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ORIGINAL ARTICLE

The risks of aorta impingement from pedicle screw may increase due to aorta movement during posterior instrumentation in Lenke 5C curve: a computed tomography study

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Abstract
Purpose To investigate the aorta movement following correction surgery for patients with thoracolumbar/lumbar scoliosis and to determine the subsequent risk of the aorta impingement for pedicle screw (PS) misplacement.
Methods Thirty-six AIS patients with a main thoracolumbar or lumbar curve were included in this study. According to the direction of the main curve, the patients were divided into Group R and Group L, with Group R comprising 16 patients with a right-sided curve and Group L comprising 20 patients with a left-sided curve. All patients underwent CT scans of the lower thoracic and lumbar spine before and after surgery. To identify the relative positions of the aorta to vertebral body, several parameters were measured from the CT images of the middle transverse planes of vertebrae from T11 to L4, including aorta–vertebra angle (α), vertebral rotation angle (β), left safety distance (LSD) and right safety distance (RSD). The risk of the aorta impingement from T11 to L4 was calculated. An intragroup comparison regarding the position of the aorta relative to the vertebral body before and after correction surgery was performed accordingly.
Results After surgery, the aorta moved toward the vertebral body among all levels in both groups. Compared with that in Group L, the aorta in Group R was significantly closer to the entry point at all levels, especially at T11. Before surgery, the aorta in Group R was at a high risk of impingement from left PS placement regardless of the diameters of the simulated screws. While in Group L, the risk of aorta impingement was mainly caused by the right placement of 45 mm PS. After surgery, both groups had an increased risk of aorta impingement from PS insertion, especially at T11. The risk of aorta impingement from PS placement was significantly higher in Group R than in Group L.
Conclusion The risk of aorta impingement increased as the aorta shifted leftward after correction surgery, especially in right-sided Lenke 5C curve. Thus, preoperative risk evaluation could be insufficient for clinical practice due to aorta movement following correction surgery. Surgeons should be aware of the potential risk of aorta impingement, especially when placing PS in patients with right-sided curves.

Keywords Scoliosis · Thoracolumbar/lumbar curve · Correction surgery · Aorta impingement

Introduction

Scoliosis is a structural, lateral, rotated curvature of the spine leading to functional disabilities and cosmetic problems. Surgical intervention is commonly recommended, when the major curve progresses to greater than 45° [1]. The advent of pedicle screw (PS) made it possible to achieve a balanced spine and rigid fusion by posterior instrumentation for thoracolumbar and lumbar scoliosis, which was once deemed a good indication for anterior instrumentation [2, 3]. Compared with anterior instrumentation, posterior instrumentation facilitated a shorter surgery time and hospital stay as well as avoiding anterior thoracotomy-related complications, such as hemothorax, pleural effusion or decrease in pulmonary function [4–6]. However, the risks of neural, vascular and visceral injuries

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from malpositioned pedicle screws (PSs) still need to be taken into consideration when placing PSs.

Among PS-related complications, aorta impingement may be the most disastrous. To avoid this catastrophic complication, many studies have been performed to investigate the position of the aorta and to analyze the risks of aorta impingement caused by PSs [7, 8]. Minor et al. [9] described a case of a 77-year-old woman who underwent posterior pedicle screw fixation with a misplaced PS at T5, which was impinging on the descending thoracic aortic wall. In another study, Kakkos et al. [10] reported two cases of thoracic aorta perforation by PS that led to acute bleeding. Collectively, previous studies primarily focused on thoracic scoliosis, whereas few investigations have been performed on the anatomy of the aorta in thoracolumbar/lumbar scoliosis patients. Qiao et al. [11] first investigated the anatomy of the aorta in these patients with thoracolumbar or lumbar scoliosis and further analyzed the aorta impingement risks of PS insertion. In their study, simulation of PS insertion before operation was performed; however, the effect of the correction procedure on the position of the aorta was not taken into consideration. In fact, posterior correction with PSs could possibly make the aorta shift from its original position, thus resulting in changing the risk of aorta impingement from PSs.

The purpose of this study was to explore the changes of the positions of the aorta relative to vertebral bodies after posterior scoliosis correction and to investigate the potential risk of aorta impingement from PS in Lenke 5C scoliosis.

Materials and methods

Under the approval of the local institutional review board, a cohort of adolescent idiopathic scoliosis (AIS) patients who underwent posterior spinal fusion (PSF) surgery between January 2009 and December 2012 were reviewed. The inclusion criteria were as follows: (1) having a single main thoracolumbar/lumbar curve with the thoracic curve less than 25°; (2) having a magnitude between 40° and 70° of the main curve; (3) having no history of spinal or aortic surgery. Patients were excluded from the study if they had a thoracolumbar junctional kyphosis or known congenital vascular abnormality. Finally, 36 patients were included in the study and were divided into two groups according to the direction of their main curve. Group R consisted of 16 patients with a right-sided main curve, and Group L consisted of 20 patients with a left-sided main curve.

Posterior correction surgery

Posterior correction surgery was performed with PSs. All PSs were inserted by senior spine surgeons from the same team with more than 10 years scoliosis surgery experience. Intraoperative MEP, SEP and wake-up test were performed for all patients. The diameters and lengths of PSs were determined on the preoperative CT scans. A safe entry into the pedicle was confirmed when the ball-tipped probe met bony resistance in all directions and cancellous bone at the tip, indicating that the hole was globally surrounded by bone. If any breach was found, the entry would be remade in a different direction. Finally, PSs with ideal length and diameter were inserted accordingly.

CT measurements

Pre- and postoperative CT scans of the lower thoracic and lumbar spine were performed with a spiral CT scanner (LightSpeed, GE Healthcare) with the following parameters: 320 mAs, 120 kVP and 5-mm thickness with a 5-mm gap between the slices. To identify the relative positions of the aorta to vertebrae, several radiographic parameters were measured from the CT images of the middle transverse planes of vertebrae from T11 to L4, including aorta–vertebra angle (α), vertebral rotation angle (β), left safety distance (LSD) and right safety distance (RSD) (Fig. 1). The radiographic parameters were defined as follows:

1. Aorta–vertebra angle (α): subtended by the tangent line of the anterior margin of the vertebral canal and the line from the posterior midpoint of the vertebral body to the midpoint of the aorta. The angle was defined as 0° when the aorta was located directly laterally to the left, 90° when located strictly anteriorly and 180° when located directly laterally to the right [12].
2. Vertebral rotation angle (β): formed between a perpendicular line starting from the posterior central aspect of the spinal canal and a straight line through the posterior central aspect of the spinal canal and the middle of the vertebral body [13].
3. Left safety distance (LSD): measured from the ideal entry point of the left PS (middle of the base of the left superior facet) and the posterior edge of the aorta.
4. Right safety distance (RSD): measured from the ideal entry point of the right PS (middle of the base of the right superior facet) to the posterior edge of the aorta.

Potential risk of aorta impingement from PS placement

PS placements before and after surgery were simulated with the length of screws set at 35, 40 and 45 mm, respectively (six scenarios). The aorta was considered to be at potential risk of impingement when the safety distance (LSD or RSD) was less than the length of PS. The percentages of the vulnerable aorta on the right and left sides of the spine at all levels were calculated accordingly.

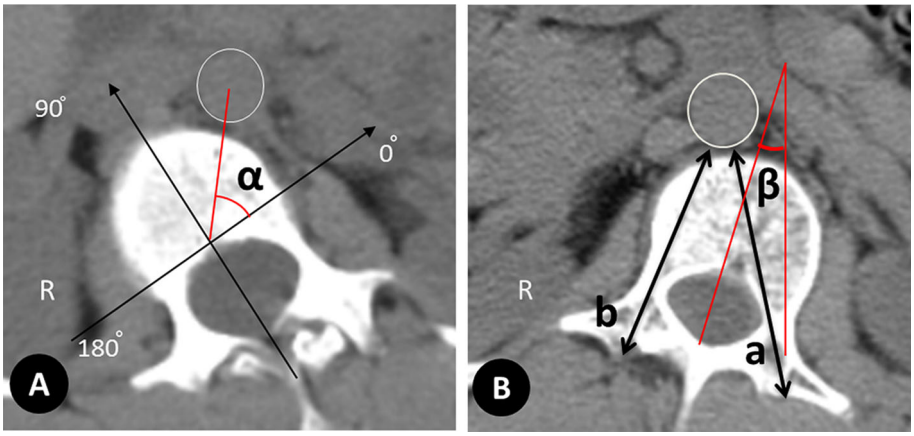

Fig. 1 Illustration of parameters measured on the CT images. **a** α Aorta–vertebrae angle; **b** β vertebral rotation angle, *a* left safety distance (LSD); *b* right safety distance (RSD)

Statistical analysis

The data were evaluated using SPSS 13.0 for Windows (Chicago, IL). Paired sample *t* test was conducted for the comparisons between α and β, and between LSD and RSD before and after surgery in each group. With regard to age, pre- and postoperative Cobb angle, flexibility of curve, the number of fused levels, postoperative Cobb angle and correction rate, independent sample *t* test was used to compare the above parameters between two groups. The percentages of aorta at a potential risk of impingement were calculated to analyze the risks of the aorta impingement from PS placement in six scenarios. An intragroup comparison regarding risk of aorta impingement after correction surgery was performed with Chi square test accordingly. Significance was set as a *P* value <0.05.

Results

The baseline characteristics of the patients are shown in Table 1. The mean age of patients was 14.9 ± 1.6 years (range 13–17 years) for Group R and 14.4 ± 0.8 years (range 12–16 years) for Group L. In Group R, the preoperative Cobb angle of the main curve averaged 46.5 ± 2.3° (range 45°–50°) and was corrected to 8.6 ± 4.9° (range 1°–16°) after surgery, while in Group L the main curve averaged 47.1 ± 1.9° (range 45°–49°) before operation and was corrected to 8.0 ± 4.7° (range 1°–19°). The mean flexibility of the curve was 56.3 ± 3.5 % (range 54.1–58.8 %) in Group R and 56.6 ± 1.6 % (range 54.0–58.5 %) in Group L. The average number of levels fused was 6.0 ± 0.6 (range 5–7 levels) in Group R and 6.0 ± 0.8 (range 5–7 levels) in Group L. The mean correction rate was 80.0 ± 11.0 % (range 66.7–100.0 %) in Group R and 72.0 ± 11.0 % (range 56.5–100.0 %) in Group L. No significant differences were observed between the two groups in terms of age, preoperative Cobb angle, flexibility of curve, the number of fused levels, postoperative Cobb angle and correction rate.

Table 1 Comparison of the patients' baseline characteristics between the two groups

	Group R ($N = 16$)	Group L ($N = 20$)	*P*
Age (years)	14.9 ± 1.6	14.4 ± 0.8	0.23
Preoperative Cobb angle (°)	46.5 ± 2.3	47.1 ± 1.9	0.64
Curve flexibility (%)	56.3 ± 3.5	56.6 ± 1.6	0.85
Number of levels fused	5.0 ± 0.6	5.0 ± 0.8	0.98
Postoperative Cobb angle (°)	8.6 ± 4.9	8.0 ± 4.7	0.72
Correction rate (%)	80.0 ± 11.0	72.0 ± 11.0	0.26

CT measurement

A summary of CT data before and after correction is presented in Tables 2, 3 and 4 and Fig. 2. Collectively, 96 vertebrae in Group R and 120 vertebrae in Group L were measured and evaluated. Before operation, the aorta in Group R was located at the left-lateral position at T11 and ran to the anterior position as it descended. In Group L, the aorta was located at the left-lateral position at T11 and moved to anterior-lateral position as it descended, changing its course at L2 and moving to the left anterior of the vertebrae. After operation, the position of the aorta in both groups got close to the vertebral body at all levels, especially at T11.

Potential risk of aorta impingement

Before operation

The aorta impingement risk increased among all levels in both groups with the length of the simulated screws augmented. In Group R, regardless of the lengths of the

Table 2 Measurements of aorta–vertebra angle (α) and vertebral rotation angle (β) before and after operation in right-side thoracolumbar/lumbar curves (R-AIS)

R-AIS	α (°)			β (°)		
	Preop	Postop	*P*	Preop	Postop	*P*
T11	57.9 ± 17.8	58.8 ± 13.5	0.747	14.0 ± 4.8	8.3 ± 4.6	0.004
T12	54. 4 ± 26.2	59.7 ± 17.9	0.102	18.3 ± 5.9	10.2 ± 6.1	<0.001
L1	56.7 ± 27.3	59.6 ± 17.8	0.447	20.9 ± 5.4	13.3 ± 6.4	<0.001
L2	61.6 ± 18.4	68.6 ± 14.0	0.075	19.9 ± 6.4	12.5 ± 7.3	0.001
L3	76.0 ± 13.3	72.7 ± 10.6	0.152	15.1 ± 6.7	11.1 ± 5.9	0.006
L4	83.1 ± 12.0	79.7 ± 10.5	0.197	11.9 ± 6.4	11.0 ± 5.13	0.469

Table 3 Measurements of aorta–vertebra angle (α) and vertebral rotation angle (β) before and after operation in left-side thoracolumbar/lumbar curves (L-AIS)

L-AIS	α (°)			β (°)		
	Preop	Postop	*P*	Preop	Postop	*P*
T11	74.9 ± 19.8	58.8 ± 13.5	0.125	18.8 ± 7.0	12.5 ± 5.9	<0.001
T12	101. 4 ± 19.3	89.0 ± 12.3	0.001	24.1 ± 3.2	18.1 ± 5.6	<0.001
L1	110.4 ± 18.0	93.3 ± 8.4	<0.001	26.4 ± 5.8	18.4 ± 6.3	<0.001
L2	111.2 ± 9.1	94.8 ± 7.6	<0.001	25.8 ± 5.4	18.9 ± 6.9	<0.001
L3	108.4 ± 9.3	96.0 ± 10.6	<0.001	24.5 ± 6.3	19.4 ± 6.2	0.002
L4	99.8 ± 11.5	91.4 ± 8.6	0.001	19.9 ± 6.8	17.8 ± 6.4	0.143

Table 4 Comparison of either LSD or RSD pre- and postoperation in left-side thoracolumbar/lumbar curves (L-AIS)

L-AIS	LSD (mm)			RSD (mm)		
	Preop	Postop	*P*	Preop	Postop	*P*
T11	43.0 ± 6.5	41.0 ± 5.7	<0.001	45.5 ± 3.8	48.0 ± 4.4	0.006
T12	52.5 ± 6.9	49.9 ± 5.9	0.09	51.4 ± 4.9	53.5 ± 4.3	0.020
L1	55.4 ± 6.5	52.5 ± 4.9	0.004	51.0 ± 4.5	54.7 ± 3.9	<0.001
L2	57.6 ± 5.7	52.1 ± 3.8	0.001	52.1 ± 3.8	53.9 ± 4.2	0.032
L3	56.5 ± 5.1	52.8 ± 3.7	<0.001	51.9 ± 5.5	54.5 ± 5.3	0.008
L4	53.8 ± 4.7	52.2 ± 3.7	0.108	49.9 ± 5.4	53.5 ± 4.7	<0.001

LSD left safety distance, *RSD* right safety distance

simulated screws, the risk was mainly caused by left PS placement (12.5–75.0 % at T11 and 6.3–68.8 % at T12). In Group L, the aorta impingement risk was mainly caused by right 45 mm PS (45.0 % at T11, 10.0 % at T12, 5.0–10.0 % at L1 and 15.0 % at L3 and L4). Collectively, a high risk of aorta impingement from PS insertion was noted at T11 and T12 levels. As shown in Table 5, the aortic impingement risk rate was higher in Group R than in Group L.

After operation

The percentage of aorta impingement from PS insertion showed a similar tendency before and after operation. However, the percentage of aorta impingement increased at the T11 and T12 levels when left PSs were inserted in Group R, while it increased at the T11 level when 35, 40 and 45 mm PSs were used in Group L (Table 6). In addition, the risk of aorta impingement from PS placement was significantly higher in Group R than in Group L (Table 7).

Discussion

With an increasing report of aorta impingement, numerous studies have been performed to investigate the position of the aorta in normal subjects or patients with scoliosis [14, 15]. In normal subjects, the aorta always resides on the left side of the thoracic spine and lies anteriorly on the lumbar spine [14], while in patients with scoliosis the aorta is more likely to locate on the lateral side of the spine. Specifically for patients with right thoracic scoliosis, the aorta shifts to the left side of the curve and is positioned more toward the left, laterally and posteriorly to the vertebral body. However for left thoracic curves, the aorta moves to the right and is positioned anterior to the vertebral body [11, 16]. In addition to the anatomy of the aorta, the risks of the aorta impingement caused by PS placement were also analyzed in earlier literature. Qiu et al. [17] evaluated the potential risk of aorta injury from PS misplacement in right thoracic AIS patients and concluded that the simulated 40 mm PS at T5, T6 and T11 posed a higher potential risk of aorta

injury. However, information regarding the risk of aorta impingement by PS misplacement after correction surgery was unavailable in their study. Theoretically, the aorta could leave its original position after the derotation procedure of correction surgery, which could lead to a high risk of aorta impingement due to the change in the relative position of aorta to vertebrae. Takeshita et al. [18] observed that the aorta moved anteromedially to the spine after the posterior correction surgery and concluded that the risk of aorta impingement could be increased from the correction of the deformity at the middle thoracic spine. Since the information about aorta movement after correction surgery in thoracolumbar or lumbar scoliosis remained limited, our study provided insight into the changes of the positions of the aorta in such situation and investigated the related risk of aorta impingement.

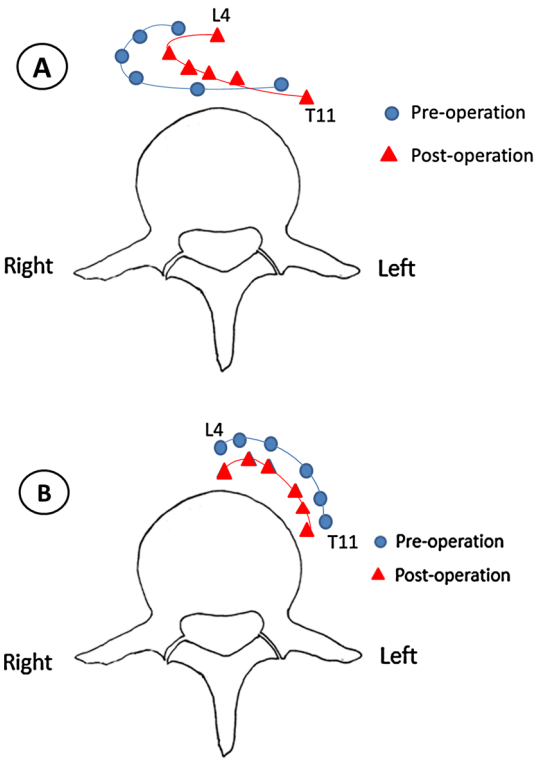

Fig. 2 The average course of the aorta relative to the spine before and after operation. The point was defined by the mean α angle and the mean LSD at each level. **a** The aorta relative to the spine in Group L. **b** The aorta relative to the spine in Group R

Our results showed that before operation, the risk of aorta impingement increased as the screw length increased. In Group R, the percentage of potential aorta risks from misplaced PSs at T12 dramatically increased to 68.8 % when inserting 45 mm PS, as compared to a 6.3 % incidence of aorta impingement by 35 mm PS. After comparing the risks of aorta impingement between the right- and left-sided curves, we found that the left PS in the right-sided curves posed a higher risk of aorta impingement. This finding was consistent with the previous study of Qiao et al. [11], who simulated PS placement in Lenke 5C curves and noted that the rate of aorta impingement was higher in the right-sided curve than in the left-sided curve. These findings might be ascribed to vertebrae rotation. In the left-sided curve, the RSD was relatively shortened because of the vertebra rotating toward the left, resulting in the aorta shifting to the right. In right curves, the LSD was relatively shortened due to the aorta getting closer to the left entry point as the vertebra rotated to the right. Further analysis of the aorta impingement risk indicated that it was mainly caused by left PSs at the T11 level in right-side curves, which might be due to the position of the aorta relative to the spine. The aorta was the closest to the spine at the T11 level when the position of the aorta to the spine was analyzed, and this finding was in line with previous studies [8, 18]. In those studies, the left pedicle–aorta (Ltp–Ao) angle and the Ltp–Ao distance from T11 to L4 were measured in Cartesian coordination and the aorta was found to be closest to the spine at the T11 level.

Postoperative risk analysis showed a similar trend with the preoperative one. Comparable with aorta movement after correction surgery in right thoracic scoliosis [18], our study showed that in Group L the aorta shifted leftward and got closer to the left entry point, especially at the T11 level. In Group R the aorta moved toward the vertebral body, leading to an increase in the rate of aorta impingement at the T11 and T12 levels. We also found that the risk of aorta impingement at the T11 level was significantly higher in Group R than in Group L. Collectively, the risk of aorta

Table 5 Comparison of either LSD or RSD pre- and postoperation in right-side thoracolumbar/lumbar curves (R-AIS)

R-AIS	LSD (mm)			RSD (mm)		
	Preop	Postop	*P*	Preop	Postop	*P*
T11	39.5 ± 5.7	40.3 ± 7.5	0.591	48.7 ± 4.7	49.6 ± 4.1	0.484
T12	42.3 ± 6.7	45.9 ± 5.3	0.028	53.4 ± 3.5	53.5 ± 3.2	0.947
L1	46.2 ± 7.3	44.4 ± 11.5	0.618	57.8 ± 3.4	55.8 ± 3.5	0.031
L2	50.1 ± 5.3	50.8 ± 3.8	0.601	59.6 ± 5.1	56.9 ± 3.8	0.097
L3	50.7 ± 6.2	51.1 ± 3.8	0.741	57.7 ± 4.0	56.6 ± 2.9	0.279
L4	51.6 ± 5.5	50.7 ± 5.1	0.440	55.7 ± 6.5	55.0 ± 3.2	0.586

LSD left safety distance, *RSD* right safety distance

Table 6 Percentages of the aorta impingement risks by simulating PS placement before and after operation

	35 mm				40 mm				45 mm			
	Group R		Group L		Group R		Group L		Group R		Group L	
	Pre-op (%)	Post-op (%)	Pre-op (%)	Post-op (%)	Pre-op (%)	Post-op (%)	Pre-op (%)	Post-op (%)	Pre-op (%)	Post-op (%)	Pre-op (%)	Post-op (%)
T11												
Left side	12.5 (2/16)	18.8 (3/16)	5.0 (1/20)	20.0 (4/20)	56.2 (9/16)	37.7 (6/16)	25.0 (5/20)	30.0 (6/30)	75.0 (12/16)	93.8 (15/16)	45.0 (9/20)	55.0 (11/20)
Right side	0	0	0	0	0	0	5.0 (1/20)	5.0 (1/20)	5.0 (4/16)	6.3 (1/16)	25.0 (5/20)	15.0 (3/20)
T12												
Left side	6.3 (1/16)	12.5 (2/16)	5.0 (1/20)	5.0 (1/20)	43.8 (7/16)	43.8 (7/16)	5.0 (1/20)	5.0 (1/20)	68.8 (11/16)	75.0 (12/16)	10.0 (2/20)	10.0 (2/20)
Right side	0	0	0	0	0	0	0	0	0	0	10.0 (2/20)	10.0 (2/20)
L1												
Left side	6.3 (1/16)	6.3 (1/16)	5.0 (1/20)	5.0 (1/20)	43.8 (7/16)	12.5 (2/16)	5.0 (1/20)	5.0 (1/20)	50.0 (8/16)	50.0 (8/16)	5.0 (1/20)	5.0 (1/20)
Right side	0	0	0	0	0	0	0	0	0	0	10.0 (2/20)	10.0 (2/20)
L2												
Left side	0	0	0	0	0	0	0	0	12.5 (2/16)	12. 5 (2/16)	5.0 (1/20)	5.0 (1/20)
Right side	0	0	0	0	0	0	0	0	0	0	5.0 (1/20)	5.0 (1/20)
L3												
Left side	0	0	0	0	0	6.3 (1/16)	5.0 (1/20)	5.0 (1/20)	0	0	0	0
Right side	0	0	0	0	0	0	0	0	0	0	15.0 (3/20)	15.0 (3/20)
L4												
Left side	0	0	0	0	0	0	0	0	0	0	5.0 (1/20)	5.0 (1/20)
Right side	0	0	0	0	0	0	5.0 (1/20)	5.0 (1/20)	0	0	15.0 (3/20)	15.0 (3/20)

Table 7 Comparison of aorta impingement by left-side PS misplacement at level T11 in both groups after operation

	35 mm		40 mm		45 mm	
	Impingement (%)	*P*	Impingement (%)	*P*	Impingement (%)	*P*
Group R	18.75	0.83	37.70	0.25	75.00	0.003
Group L	20.00		30.00		55.00	

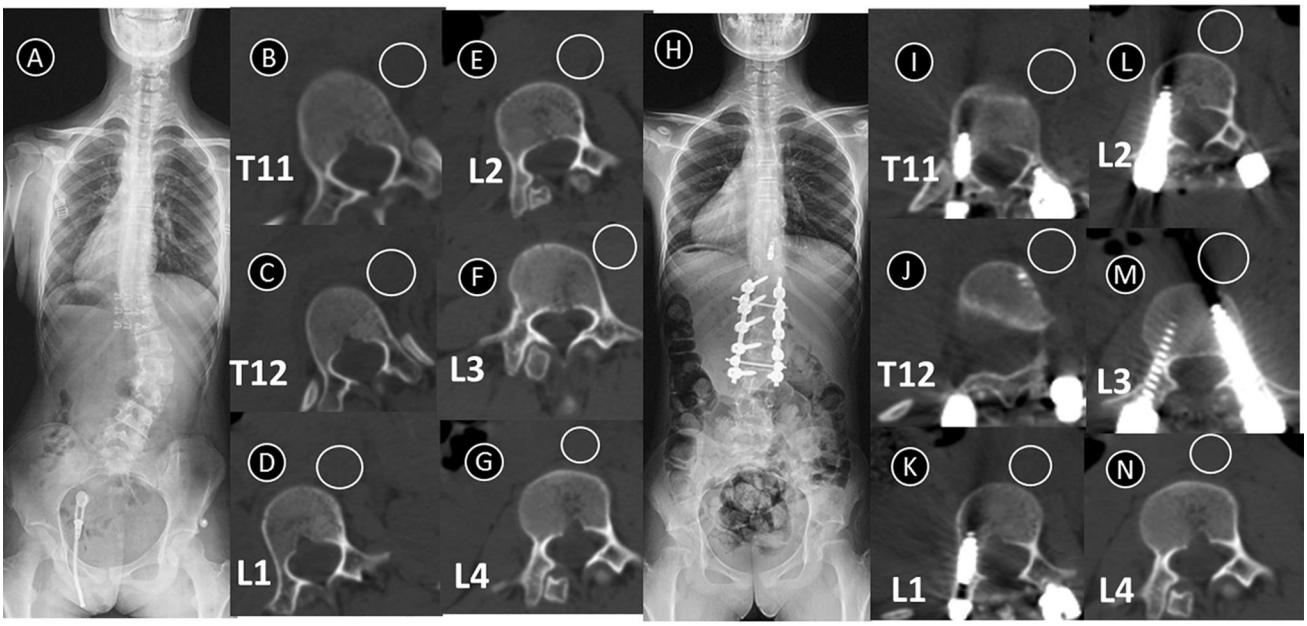

Fig. 3 A female AIS patient with a right lumbar curve. **a** Preoperative Cobb angle: 48°. **b–g** The course of the aorta relative to the spine from T11 to L4 preoperatively. **h** Posterior correction surgery with pedicle screws was performed from T11 to L3 levels. Postoperative Cobb angle: 8°. **i–n** The course of the aorta relative to the spine from T11 to L4, postoperatively

impingement increased in both groups after correction surgery, especially when inserting left-side PSs at the T11 level in Group R (Figs. 3, 4). In addition, the pre- and postoperative risk analysis showed that the aorta impingement risks were constantly elevated as the screw length increased especially in right curves, and 35 mm PSs seemed to carry smaller risks of aorta impingement at the thoracolumbar region when compared with 40 mm PSs. However, the difference in the risks was not significant, and 40 mm PS could provide bigger fixation strength. Weighing the pros and cons, we believed that 40 mm PSs should be used at the thoracolumbar region for a more stable correction. Surgically, the ideal length of PSs should be further determined by the ball-tip probe method to prevent aorta impingement occurrence. Although there were no data reporting aorta injury from misplaced PSs in thoracolumbar or lumbar scoliosis, our study provided insight into the possibility of aorta impingement following misplaced PSs. We speculated that comparable with aorta impingement in thoracic spine, aorta impingement in the thoracolumbar or lumbar scoliosis could consequently lead to aorta injury [19, 20]. Faro et al. [21] found histopathologic changes, including thinning of the bovine aortic wall secondary to screw impingement.

As one of the surgical interventions for Lenke 5C scoliosis, anterior instrumentation with vertebral screws has the advantage of avoiding aorta impingement. However, in terms of clinical outcomes, posterior instrumentation with PSs could provide a better opportunity to improve coronal plane correction [22]. Therefore, for patients with Lenke 5C scoliosis in our center, posterior instrumentation with PSs was performed. Surgically, to achieve better clinical outcomes, vertebral column manipulation (VCM) is commonly used to decrease axial plane deformity [23]. Herein, we also recommend performing VCM with ideal length pedicle screws.

Several potential limitations should be mentioned. The potential risk of aorta impingement was evaluated with patients in the supine position, which could be altered when the patient is placed in prone position during the

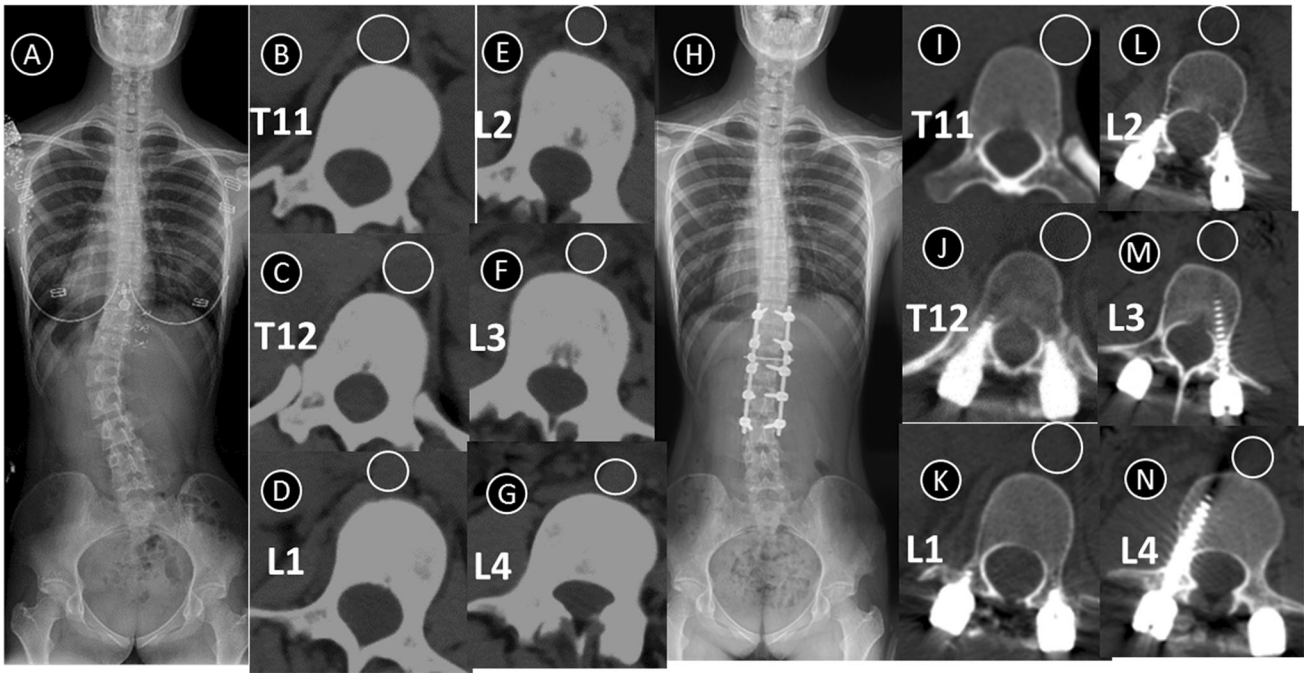

Fig. 4 A female AIS patient with a left lumbar curve. **a** Preoperative Cobb angle: 45°. **b–g** The course of the aorta relative to the spine from T11 to L4 preoperatively. **h** Posterior correction surgery with pedicle screws was performed from T12 to L4 levels. Postoperative Cobb angle: 4°. **i–n** The course of the aorta relative to the spine from T11 to L4, postoperatively

surgery. A previous study conducted in patients with right thoracic AIS showed that the aorta was potentially at a higher risk of injury in the prone position [24]. Further studies are warranted to determine whether Lenke 5C patients could also have elevated risk of aorta impingement when they are in the prone position. Recently, as one of the intraoperative imaging assistance techniques, intraoperative CT scans (O-arm) could allow visualization of the aorta and estimation of the risk of screw displacement, which could consequently decrease the risk of aorta impingement [25]. Therefore, O-arm could be used to decrease intraoperative risk of aorta impingent if possible. Pre- and postoperative CT scans were performed in the current study to investigate aorta movement following scoliosis surgery. However, radiation exposure of patients should not be ignored.

Conclusion

The risk of aorta impingement increased as the aorta shifted leftward after correction surgery, especially in right-sided Lenke 5C curve. Thus, preoperative risk evaluation could be insufficient in clinical practice due to aorta movement following correction surgery. Surgeons should be aware of the potential risk of aorta impingement, especially when placing PS in patients with right-sided curves.

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