TACTICS FOR THE TREATMENT OF POTENTIAL AND TRUE THORACIC AORTA INJURIES BY PEDICLE SCREWS IN THE ABSENCE OF ACUTE BLEEDING

Analysis of a small clinical series and literature data

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Objective. To analyse the results of treatment of patients in whom, after fixation of the thoracic spine, contact of screws with the aorta with its wall injury was revealed.
Material and Methods. Three own observations and literature data were analysed.
Results. Three patients with potential (1 case) and true (2 cases) injury to the thoracic aorta by a transpedicular screw underwent simultaneous surgical intervention including thoracic endovascular aortic repair (TEVAR) followed by remounting (2 cases) or removal of the transpedicular fixation system. An analysis of publications on this topic is presented.
Conclusion. Intramural hematoma caused by screw malposition is an indication for aortic repair due to the risk of its dissection or rupture. It is advisable to give preference to endovascular methods of treating vascular injuries under conditions of local anesthesia as the first stage, and then to perform the revision of transpedicular fixation system under anesthesia.
Key Words: vascular complications, aortic injury, screw malposition, transpedicular fixation, TEVAR, vertebral fracture.
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Vertebral fractures make up 2–12 % of cases of traumatic injuries to the musculoskeletal system. 10–15 % of them undergo surgical treatment. Meanwhile, the malposition of the screws is observed in 4–30 % of cases, including the incorrect direction of the screws and their protrusion beyond the vertebral body, which is associated with excessive length [1, 2]. It is considered that screw malposition of 4 mm or more is a potential danger for neurological and vascular complications [3, 4]. Such cases often occur during surgical treatment of spinal deformities [5].

Aortic injury is a very rare but extremely dangerous complication. In addition, complications of this type are more often observed in the thoracic spine due to the anatomical features of the vertebrae [6, 7]. Such complications include perforation with the development of bleeding or the formation of a hematoma, wall erosion, or the formation of pseudoaneurysms [8]. Usually, complications associated with an aortic injury manifest at the time of the injury. However, they are frequently delayed and discovered years later or by chance [9]. The frequency of such complications is not associated with the surgeon's experience [10]. Injuries to the great vessels during transpedicular fixation (TPF) occur with a frequency of 0.01 %; aortic injuries are even rarer, while the mortality rate is 15–65 % [11]. Treatment policy can vary from case follow-up to open or endovascular interventions with screw re-installation [12].

The objective is to analyze the results of treatment of three patients in whom, after fixation of the thoracic spine, contact of screws with the aorta with its wall injury was revealed.

These data define surgeons' alertness when planning TPF and performing repositioning maneuvers, as well as help in the development of tactical solutions for the timely relief of such a complication.

Clinical case 1. A 55-year-old male patient M. examination for thoracic spine pain revealed compression fractures of the T7–T8 vertebral bodies. Decompression laminectomy of T7–T8, TPF of T6–T9 were performed. The control CT scan (Fig. 1) of the thoracic spine showed an incorrect position of the pedicle screw in the form of a lateral malposition with adherence to the aortic wall.

After the case conference, thoracic endovascular aortic repair (TEVAR) was performed with a stent graft under local anesthesia, followed by endotracheal anesthesia, putting the patient in the prone position, and revision of the transpedicular fixation system with the remounting of the left screw in T6.

The patient has completely returned to work and daily life. The follow-up period was a year and eight months.

Clinical case 2. As a result of an accident in 1999, a female patient D. got a comminuted fracture of the T8 vertebra.

In the central district hospital, she underwent decompression and stabilizing surgery with resection of the T8 body, fusion of the T7–T9 by auto bone, TPF of the T6–T10. The postoperative period went smoothly; the patient recovered and led an active lifestyle.

At the beginning of 2020, the patient began to experience pain syndrome in her back, and for some time she was self-treated but unsuccessfully. The patient sought medical advice at her place of residence, where she underwent a CT scan of the thoracic spine. CT findings revealed a perforation of the thoracic aorta with a pedicle screw at the T6 level. It was recommended to perform MSCT aortography (Fig. 2), which revealed at the T6 level perforation of the thoracic aorta with a pedicle screw and intramural hematoma 7 mm in diameter.

After the case conference, the thoracic endovascular aorta repair was performed with a stent graft under local anesthesia. After that, under anesthesia, the patient was laid on her stomach, and the TPF system was removed in the second stage. The surgery was performed without complications.

The patient was discharged on the 5th day after the surgery. She is fully active, working and doing sports. The follow-up period was two years and eight months.

Clinical case 3. As a result of an accident in December 2020, a female patient V. got a concomitant injury. According to emergency indications, she underwent osteosynthesis of the middle third of the left tibia with a plate, the middle third of the radius with a nail, as well as stabilization of the spine: fixation of C6–C7 with a plate, decompressive laminectomy of T6, and TPF of T4–T5–T7. According to the control CT findings in June 2021 (6 months after surgery), the malposition of three pedicle screws on the left was found, including at the T4 level. The screw pushes against the aortic arch wall, penetrates the thoracic aorta at the T5 level, causing intramural hematoma; the vessel lumen is deformed; and a parietal thrombus up to 3.5 mm is visible, at the T7 level – into the descending portion of the aorta (Fig. 3).

During the case conference it was decided to perform a stage-by-stage surgical treatment: the first stage is thoracic endovascular aortic repair, and the second is the reinstallation of the pedicle screws in the thoracic spine.

After the first stage of thoracic endovascular aortic repair with a stent graft under local anesthesia, the patient was laid on her stomach under anesthesia to remounting of the structure with the reinstallation of the left pedicle screws of T4, T5, T7 at the second stage. Minimum length screws were used during the procedure. The surgery was performed without complications.

Control CT findings: correct position of the stent graft and absence of contact of the pedicle screws with the aortic wall. On the fifth day, the patient was discharged in satisfactory condition, and she started remedial gymnastics. The follow-up period was a year and five months.

Discussion

We have carried out a search for similar cases in eLibrary.ru by the keywords: aorta, screw, vessel, injury, and endovascular repair. We have found one case description, as well as two scholarly publications matched these criteria. One of these descriptions is devoted to the analysis of injuries to retroperitoneal structures and abdominal organs in TPF; the second one – to the analysis of the pedicle screw malposition [13]. When searching in the PubMed National Medical Library for the keywords TEVAR and screw, three articles were found. When searching for the following keywords: aorta, screw, and endovascular, 93 academic papers were found. Most of them describe vascular

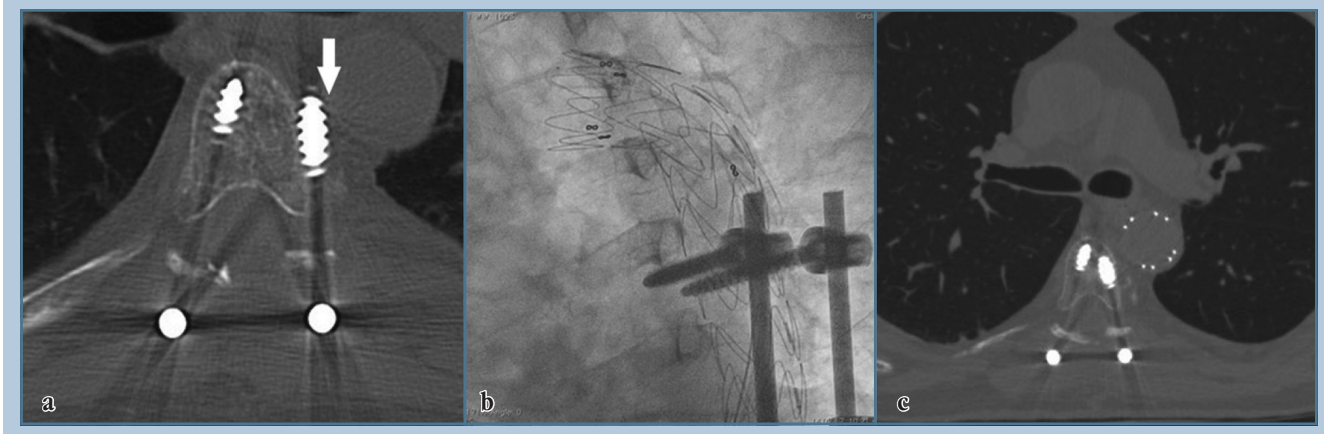

Fig. 1
Examination data of a 55-year-old male patient M.: **a** – on preoperative CT scan, deformity of the aortic wall, formation of intramural hematoma (white arrow); **b** - intraoperative fluoroscopy after placement of a stent graft into the aorta; **c** – on postoperative CT scan, the position of the screw is correct

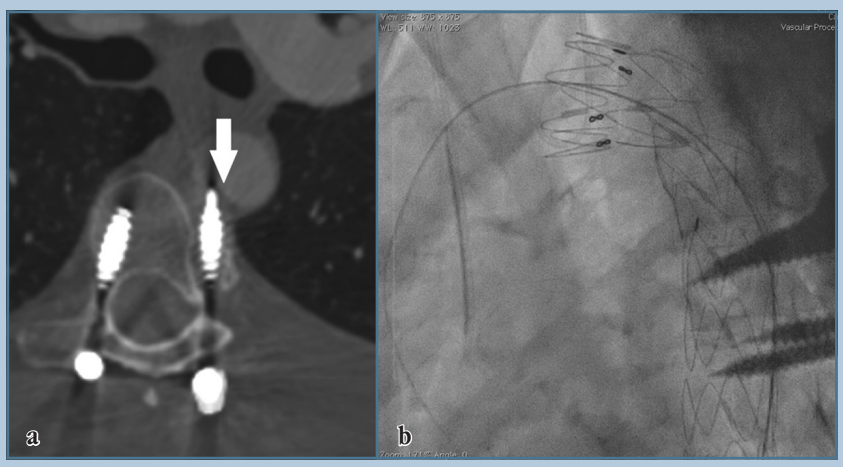

Fig. 2
Examination data of a female patient D.: **a** – on preoperative CT scan, lateral malposition of the left T6 screw, aortic perforation with intramural hematoma formation (white arrow); **b** – intraoperative fluoroscopy after placement of a stent graft into the aorta

injury during procedures on the lumbar spine, as well as the analysis of the world literature. Therefore, there is not enough information concerning the injuries to the aorta and great vessels in TPF. Thus, there is no consensus on the treatment tactics in such cases.

It is proposed to minimize the risk of screw malposition and injury to the great vessels using navigation systems and individual navigation matrices [14]. Unfortunately, such systems are available not in all hospitals and are not widespread yet.

It is required to perform CT of the targeted spine and CT aortography to allow diagnosis and to specify the further treatment strategy. In case of great vessel injuries, preference is given to endovascular treatment techniques. They are highly effective, minimally invasive, and have a low number of complications compared to classical thoracotomy and laparotomy approaches, as well as an absence of restrictions for patients in the postoperative period [15–17]. If they are ineffective or impossible to perform, open surgeries are performed, followed by a higher frequency of postoperative complications [11, 18]. It is worth noting that vascular injuries with acute onset of symptoms discovered intraoperatively or within the first hours after surgery are usually restored by the open method. This is due to the fact that laparotomy is often required to sanitize the abdominal cavity and to suture the defect in the vessel wall. Therefore, the outcome is directly associated with the rate of diagnosis and treatment of the complication. Vascular injuries that are detected in the delayed period and are asymptomatic are mainly subjected to endovascular treatment.

The need for revision surgery remains controversial.

Bleeding formation can be not only due to perforation of the aortic wall. Penetration or adhesion of the screw with the formation of microtrauma of the vessel is sufficient, which can eventually result in thinning and erosion. Additionally, the constant pulsation of the aorta and its increase in diameter with aging due to the development of hypertension result in an even greater risk of injury. Intramural hematoma is an indication for endovascular repair, as it is a signal of a rupture or dissection of the aorta. Osteoporosis, infections and other factors may be the cause of delayed screw migration and instability of the surgical hardware [17]. Consequently, in the case of delayed detection of screw malposition, the probability of thinning, erosion of the vessel with the development of bleeding occurs the higher the longer its contact with the screw.

There are no unambiguous recommendations regarding the sequence for performing procedures for such injuries, namely, what to do first – endovascular aortic repair or remounting of the TPF system. If the screw surface contacts the aorta by more than 5 mm, it is essential to perform endovascular repair at the first stage, even in the absence of signs of leakage or bleeding, followed by the surgical hardware revision. If the contact is less than 5 mm, the screw can be removed or reinstalled without a preliminary vascular stage, but with postoperative angiography control [4]. One more option is the removal of the penetrating screw under the control of aortography with the rejection of endovascular aortic repair in the absence of signs of extravasation [19]. Nevertheless, this strategy is not always safe. Contrary to MSCT angiography, classical angiography is not a valid diagnostic technique for aortic injuries.

The literature sources present a case of aortic injury by a T11 vertebra screw, in which a thoracotomy, suturing of the defect, and resection of the extracorporeal part of the pedicle screw were performed [20]. This strategy seems excessively complicated.

Relying on the MSCT findings, our own experience and the data of the world literature, we believe it is correct to recommend the following solution: the first stage is to perform thoracic endovascular aortic repair, the second stage is procedures with pedicle screws. This sequence in our two observations is defined by the fact that the patients had intramural hematoma that with the initial removal of the screw, could, with a high probability, cause acute dissection or rupture of the aorta (when manipulating the screw thread) and the subsequent development of major bleeding. The first-stage installation of the stent graft permits strengthening the aortic wall at the site of the defect, significantly reducing the likelihood of dissection and perforation. It is necessary to point

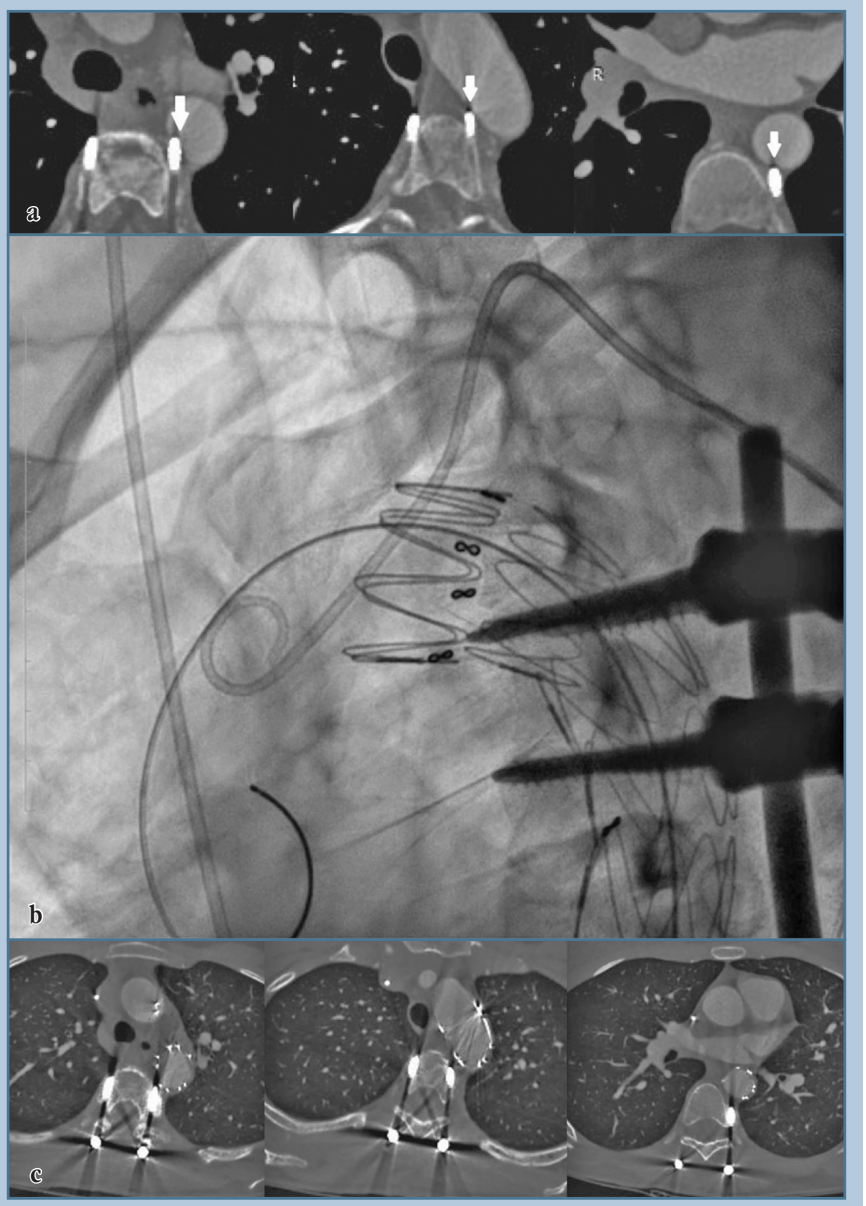

Fig. 3
Examination data of a female patient V.: **a** – on preoperative CT scan, contact of the T4 screw with the aortic arch, perforation of the aorta with the T5 screw with the formation of intramural hematoma, contact of the T7 screw with the descending thoracic aorta (white arrows); **b** – intraoperative fluoroscopy after placement of a stent graft into the aorta; **c** – on postoperative CT scan, the position of the pedicle screws is satisfactory, the system is stable, the position of the stent graft in the aorta is correct

out that even with such a strategy, the probability of graft perforation remains. Nevertheless, in this case, it will be more local, cause no dissection, and there is always the possibility of sealing with an additional stent graft.

The first and third patients underwent screw reinsertion due to the short period after the fracture. Since a bone block was formed in the second case (more than 20 years after the initial intervention), the TPF system was removed.

Considering our own data and literature analysis, it can be claimed that all spinal procedures, even minimally invasive ones, must be performed in multispecialty hospitals with units of surgery, vascular surgery, suitable intensive care unit, and a transfusion medicine unit. Otherwise, the probability of fatal outcome due to the development of vascular problems is high.

Conclusion

There are no consensus guidelines for the strategy of treating aortic injuries with pedicle screws in the world literature. Intramural hematoma caused by screw malposition is an indication for endovascular aortic repair due to the risk of dissection or rupture. We recommend to give preference to endovascular methods of treating vascular injuries under conditions of local anesthesia as the first stage, and then to perform the revision of the TPF system under anesthesia.

The study had no sponsors. The authors declare that they have no conflict of interest. The study was approved by the institution's local ethics committee. All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication.

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