported an esophageal injury from thoracic pedicle screw placement in a polytrauma patient with a T5–T6 fracture dislocation. The esophagus was not perforated initially. Prolonged intubation and tracheostomy caused an acquired tracheomalacia. As a result of tracheal expansion, the trachea ultimately pushed the esophagus back into the protuberant pedicle screw. Although the esophagus was not perforated before revision of the spinal hardware, esophagoscopy showed attenuation of the posterior esophageal wall with blanching and surrounding telangiectasia [12]. For O'Brien et al. [12], it is likely that late esophageal perforation and mediastinitis would have occurred if the screws at T3 had not been revised. It is often not possible to know whether the perforation occurred during surgery or whether this perforation occurred secondarily. Even without direct esophageal perforation by screw, perforation can occur with repetitive friction and microtrauma, which leads to pressure necrosis of the esophagus [10, 12]. For O'Brien et al. [12], the inability of a polytrauma patient to report dysphagia caused by esophageal impingement may underscore the need for postoperative CT to assess thoracic pedicle screw placement. Cerebral palsy patients are also unable to report symptoms postoperatively because of altered levels of consciousness. It would, therefore, seem logical to also propose a postoperative CT scan to cerebral palsy patients. Sariyilmaz et al. [13] reported the case of a 15-year-old girl who underwent posterior instrumented fusion for adolescent idiopathic scoliosis. Ten years after the surgery, the patient developed a complaint of dysphagia due to an esophageal perforation from

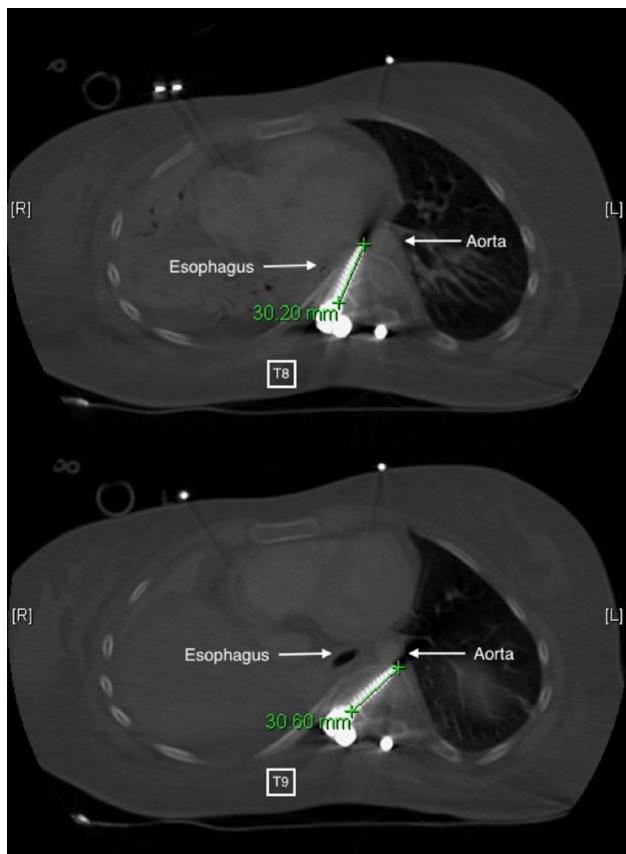
a malpositioned T4 pedicle screw. After implant removal, the esophageal perforation healed without complications. It is likely that the frequency of this complication is underestimated. Some cases have probably not been published and the good clinical tolerance of some of these perforations may underestimate the complication rate.

## Rationale for treatment and evidence-based literature

Treatment of esophageal perforations is controversial [10]. Conservative treatment with local drainage, administration of parenteral antibiotics, and tube feedings is usual when a foreign body is not in the esophagus [10]. If a screw is in the esophagus, the treatment can involve early surgical closure, debridement, drainage, and removal of the screw. If a mal-positioned screw has not initially perforated the esophagus, surgical removal is urgently indicated. Indeed, a secondary perforation of the esophagus can lead to an increased risk of mortality due to mediastinitis. If the screw has already perforated the esophagus on the CT scan without any complication, as in our case, the systematic removal of the screw is debatable. Our patient kept her intra-esophageal screw for 3 years without any evident clinical symptoms. In the literature, the emergence of clinical signs of intolerance is delayed, with an average onset of symptoms of 2.5 years after surgery [10]. This period can be up to 10 years [13].

The esophagus is one of the most vital structures in the proximal thoracic region and is located just anterior to the vertebral bodies [13, 14]. It is at a potential high risk of injury from implant malposition [12, 14]. The risk of injury is greater in patients with scoliosis due to translation and rotation of the vertebra [13]. Vaccaro et al. [7] showed that a breach of a few millimeters of the anterior or anterolateral cortical boundaries of the vertebral body may not initially damage the adjacent soft tissue structures (aorta and esophagus) because of the mobility of these structures. However, chronic irritation, especially due to the pulsatile aorta and esophageal peristalsis, may result in delayed damage to these structures [12]. It is interesting to note that, in this study, of 90 thoracic screws, put in place without the use of computerized tomographic (CT) scans or plain radiographs, by five well-trained spine surgeons, 37 (41%) had penetrated the cortex of the pedicle [7]. In a CT scan study, Jiang et al. [2] evaluated the changed relative position of the esophagus in 42 proximal thoracic curves of adolescent idiopathic scoliosis patients. They also analysed the potential risks of esophageal injuries from thoracic pedicle screw insertion. In patients with fractional (defined as neutral or negative T1 tilt without true apical vertebra) right proximal thoracic curves, the esophagus moves anterolaterally to the left. This group is at a high risk of injury with left anterior penetrated screws

(100% at T2–T4, 59% at T5) but safe with right anterior penetrated screws at each level (0% at T2–T5). In patients with complete (characterized by a left elevated upper corner of T1 vertebra located on the convex side of C7 plumb line) proximal thoracic curves, as in our case, the esophagus shifts to a right anterolateral position (Figs. 4, 5). In this group, the esophagus was found to be at a high risk of injury with right anterior penetrated screw (75% at T2, 100% at T3–T5), but safe with left anterior penetrated screw at each level except at T2 (35% at T2, 0% at T3–T5). Takeshita et al. [14] showed, in a morphologic CT scan study on patients with scoliosis, that the mean width of the pedicles was 2.7 mm (concave) and 4.3 mm (convex) at the T4 level. The mean lengths of the pedicles at the T4 level were 30.5 mm (concave) and 29.4 (convex). Insertion of long screws should always be avoided, as they pose a potential penetration risk of the azygos vein and the parietal pleura on the right and the thoracic aorta and the esophagus on the left [7]. Sarıyilmaz et al. [13] advise against the use of screws longer than 35 mm in the upper thoracic region. In our patient, the screw which perforated the esophagus was 30 mm. In this case, it would have been necessary not to exceed 25 mm



**Fig. 5** Axial-computed tomography scan of T8 and T9 levels. Note the close relation between the screw and aorta, and the right lateralization of esophagus

(the length of T4, T5, and T6 screws were 30 mm) or to use hooks in thoracic spine. If a preoperative CT scan had been performed to measure the maximum length of the pedicle, this complication would not have occurred. For Di Silvestre et al. [4], in the upper thoracic spine, the screw insertion must be more convergent and the length not more than 25–30 mm. Probably, preoperative CT images should be used systematically to measure the exact chord length of the vertebra [2, 12]. However, preoperative planning cannot completely eliminate the risk of screw malposition [12].

Intraoperative fluoroscopy visualization of the anterior vertebral body is difficult, especially in the upper thoracic spine [12], which explains the development of CT guidance. Chan et al. [15] systematically reviewed the screw-related complication and breach rates from posterior spinal instrumentation and fusion with pedicle screws for patients with severe adolescent idiopathic scoliosis when using free-hand methods for screw insertion compared with image guidance methods. Seventy-nine cohort studies were identified. From individual cohort studies, moderate evidence shows that CT guidance has lower point estimates of breach rates than free-hand methods at 7.9% compared with 9.7–17.1%. Screw-related complication rates are conflicting at 0% in CT navigation compared with 0–1.7% in 13 low- and moderate-quality studies.

## Procedure

The possibility of removing the screw was discussed, suturing the esophagus and interposing a flap of large omentum to avoid a secondary fistula. However, due to the patient's esophago-gastric surgical history the large omentum was unlikely to be intact. The T5 screws put this patient at risk of an aorto-esophageal fistula which is invariably fatal. There is also risk of infection ever present. After a discussion with medical staff (vascular, orthopaedic and digestive surgeons, and anaesthetist) and family, a decision against surgical removal was made based on the benefit–risk for the patient. This surgery was deemed too high risk in this fragile patient. Postoperative complications of such surgery can also be important, although favourable evolutions have been described without treatment [10, 11]. There is a risk of creating an esophageal fistula and causing secondary bone infections [16]. Our therapeutic decision was easier to make, because we had a 3-year follow-up without complications. This therapeutic abstention would have required further reflection if we had found the esophageal perforation immediately after the arthrodesis. To the best of our knowledge, this is the first case of an esophageal perforation by a posterior pedicle screw without removal of the screw. For the therapeutic strategy, we cannot draw definitive conclusions about one case. However, the systematic removal of

a malpositioned screw must be discussed, on a case-to-case benefit–risk basis especially if the patient has numerous comorbidities, given the long-term tolerance of a number of these improperly positioned implants.

## Outcome

We cannot exclude the possibility of a delayed complication (aorto-esophageal fistula, infection, or mediastinitis), even if this remains unlikely given the good tolerance at 10-year follow-up. At 10-year follow-up after spinal arthrodesis, the patient showed no apparent discomfort. She was fed mainly by her gastrostomy and a little by oral nutrition.

## Compliance with ethical standards

**Ethical statement** This study is in accordance with the ethical standards of the institutional committee and with the 1964 Helsinki declaration and its later amendments. Informed consent was obtained from the family, who gave written permission for use of the data for this case report.

**Conflict of interest** No funds were received in support of this work.

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