Case Report

Two uncommon cases of thoracic aortic injury caused by rib fractures

Hao Xie, Shaonan Ning, Nan Li, Lei Song, Yanbin Wang, Qiang Zhang

Department of Thoracic Surgery, Beijing Jishuitan Hospital, Beijing 100035, China

Correspondence to: Qiang Zhang, MD. Department of Thoracic Surgery, Beijing Jishuitan Hospital, No. 31 East Street, Xinjiekou, Xicheng District, Beijing 100035, China. Email: 13611073708@163.com.

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Case 1

A 34-year-old female patient was transferred to our hospital due to "more than 5 days of chest, left shoulder, left forearm pain, swelling, and limited activity caused by car accident". After injury, the patient had collapsed chest and pain, swelling and pain of the left shoulder, bleeding, and limited activity of the left forearm and hand. Physical examination revealed absent left upper limb, collapsed left thorax, extensive soft tissue injury, paradoxical left thoracic movement with tenderness. Breath sound was rough and diminished on the left. Her hemoglobin (HGB) was 79 g/L. The vital signs were unstable. Because the left forearm injury was an open injury, and the soft tissues of her chest wall were infected, chest surgery was not advisable. The patient was admitted to the intensive care unit (ICU) for the treatment of infection and supportive treatment after amputation. On the 13th day after injury with infection eliminated and stable vital signs, the patient underwent left thoracoscopic exploration under general anesthesia.

After positioning, the blood pressure began to decline. Thoracoscopy demonstrated fracture of the posterior left 4th to 8th ribs. Large blood clots were covering the thoracic aorta. The fractured ends of the left 4th, 5th, and 6th ribs had penetrated the posterior wall of the thoracic aorta (*Figure 1*). A 5-mm ulcer formation was observed on the aorta with active bleeding, and hemostasis was conducted by compression. The incision on the chest wall was extended to 25 cm entering the pleural cavity through the 6th intercostal space. 5-0 polypropylene suture (VPF711X; Covidien, Dublin, Republic of Ireland) was used for interrupted full thickness suturing of the aorta. The broken ends of the 4th to 8th ribs were partially removed and hammered. A 28 Fr chest tube was placed (*Figure 2*). The intraoperative blood loss was 2,000 and 1,600 mL of homologous blood and 300 mL of autologous blood were transfused. After surgery, the HGB rose to 89 g/L. On the 1st day after surgery, the patient was transferred to the general ward. The chest computed tomography (CT) was reexamined on the 3rd postoperative day and found bilateral pleural effusion and partial left lung atelectasis (*Figures 3-6*) which improved after conservative treatment. There were no serious postoperative complications, such as paraplegia or paralysis, renal or respiratory failure, myocardial infarction, ventricular arrhythmia, or congestive heart failure. The patient was discharged on the 25th day after injury. The patient was found to be well in the outpatient clinic 11 months after surgery.

Case 2

A 66-year-old man was admitted to the emergency department due to "chest damage caused by building collapse 4 days ago." The patient suffered from chest pain, chest tightness, difficulty in breathing, and abdominal pain. In the outside hospital, chest CT scan (*Figure 7*) showed left hemopneumothorax, as well as fracture of the left 8th to 11th ribs and left T8 to T9 transverse processes. After receiving closed thoracic drainage in the external hospital, the patient was transferred to our hospital for further treatment. Physical examination showed stable vital signs, extensively bruised left chest wall skin, and tenderness on compression. There was a bone rubbing feeling. Bilateral percussion showed hyper-resonance, and the breath sound on the left was diminished. CT chest also demonstrated

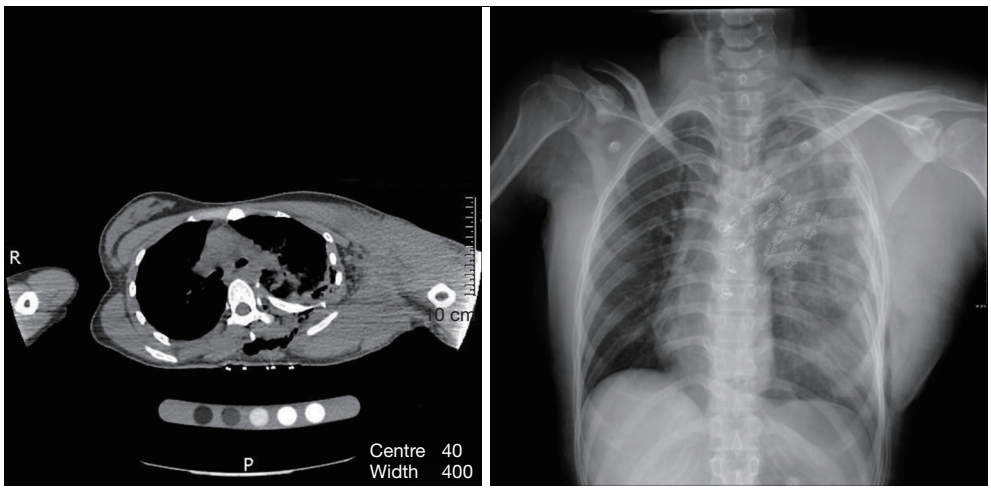

Figure 1 It showed the severe rib fracture on the left side of the patient with displacement of fractured ends on CT. The fractured ribs were close to the thoracic aorta, while there was no a large amount of bleeding in the chest and obvious thoracic aortic injury.

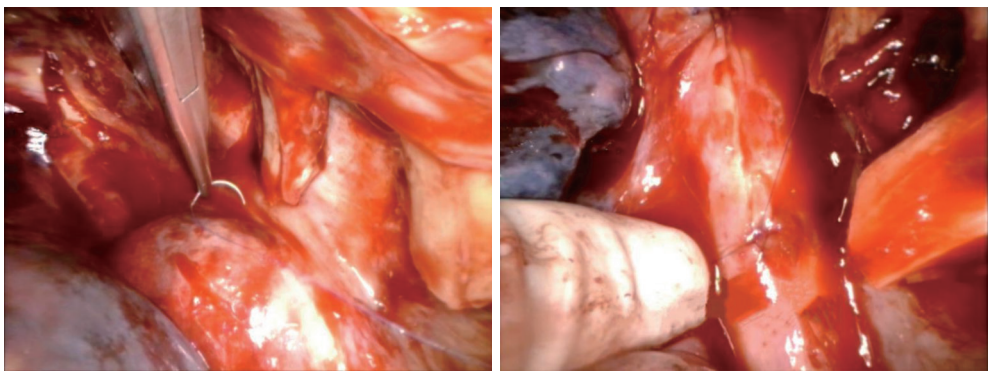

Figure 2 It showed intraoperative findings of thoracic aortic injury caused by the broken end of the rib fractures, with thoracic aortic tear. A 5-0 non-absorbent single-strand polypropylene suture (VPF711X; Covidien, Dublin, Republic of Ireland) was used for intermittent suture of the full layer of the aorta.

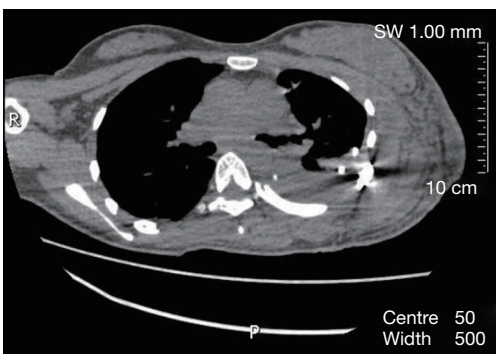

Figure 3 It showed that the rib fracture was fixed after surgery, and a small amount of fluid was found in the chest.

bilateral pleural effusion. High-density shadow was observed on the dorsal side of the left lung. Because of the suspected thoracic aortic injury caused by rib fracture, the patient underwent enhanced CT examination after admission. It demonstrated a half-moon-shaped high-density shadow on the dorsal side of the left thoracic cavity, and a slightly low-density shadow was observed on the anterior edge. There was contrast enhancement. There was a local thickening of the right pleura as well. On the 11th day after the injury, thoracoscopic exploration was performed through the 7th intercostal space near the left posterior axillary line. About 300 mL of bloody effusion and 300 mL of blood clot were

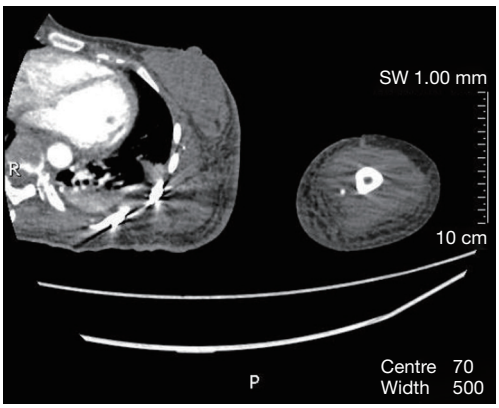

Figure 4 It showed that there was no stenosis, leakage, and false lumen formation in the thoracic aorta after surgery.

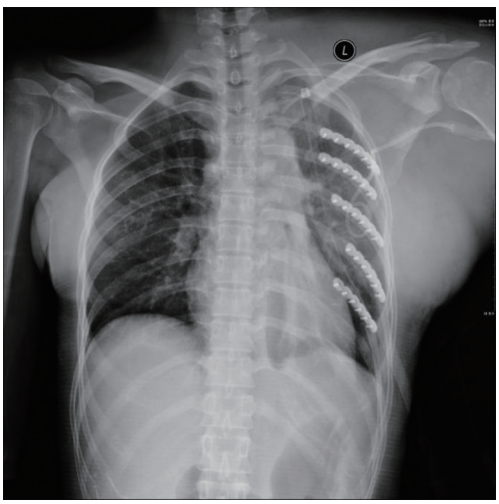

Figure 5 It showed the postoperative chest radiograph. The chest radiograph of the patient on the 8th day after surgery showed that the pleural effusion was basically drained clean.

observed in the thoracic cavity. It was seen that the residual end of the left 10th rib fracture punctured the thoracic aortic adventitia, and local ulcer formation, with about 4×3 mm in size and 2 mm in depth, and no active bleeding. A 4 cm longitudinal paraspinal incision was made at the level of 10th rib. The fracture was separated and the 2 cm of the rib was excised. A 5-0 polypropylene suture (VPF711X; Covidien, Dublin, Republic of Ireland) was utilized for intermittent suture of the adventitia of the aorta. A 36 Fr chest tube was placed. The chest CT scan was conducted on the 1st day after surgery (*Figure 8*). The patient was discharged 21 days after the injury and no complication

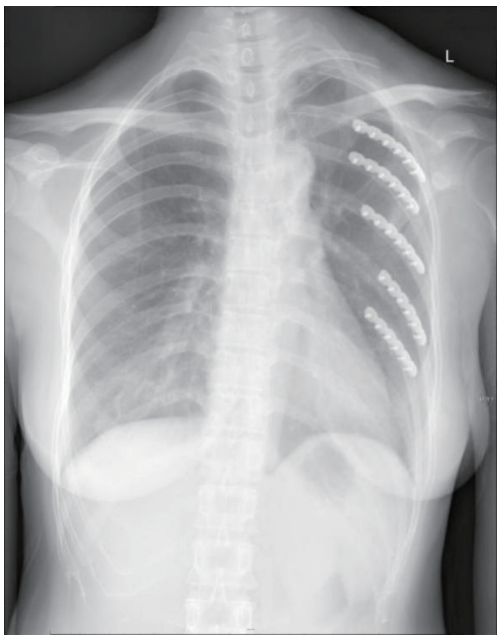

Figure 6 It showed the chest condition of the patient 1 year after surgery. The bilateral costophrenic angles were clear and sharp. The ribs were in a fixed state as well.

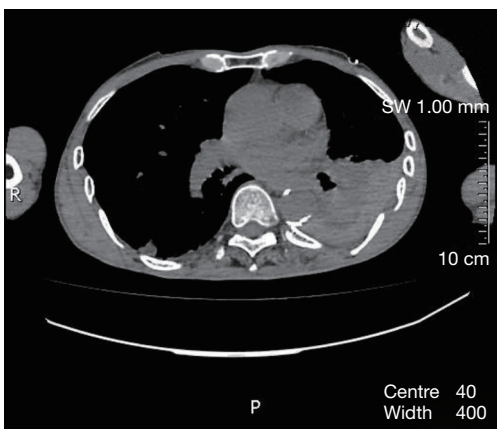

Figure 7 It showed that the left rib fracture of the patient was near the thoracic aorta. There was an effusion in the thoracic cavity, and it was suspected that the thoracic aorta was injured.

occurred. The patient was re-examined at the clinic 3 months after the injury (*Figure 9*), and no discomfort or related complications was observed.

Discussion

Thoracic trauma account for 10–15% of all trauma, and

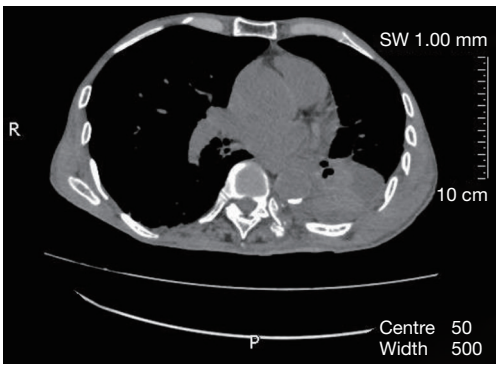

Figure 8 It showed that there was an effusion in the thoracic cavity of the patient after surgery, and the broken end of the rib fracture has been hammered.

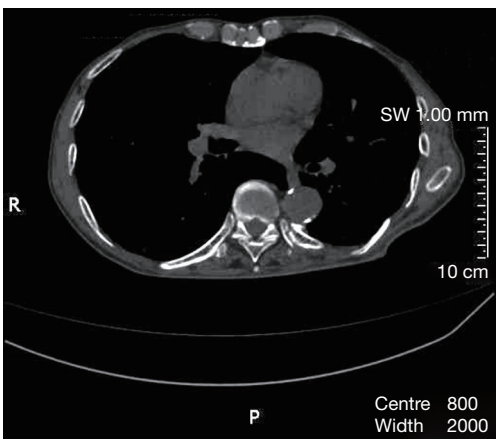

Figure 9 It showed that there was no effusion in the thoracic cavity 3 months after the injury, and the broken ends of the rib fracture were smooth. There was no dissection and aneurysm formation of the thoracic aorta.

trauma-related causes of death accounted for 25% (1). Mwipatayi *et al.* statistically analyzed 4,790 major traumatic injuries in the Royal Perth Hospital between June 2000 and April 2012. There were 47 cases of blunt thoracic aortic injuries, accounting for approximately 1%. Among the 47 patients, 40 cases were due to motor vehicle accident; 2 cases due to falling from a height of more than 3 meters; 5 cases due to motorcycle accident (2). Aortic injury was mostly blunt injury, and injury of thoracic aorta by rib fractures had been rarely reported in the past 20 years (3). In a retrospective analysis of 18 patients with thoracic aortic rupture from 1991 to 2009 by Chiba *et al.*, all patients were accompanied by chest injury and 6 patients died within 2 h after receiving emergency surgery. The mortality rate was as high as 33.3% (4). Choi *et al.* summarized 48 cases of blunt aortic injury between 1998 and 2012, and also found that 11 cases were associated with rib fractures (5). Aortic injury has high mortality and disability, in which only about 15–20% of patients can survive till arrival at hospital to receive treatment (6). The mortality rate of traditional thoracotomy for thoracic aortic injury may reach 31% (7). The aortic injury mostly occurred at the aortic isthmus, followed by the descending aorta, and the ascending aorta ranked the third (4). A previous study suggested that the risk of descending aortic injury in deceleration injury was higher than that of the aortic isthmus (8). In several case reports of thoracic aortic laceration, all sites of injury from rib fracture were the descending aorta (9-12).

In the diagnosis of thoracic trauma, chest CT scan is the main diagnostic method. For the thoracic aortic injury, diagnosis by CT scan was not accurate enough, and aortic angiography was carried out. The main diagnostic modality today is CT angiogram (CTA). Merrill *et al.* reported that the positive rate of aortic angiography was approximately 10–12% (13). In a case report, the thoracic aortic injury caused by the rib fractures was also examined by CTA. However, the thoracic aortic injury at that site was not found (11). Patil and Nierich reported that transesophageal echocardiography (TEE) can be used as an early non-invasive technique for the diagnosis of acute thoracic aortic disease to help determine the extent of thoracic aortic tear and the presence of hematoma or thrombosis. TEE had a specificity of 100% in the diagnosis of thoracic aortic laceration (14). After Symbas *et al.* first completed aortic tear treatment in 1959 (15), thoracotomy repair of thoracic aortic injury has been the mainstream treatment method for such fatal trauma. By the 1990s, with the gradual development of vascular surgery, thoracic endovascular aortic repair (TEVAR) was an effective method for the treatment of aortic injury and has been reported in several previous studies (16-18). In some trauma centers, thoracotomy treatment for thoracic aortic injury was frequently employed. In the reported data, the mortality and disability rate of patients were significantly reduced (5).

Left thoracotomy has been mainly used for the treatment of thoracic aortic injury, and some patients would adopt a median sternotomy. If necessary, the surgeon would perform bilateral thoracotomy. The main method for aortic repair was to replace the injured aorta with a graft. This procedure required opening the pericardium and incision between the pulmonary artery and the aorta to clamp the

aortic arch between the origin of the left carotid artery and the left subclavian artery. During the aortic cross-clamping (73–47 min), the distal aortic perfusion was maintained by extracorporeal circulation (cardiopulmonary bypass time, 93–63 min) (5). The TEVAR treatment was generally performed by determining the condition of the thoracic aorta in the injured area with CT examination. After excluding the contraindications and clarifying the injured site, the operation was undertaken, followed by systemic heparinization. Some patients needed the general anaesthesia to control blood pressure. Angiography was carried out by puncture and catheterization through radial artery. The origin of vertebral artery was observed, and the occurrence of spinal cord injury was monitored during surgery. The perfusion pressure was maintained at 90–120 mmHg to prevent the occurrence of spinal cord ischemia. In some patients with vertebral artery dysplasia, one may need to perform a common carotid artery-subclavian artery bypass or "chimney" technique to preserve the left subclavian artery. Digital subtraction angiography and Doppler colour flow imaging were required after implantation of the stent in order to verify the correct position of the stent and detect any primary endoleak (17). These two treatment methods should be observed for postoperative complications, such as paraplegia, hemiplegia, liver failure, renal failure, and pulmonary infection.

For the female patient with thoracic aortic tears reported in the present study, the cause of injury was the constantly rubbing of rib fractures with the thoracic aorta, which induced damage to the adventitia of the thoracic aorta and formation of ulcers. Therefore, the vital signs of the patient were stable after injured for a long-time. In order to relieve the flail chest of the patient caused by multiple rib fractures, we performed a thoracotomy to fix the rib fracture. No obvious thoracic aortic injury was found in the chest CT scan before surgery. It was revealed that a large amount of hemothorax was caused by blood loss from the rib fracture. Thus, we prepared a large amount of allogeneic blood before the operation. In video-assisted thoracoscopic surgery (VATS), a large amount of effusion was removed. The broken end of the 7th rib fracture was found to have penetrated the thoracic aorta. When the blood clot that covered the surface was removed, blood ejected from the aorta. Hence, emergency thoracotomy was carried out to repair the bleeding aorta. The rib fracture ends were removed and hammered. We suspected that the broken ends of the rib fracture eventually damaged the patient's thoracic aorta, and it also caused rupture and bleeding. This process was very similar to that reported in a 63-year-old patient by Kitamura *et al.* (11).

For the second patient, since it was suspected that the rib fracture may cause damage to the thoracic aorta, we performed a thoracic aortic CTA before surgery. The results did not show thoracic aortic injury. However, ulcer formation was found in the aortic adventitia during surgery. The cause of this injury was also due to sharp injury caused by broken ends of rib fractures. In fact, some thoracic aortic injuries due to iatrogenic causes were also sharp injury (19). In a limited number of cases of thoracic aortic injury caused by rib fractures, some patients demonstrated delayed bleeding, which may be due to the fact that the rib fracture ends maybe plugging the hole in the aorta. In these situations, it would be obviously unwise to adopt the TEVAR treatment because it might cause a false lumen. However, according to the criteria adopted by Ad Hoc Committee for Standardized Reporting Practices in Vascular Surgery of The Society for Vascular Surgery/American Association for Vascular Surgery, it can be considered as failed operation once this happened. We believe that it is necessary to perform surgery as soon as possible for the thoracic aortic injury caused by rib fractures. Thus, the injury of thoracic aortic adventitia caused by the long-term friction of the rib fracture ends due to respiratory movement would be reduced. The rib fracture ends that caused the thoracic aortic injury were treated intraoperatively to avoid re-injury of the thoracic aorta. In the paravertebral fracture of the left thoracic ribs, since the rib fracture ends were close to the thoracic aorta, there could be a possibility of chronic injury caused by rubbing of the thoracic aorta by broken ends. Even if no obvious thoracic aortic injury was found in the chest CT scan, surgical exploration should be conducted to avoid delayed rupture of the thoracic aorta. When it is suspected that the rib fractures have caused thoracic aortic injury although there is no definite evidence on chest CT scan, VATS can be undertaken for further exploration. VATS can completely remove pleural effusion and blood clots and determine whether there is thoracic aortic injury or not to guide further treatment.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Informed Consent: Written informed consent was obtained from the patient for publication of this manuscript and any accompanying images.

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