

The Effect of lumbar lordosis on the distance between preemptive nail position of lumbar pedicle screw and prevertebral large vessels

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Research Article

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Abstract

Objective: To study the effect of lumbar lordosis on the distance between preemptive nail position of lumbar pedicle screw and anterior large vessels in imaging.

Methods: With the lumbar intervertebral disc plain CT scan data of 107 healthy human subjects, we had measured the lumbar lordosis angle, the distance between preemptive nail position of lumbar pedicle screw and anterior large vessels of each patient, and statistical analysis was performed by SPSS (v25.0).

Results: 1. No correlation was found between lumbar lordosis and the distance between preemptive nail position of lumbar pedicle screw and anterior large vessels in healthy people, but there was a weak positive correlation between lumbar lordosis and age. 2. In healthy people, the distance between L1-2 right preemptive nail position of lumbar pedicle screw and anterior large vessel was larger than that on left side, while the distance between L3-5 right preemptive nail position of lumbar pedicle screw was smaller than that on left side.

Conclusion: lumbar lordosis does not affect the distance between preemptive nail position of lumbar pedicle screw and anterior large vessels. Placing pedicle screw on the right side of L1-2 is more safe than placing it on the left side, and placing pedicle screw on the left side of L3-5 is more safe than on the right side.

Introduction

Nature lumbar lordotic curve is the third curve of the spine, which is developed around the time when infants learning to walk. Physiological lumbar lordotic curve has many biomechanical functions, such as making the lumbar vertebrae elastic, so as to reduce the shock impact on the body when carrying weight and strenuous exercise. When the physiological curvature of the lumbar spine becomes straight, it will cause degeneration and disorder of the vertebral facet joints, thus leading to a series of diseases such as lumbar disc herniation and lumbar spondylolisthesis[1]. Through CT angiography of the lower lumbar spine, Kang Zhongshan et al. found that mean distance from the bifurcation point of abdominal aorta to the lower edge of L5 vertebral body was 39.1 mm in men and 37.4 mm in women; and the mean distance from the convergence point of common iliac vein to the lower edge of L5 vertebral body was 27.1 mm in men and 27.1 mm in women[2]. However, when we draw these conclusions, we did not consider the measurement of the distance between the vertebral body and the large blood vessels will be affected by different lumbar lordosis angle of each patient. At present, there is lack of relevant literature on the influence of lumbar lordosis on the distance between preemptive nail position of lumbar pedicle screw and large blood vessels. The purpose of this paper is to observe the influence of lumbar lordotic curve on the distance between preemptive nail position of lumbar pedicle screw and large blood vessels through plain CT scan of lumbar intervertebral disc.

1. Materials And Methods

1.1 General Information

107 patients, 38 men and 69 women who underwent plain CT scan of lumbar intervertebral disc in the Affiliated Hospital of Chengde Medical University from April 2018 to September 2020, were enrolled in the study.

Inclusive criteria: ☐ the scanning segments included L1-S1; ☐ the imaging data were clear and high-quality, and there was no foreign body artifact interference; ☐ the imaging results were reported to patients with normal lumbar structure.

Exclusion criteria: ☐ CT image data of non Affiliated Hospital of Chengde Medical University, with poor image quality and unclear display; ☐ patients diagnosed with scoliosis, vertebral fracture, tumor or tuberculosis; ☐ patients with lumbar or retroperitoneal surgery history affecting normal anatomy.

1.2 Method

According to Magerl technique of pedicle screw placement, The pedicle screw should be aimed 10 degrees laterally, the angle of pedicle screw was 10 degrees laterally. We assumed the pedicle screw is on the central axis of the pedicle, and A represents the intersection point of the extension cord at the end of right side of the pedicle screw and the anterior edge of the vertebral body, and B represents the intersection point of the extension line of the end of pedicle screw on the other side and the front edge of vertebral body, and then we respectively measured the shortest distances between each point (A, B) and the anterior abdominal aorta, inferior vena cava, left and right common iliac artery and left and right common iliac vein. Then we measured the same distances at 5 different layers/Levels: L1, L2, L3, L4 and L5.

We used C to represent the shortest distance between preemptive nail position of lumbar pedicle screw and large vessel: the distance from point A to the posterior wall of the large vessel. As well, we used D to represent the shortest distance from point B to the posterior wall of the large vessel. ☐ Fig 1 ☐

Lumbar lordosis angle (Cobb angle): the acute angle formed by the line between L1 upper endplate and S1 upper endplate, and then making the vertical line of these two lines. ☐ Fig 2 ☐

1.3 Statistical Data Processing

The measurement data were expressed as mean \pm standard deviation and t-test was used. Pearson correlation analysis was used to test the correlation between Cobb angle and C, D values. SPSS (v25.0) was used for statistical analysis, and the difference was statistically significant when $P < 0.05$.

2. Results

2.1 General information of research objects

In this study, 107 healthy people were selected, including 38 men and 69 women, with an average age of 30.31 ± 9.03 years old,, and the average lumbar lordosis angle was 46.24 ± 7.87 degrees.(Table 1)

2.2 Correlation analysis of research objects

There was no correlation between Cobb angle and C, D distance of all vertebrae, which indicated that different lumbar lordosis did not affect the accuracy of C and D distance measurement.Cobb angle was weakly positive correlated with age, suggesting that lumbar lordosis increased with age.(Table 2)

2.3 Objective to compare the distance between the left and right preemptive nail position of lumbar pedicle screw and the anterior large vessels

The distance between the preemptive nail position of lumbar pedicle screw on the right of the L1 vertebra and inferior vena cava was 0.094 ± 0.25 cm whereas the distance between the preemptive nail position of lumbar pedicle screw on the left of the L1 vertebra and abdominal aorta was 0.26 ± 0.12 cm, and there was statistical difference between them ($T=29.405$, $P=0.000 < 0.05$). The distance between the preemptive nail position of lumbar pedicle screw on the right of the L2 vertebra and inferior vena cava was 0.64 ± 0.27 cm, and the left side was 0.34 ± 0.15 cm, and there was statistical difference between them ($T=12.894$, $P=0.000 < 0.05$). The distance between the preemptive nail position of lumbar pedicle screw on the right of the L3 vertebra and inferior vena cava was 0.33 ± 0.15 cm, and the left side was 0.47 ± 0.23 cm, and there was significant difference between them ($T=-7.068$, $P=0.000 < 0.05$). The distance between the preemptive nail position of lumbar pedicle screw on the right of the L4 vertebra and anterior large vessels was 0.21 ± 0.12 cm, and the left side was 0.42 ± 0.19 cm, and there was statistical difference between them ($T=-10.902$, $P=0.000 < 0.05$). The distance between the preemptive nail position of lumbar pedicle screw on the right of the L5 vertebra and anterior large vessels was 0.19 ± 0.15 cm, and the left side was 0.24 ± 0.21 cm. There was significant difference between them ($T=-1.988$, $P=0.049 < 0.05$). (Table 3)

3. Discussion

3.1 Physiological significance of lumbar lordosis

Adult spine and lumbar spine in the sagittal plane will produce a forward physiological arc, called lumbar lordosis. The existence of lumbar lordosis not only increases the ability of spinal shock buffering, but also makes the lumbar spine as elastic as spring, so as to reduce the shock impact on the body when carrying weight and strenuous exercise. Tony S. Keller et al. found that the vertical gravity loads of lumbar disc increased significantly with decreasing lumbar lordosis. With the reduction or disappearance of lordosis, it will lead to the degeneration of intervertebral disc tissue and cause lumbar disc herniation[3].

3.2 changes of lumbar lordosis under different postures and mattress hardness

Through the research results, Kondeqi et al. showed that: the lumbar sagittal curvature in the standing position is differs from it in the lateral position. The Cobb angle of L1-S1 lumbar spine in the standing

neutral position is greater than that in the lateral lying neutral position, which indicates that the physiological load state has an obvious influence on the lumbar sagittal curvature, and hence the lumbar range of motion in the standing position is larger than that in the lateral position[4]. Not only will the changes of body position have an impact on lumbar lordosis, but also the soft and hard degree of mattress have an impact on lumbar lordosis. Zhao Xiaodong and others believed that: hard plate and medium hardness mattress are conducive to maintaining the normal lower lumbar lordosis angle, and the medium hardness mattress can also bring comfort when lying in bed[5]. In this study, all the subjects were measured in the supine position on hard bed, which reduced the experimental error.

3.3 the influence of lumbar lordosis on the distance between vertebral body and large vessels in healthy people

The results of this study showed that: lumbar lordosis does not affect the distance between preemptive nail position of lumbar pedicle screw and anterior large vessels. The reasons may be as follows: when the lumbar lordosis increases, the abdominal aorta and inferior vena cava will also produce physiological lordosis, but the relative position with the lumbar vertebral body remains unchanged. In addition, Charles D. moussallem et al. considered that with the increase of lumbar lordosis, the bifurcation point of abdominal aorta and the junction of inferior vena cava moved to the proximal end[6]. Although lumbar lordosis has little effect on the relative position of the lumbar vertebrae and the anterior vertebral vessels, it is still necessary to prevent vascular injury during the operation.

3.4 the relationship between the location of the pedicle screw and the anterior large vessels

According to literature statistics, the incidence of vascular injury in posterior lumbar surgery is between 0.01% and 0.05%, but the mortality rate is as high as 15% to 61%, and this data has not decreased in the past 50 years[7,8]. After a retrospective analysis of 77 patients with vascular injury complications, Bingchuan Liu et al. found that the injury of common iliac artery and common iliac vein was the most common[8]. Early presentation is shock due to rupture of a large retroperitoneal vessel. Late complications include development of pseudoaneurysms and arteriovenous fistulas[9]. Since the lumbar lordosis is not significantly related to our measurements at any vertebral level, our results will be more convincing: from L1 to L5, the distance between preemptive nail position of lumbar pedicle screw on the right side and anterior large vessel in the healthy population gradually decreased, whereas on the left side the distance gradually increased, and the distance between the preemptive nail position of lumbar pedicle screw on the right of the L1 vertebra and anterior large vessel was the longest ($0.94 \pm 0.25\text{cm}$), and the distance between the preemptive nail position of lumbar pedicle screw on the right of the L5 vertebra and anterior large vessel was the shortest ($0.19 \pm 0.15\text{cm}$). This further suggests that the risk of vascular injury in the right lumbar pedicle screw placement increases gradually from L1 to L5, and exceeds the risk of left pedicle screw placement at the L3 level. Foxx Kand others[10] believed that increasing the depth of pedicle screw placement can effectively improve the strength and stability of pedicle screw fixation. This suggests that we can measure the relevant data through the relevant imaging data before operation, appropriately increase the depth of fixation, and formulate individualized operation plan for each patient.

Limitations of this study: the patients underwent the CT scan in the supine position, but the posterior surgery is doing with the patient in prone position. Ganesan C et al. considered that the auxiliary examination in supine position can reduce the distance between vertebral body and large blood vessels before vertebral body, and in prone position, both the bifurcation point of abdominal aorta and confluence point of inferior vena cava would be moved to the proximal end in prone position.

4. Conclusion

In conclusion, lumbar lordosis does not affect the distance between preemptive nail position of lumbar pedicle screw and anterior large vessels. In healthy people, placing the pedicle screw placement on the right side of L1-2 is more safe than that on the left side, and placing the pedicle screw on the left side of L3-5 is more safe than that on the right side.

Declarations

Ethics approval and consent to participate

The present study was approved by the Ethics Committee of the Affiliated Hospital of Chengde Medical University. Informed consent obtained from each participant was written. All protocols are carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request. Readers can access the data and material supporting the conclusions of the study by contacting Zhao Li at 654720450@qq.com.

Competing interests

The authors declare that they have no conflict of interest.

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Not applicable.

Authors' contributions

SH designed the study. ZL and WCG wrote the main manuscript text. FC and ZHS analyzed the data.

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Tables

Table 1. Age, gender and lumbar lordosis of the research subjects

Total number of people	Men	Women	Age (years)	Lumbar lordosis (°)
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107	38	69	30.31±9.03	46.24±7.87
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Table 2. Pearson correlation analysis of Cobb angle with age, C and D values in healthy population

group		Age	L1D	L1C	L2D	L2C	L3D	L3C	L4D	L4C	L5D	L5C
Cobb angle	Correlation coefficient	0.208	-0.185	-0.074	-0.066	0.007	-0.041	-0.109	0.016	-0.087	0.087	0.066
	P value	0.031	0.56	0.448	0.502	0.941	0.673	0.265	0.869	0.371	0.374	0.497

Table 3 the distance between the left and right preemptive nail position of lumbar pedicle screw and the anterior large vessels in healthy people

	L1	L2	L3	L4	L5
D [cm]	0.94±0.25	0.64±0.27	0.33±0.15	0.21±0.12	0.19±0.15
C [cm]	0.26±0.12 [□]	0.34±0.15 [□]	0.47±0.23 [□]	0.42±0.19 [□]	0.24±0.21 [□]

Note: □ compared with D, P < 0.05

Figures

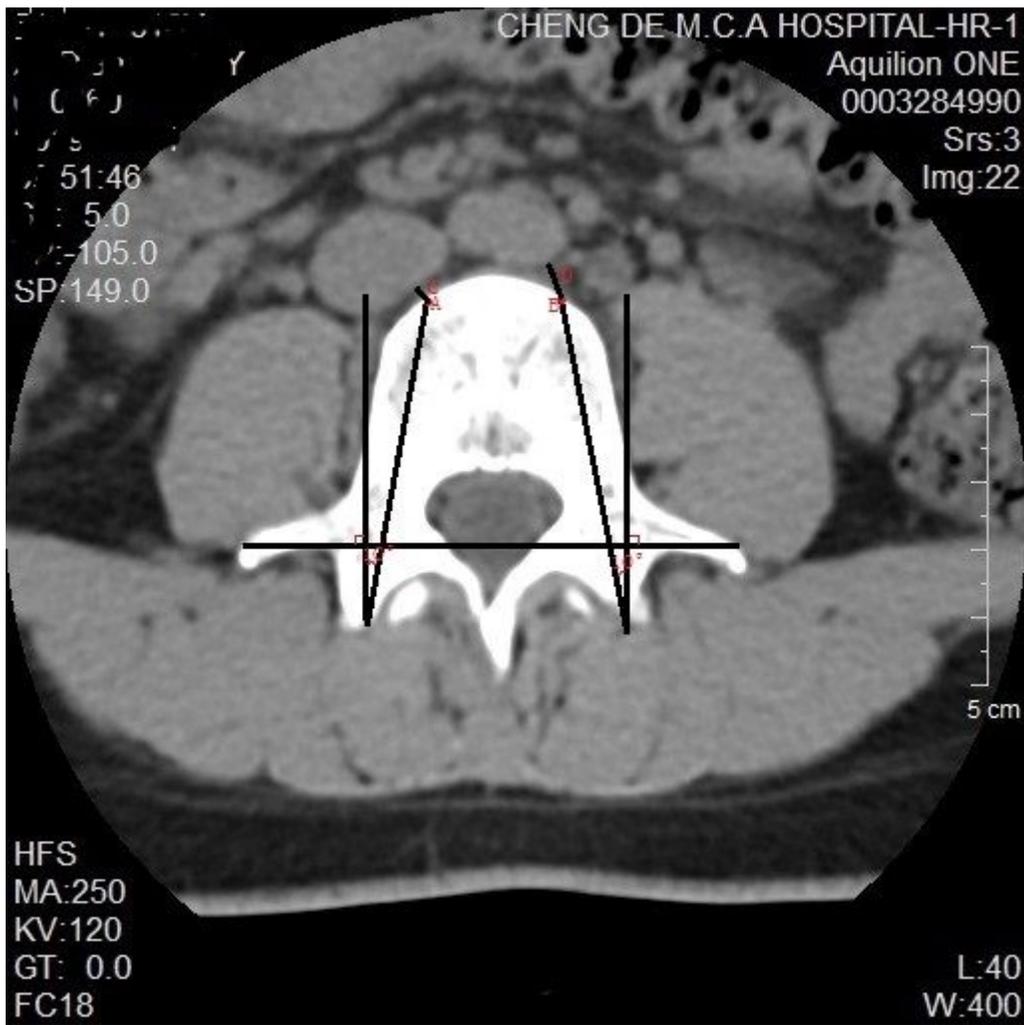


Figure 1

the measurement of distance between preemptive nail position of lumbar pedicle screw and anterior large vessels

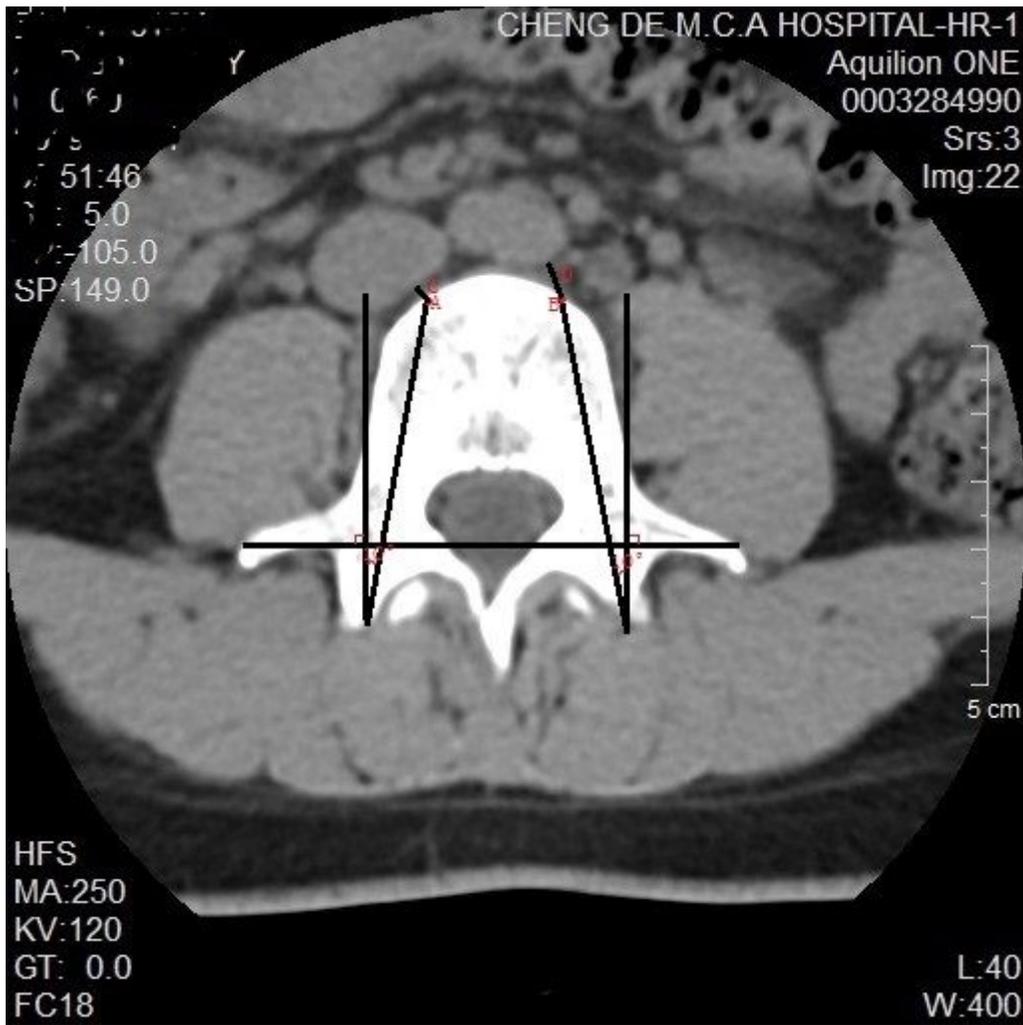


Figure 1

the measurement of distance between preemptive nail position of lumbar pedicle screw and anterior large vessels



Figure 2

the measurement of Cobb angle



Figure 2

the measurement of Cobb angle