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A MORPHOMETRIC STUDY OF VENTRAL NERVE ROOTS AND RETROPERITONEAL VESSELS IN RELATION TO A MINIMALLY INVASIVE LATERAL APPROACH TO DETERMINE SAFE WORKING ZONE

Orthopaedics

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ABSTRACT

Background: The minimally invasive lateral retroperitoneal transpsoas approach is a new method that was designed to minimize problems related with standard or minimally invasive anterior or posterior lumbar spine techniques. The current work used magnetic resonance imaging to determine the anatomic location of the ventral root and retroperitoneal arteries in respect to the vertebral body and to establish the anatomical safe zones. **Method:** We examined lumbar spine MRI in 50 individuals retrospectively (L1-L2 to L5-S1 levels). The ventral root and surrounding major arteries were identified using axial T1 and T2 scans. Axial MR scans were utilized to determine the anterior-posterior (AP) diameter of the vertebral endplate, the overlap between the ventral root and the posterior border of the vertebra, and the overlap between the retroperitoneal big vessels and the anterior edge of the vertebra. The safe zone was then determined. **Results:** From L1–L2 to L5–S1, the mean AP diameter of the vertebral body and the overlap of the vertebral body with the nerve roots and retroperitoneal arteries grew gradually. When we examined the extent of overlap of retroperitoneal arteries with the ventral border of the lower vertebral body endplate, we discovered that the right vascular structures were more posterior than the left vascular structures. The safe working zone was 81.86 percent of the lower endplate of the sagittal diameter of the vertebral body at L1–L2, 70.03 percent at L2–L3, 69.32 percent at L3–L4, 50.08 percent at L4–L5, and 17.92 percent at L5–S1 levels. **Conclusion:** The retroperitoneal transpsoas method is a less invasive and more efficient alternative to the conventional posterior, open lumbar procedures. It can be used to treat trauma, degenerative disc disease, adult degenerative scoliosis, spondylosis with instability, spondylolisthesis, lumbar stenosis, and neighboring segment failure.

KEYWORDS

Lumbar spine, minimally invasive, Ventral root, Retroperitoneal vessels, Vertebral body, Safe zones, Magnetic resonance imaging

INTRODUCTION

Spinal fusion is a popular therapy for diseases of the spine such as disc degeneration, Spondylolisthesis, deformity, and fracture. Lumbar spinal fusion can be accomplished by posterolateral or/and interbody fusion. The reported procedures for achieving interbody fusion are the posterior approach (PLIF: posterior lumbar interbody fusion), the transforaminal approach (TLIF: transforaminal lumbar interbody fusion), and the anterior approach (ALIF: anterior lumbar interbody fusion). Although these procedures give anterior column support and acceptable clinical results, they are not without risks [1,2].

To overcome the complications, recently the minimally invasive lateral retroperitoneal transpsoas approach technique developed for lumbar spine. There are two described types: DLIF (direct lumbar interbody fusion) and XLIF (extreme lumbar interbody fusion). It is prescribed for degenerative disc disease, scoliosis, and far-lateral disc herniation [3-6]. This method employs a tiny incision that prevents substantial abdominal muscle damage while allowing lateral access to the disc region from L1–L2 to L4–L5. Because of the position of the iliac crest, the trans psoas approach to the L5S1 disc region is not practicable [5]. For exposure, the XLIF and DLIF methods do not need retroperitoneal big vessel modification [7].

However, the retroperitoneal arteries and ventral nerve roots are located near to the surgical tract, increasing the risk of damage to these anatomical structures. As a result, precise understanding of these anatomic connections is required for minimally invasive retroperitoneal transpsoas approach and interbody fusion. It is difficult to select the precise spot at which to divide the psoas muscle. If the entrance site is too far anterior or too far posterior, the vessels or nerve roots may be injured. A thorough understanding of the regional anatomy of the lumbar plexus is required to assure safe transit via the psoas muscle. The surgeon will be able to see the neural structures at the operative levels and ensure that abdominal vessels do not impede the lateral disc space if the axial MRI images are examined prior to surgery [8]. The purpose of this research is to identify the anatomic connection between the vertebral body and the surrounding arteries and nerves in order to define the surgical safe zone for performing lateral approach operations.

MATERIALS AND METHODS

A retrospective and observational study was carried out at "SETH G S MEDICAL COLLEGE & KEM HOSPITAL, Mumbai" during a period of 1 year from 2018 to 2019 or at least 50 MRI samples. Inclusion criteria for MRI was all patients of Indian origin irrespective of age and gender who got their MRI lumbosacral (LS) spine done at MRI, Radiology Dept of the institute without any significant abnormality reported. Patients who got their MRI LS spine done at KEM hospital showing pathology of vertebrae, patients with history of spine fracture, deformity, infection and tumor, previous lumbar surgery, and MRI of post-operative patients were excluded from the study.

A total of 50 lumbar spine MRI scans from individuals with no spinal deformity were examined. The ventral root and surrounding major arteries were identified using axial T1 and T2 scans. The following parameters were measured using axial MR images: the anterior-posterior (AP) diameter of the vertebral endplate (A), the overlap between the ventral root and the posterior margin of the vertebra (B1, B2), and the overlap between the retroperitoneal large vessels and the anterior edge of the vertebra (B1, B2). (C1 and C2) Millimeters were used for the measurements. The PACS software computer digitizer was used to take measurements.

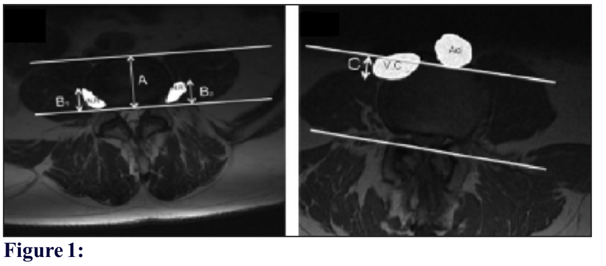

Figure 1:

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Distance A is the vertebral body's AP diameter.

B1 and B2 are the distances between the nerve root's ventral edge and the vertebra's posterior edge.

Distance C is the overlap between the vertebra's ventral border and the vena cava's posterior border.

The relative vertebral body diameter prior to the nerve root and posterior to the retroperitoneal vessel is the surgical safe zone.

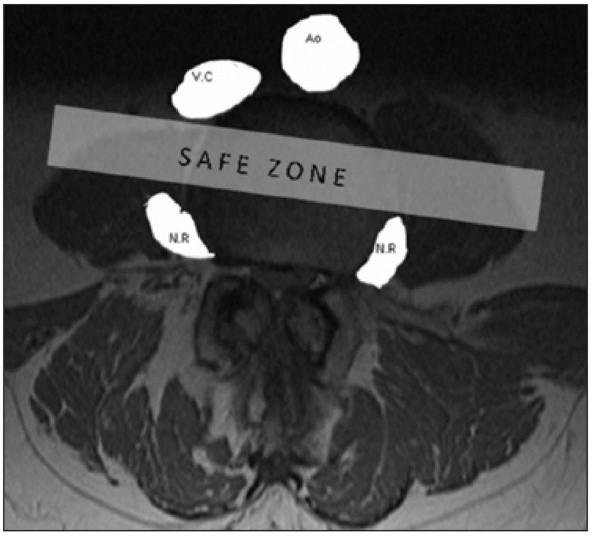

Figure 2:
The size of the safe zone was calculated by using the following formula for each patient:
Safe zone (mm) = A – B – C
where, A = Anteroposterior diameter of the vertebral body

B denotes the distance between the ventral edge of the left or right nerve root and the posterior margin of the vertebra (whichever is more)
C Indicates Overlap between the vertebral ventral border and the aorta or vena cava posterior border (whichever is more)

The following formula was used to compute the safe zone percentage:
A-B-C x 100 / A

Statistical Analysis

The measures of the nerve roots and blood vessels were given as 95 percent CIs, but the vertebral body AP and breadth diameter were presented as means with standard error. SPSS (version 15.0, Chicago, IL) was used for statistical testing, with -values set to 0.05. The difference between the different levels within the normal group was compared using one-way repeated analysis of variance. The interclass correlation coefficient was used to assess interobserver reliability. P>0.05 considered NOT significant by One-way ANOVA test. P<0.05 considered significant by post-hoc analysis after one-way ANOVA test.

OBSERVATIONS AND RESULTS

MRI scans were used to measure the intervertebral segments of 22 females and 28 males. Patients varied in age from 18 to 78 years old, with a mean age of 47.67+16.31 years. It was observed that the mean AP diameter of the vertebral body increases from L1-L2 to L5-S1 levels as shown in Figure 3. The range being 32.72 – 32.94 for L1-L2 (Group A), 32.62- 32.86 for L2-L3 (Group B), 33.73 – 33.93 for level L3-L4 (Group C), 33.69 – 33.96 for level L4-L5 (Group D) and 34.85 – 35.07 for level L5-S1 (Group E).

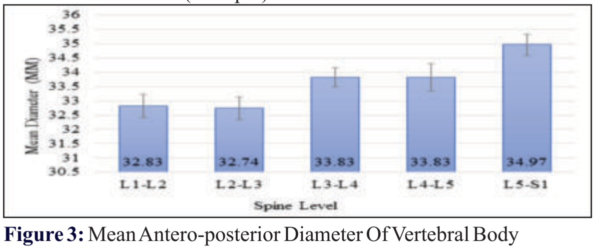

Figure 3: Mean Antero-posterior Diameter Of Vertebral Body

Table 1 shows data on the location of nerve roots as well as the position of right and left retroperitoneal vessels. Both sides of the spine were measured for the extent to which the retroperitoneal arteries and nerve roots overlapped with the lower endplate of the vertebral body. The nerve root projection is the same on both sides. From L1–L2 to L5–S1, the overlapping of the vertebral body with the nerve roots and retroperitoneal arteries grew gradually. When the extent of the overlap of the retroperitoneal arteries with the ventral border of the lower vertebral body endplate was examined, we discovered that the right vascular structures were more posterior than the left vasculature.

Table 1: Data On The Location Of Nerve Roots, As Well As The Position Of The Right And Left Retroperitoneal Vessels

Parameters	Spine Level	Mean ± SD (mm)	Min (mm)	Max (mm)	95% CI low	95% CI High
B1	L1-L2	3.33±0.30	2.95	3.89	3.24	3.42
	L2-L3	5.57±0.23	5.24	6	5.50	5.63
	L3-L4	5.85±0.26	5.43	6.3	5.77	5.92
	L4-L5	9.24±0.43	8.45	9.98	9.11	9.36
	L5-S1	17.52±0.85	15.5	18.7	17.27	17.76
B2	L1-L2	3.30±0.25	2.9	3.9	3.22	3.36
	L2-L3	5.52±0.22	5.23	5.99	5.45	5.58
	L3-L4	5.82±0.27	5.44	6.29	5.74	5.9
	L4-L5	9.24±0.44	8.65	9.98	9.11	9.37
	L5-S1	17.80±0.59	16.3	18.7	17.63	17.97
C1	L1-L2	2.52±0.51	1.75	3.77	2.37	2.67
	L2-L3	4.13±0.39	3.48	4.9	4.01	4.24
	L3-L4	4.40±0.39	3.78	5.34	4.28	4.51
	L4-L5	7.40±0.48	6.55	8.2	7.26	7.54
	L5-S1	9.31±0.79	7.36	10.3	9.08	9.54
C2	L1-L2	0.33±0.27	0	0.9	0.24	0.4
	L2-L3	0.30±0.11	0.1	0.48	0.27	0.33
	L3-L4	0.33±0.1	0.1	0.55	0.29	0.36
	L4-L5	2.49±0.47	1.75	3.65	2.36	2.63
	L5-S1	10.66±1.6	1.22	12.41	10.19	11.12

[Average distance between both the ventral edge of the right nerve root and the posterior edge of the vertebra (B1), and average distances between the ventral edge of the left nerve root and the posterior edge of the vertebra (B2) (B2), Mean Overlap between the vertebral ventral border and the vena cava posterior border (C1), Mean Overlap between the vertebral ventral border and the aorta posterior border (C2) (C2)]

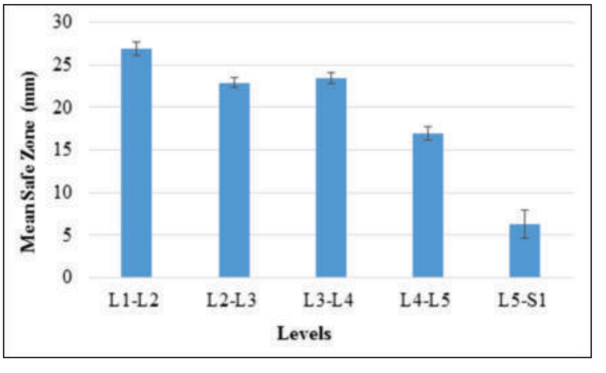

Figure 4: Mean safe zone diameter at different levels (mm)

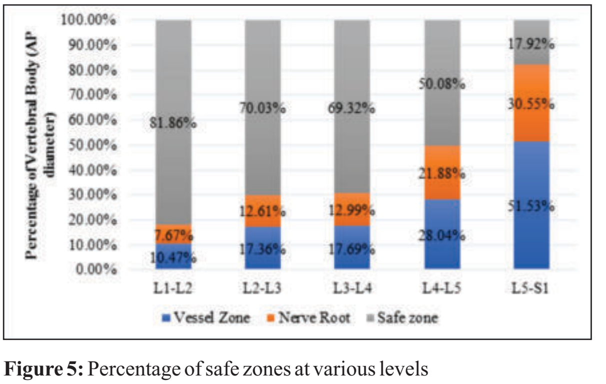

Figure 5: Percentage of safe zones at various levels
As shown in Figure 4, the mean values of the safe zones and the % were

determined. The safe working zone was 81.86 percent of the lower endplate of the sagittal diameter of the vertebral body at L1–L2, 70.03 percent at L2–L3, 69.32 percent at L3–L4, 50.08 percent at L4–L5, and 17.92 percent at L5–S1 levels.

Between L1–L2 and L5–S1, the safe working zone reduces significantly ($p<0.05$). In comparison to the L1–L2, L2–L3 levels, the more anterior location of the nerve root and the more posterior position of the retroperitoneal arteries at the L4–L5 and L5–S1 levels results in a considerable decrease of this region. (Figure 5).

DISCUSSION

Hasegawa et al [9] reported the typical anatomic characteristics of the lumbosacral nerve roots using an MRI investigation. They discovered that the length of the nerve roots rose progressively, reaching a maximum at L5, and that the nerve root origin for the caudal nerve roots was located at a more cephalad position. Regev et al [8] used MRI examinations to do a morphometric research to determine the anatomic location of the nerve roots and major retroperitoneal veins in respect to the vertebral body. Exams from properly aligned vertebrae, spondylolisthetic segments, and segments from the apex of degenerative lumbar scoliosis were reviewed. They discovered that at the L4–L5 level, the probability of damage to the ventral nerve roots and retroperitoneal big vessels rose substantially. The main benefit of this study is that it uses clearly recognizable radiographic reference sites and the relative ratio between distinct anatomical components and the vertebral body for radiographic assessment. These precautions can be used during surgical operations. These findings are congruent with the findings of the current investigation.

There was a substantial lowering of the safe zone at the L4–L5 level in the current research. The more anterior position of the nerve root and the more posterior position of the retroperitoneal arteries at the L4–L5 level produce a considerable decrease of this area when compared to the L1–L2, L2–L3 levels. We discovered that the decrease in safe zone size at the L4–L5 level was caused by the nerve roots' more anterior location compared to the L3–L4 level. This treatment appears to be most hazardous at L4–L5, where nerve and vascular injury is theoretically a significant risk. These can be life-threatening consequences. Because of the vascular anatomy, discectomy and intersomatic fusion are usually done on the left side via the tranpsoas route. However, depending on the surgeon's inclination and the features of the level being operated on, it can be performed on the right side (in the case of asymmetric disc collapse for example). We estimated this safe zone using measurements acquired on the right side since the projection of arteries is more posterior on the right than on the left, but the projection of nerve roots is the same on both sides. We feel it is critical not to exaggerate the size of this region by considering simply the approach side (for the left-hand side). There may already be a contralateral disc fracture, or the annulus may have been injured by the forceps during discectomy, resulting in a contralateral vascular lesion. However, one important limitation of MRI investigations is the inability to detect the sympathetic trunk, the genitofemoral nerve, or other branches of the lumbar plexus that pass through the retroperitoneal adipose tissue.

A well-known consequence of the mini-invasive lateral transpsoas technique is postoperative sensory loss [10]. Intraoperative EMG neural monitoring can also be utilized to decrease the risk of nerve damage when moving the dilating device through the psoas muscle [11]. It adds extra safety during this operation, since visibility is limited compared to an open treatment. This perioperative test, however, has been challenged since it only aids in the identification of motor nerves [10]. Fluoroscopy in the coronal and sagittal views is commonly utilized to assess the size of the cage and to provide guidance throughout the surgical process. Dilating and retracting equipment must be carefully positioned because if it is put posteriorly, it may cause neurological damage, particularly at the L4–L5 level. [12]. This treatment appears to be most hazardous at L4–L5, where nerve and vascular injury is theoretically a significant risk. Furthermore, the superior iliac crest limits the possible exposure location to L4–L5. Based on our findings, it is better to employ other methods such as TLIF or ALIF at the L4–L5 level. This method is no longer used at this level. Our preoperative preparation includes carefully determining safe zones for the other levels. A straightforward way is to provide these statistics on peroperative fluoroscopy images.

Preoperative planning and safe zone delineation are straightforward procedures for determining the relative location of neurological and vascular anatomic structures in respect to the surgical site. It allows for the assessment of the theoretical risk of neurovascular damage during the surgery. This technique can assist spine surgeons in preventing perioperative problems and preparing for surgery. These studies show the value of preoperative planning in transpsoas approach surgery, but they cannot replace anatomical expertise and particular care during surgery. For safe passage through the psoas muscle during the minimally invasive lateral transpsoas approach, a thorough understanding of the regional anatomy of the lumbar plexus is necessary. Furthermore, intraoperative monitoring and safe zone identification are two important adjuncts for reducing neurovascular damage during the transpsoas approach.

CONCLUSION

The retroperitoneal transpsoas method is a less invasive and more effective alternative to the conventional posterior, open lumbar procedures. It can be used to treat trauma, adult degenerative scoliosis, degenerative disc disease, spondylosis with instability, lumbar stenosis, spondylolisthesis, and neighboring segment failure. There is a learning curve to overcome, as with other minimally invasive procedures, in order to reduce the danger of iatrogenic nerve damage. When conducting a MIS LIF, it is critical to stay in the posterior third of the disc space at L1-L2, L2-L3, and L3-L4, or at the middle of the vertebral body at L4-L5. T-EMG can assist advise the surgeon and warn them to the near vicinity to neighboring motor neurons. Even after treatment, transitory sensory impairments and, in some cases, weakening may develop, and it is critical to communicate this possibility with the patient prior to surgery.

REFERENCES

1. Hackenberg L, Halm H, Bullmann V, Vieth V, Schneider M, Liljenqvist U (2005) Transforaminal lumbar interbody fusion: a safe technique with satisfactory three-to-five-year results. Eur Spine J 14:551–558.
2. Yan DL, Pei FX, Li J, Soo CL (2008) Comparative study of PLIF and TLIF treatment in adult degenerative spondylolisthesis. Eur Spine J 17:1311–1316.
3. Anand N, Baron EM, Thaiyananthan G, Khalsa K, Goldstein TB (2008) Minimally invasive multilevel percutaneous correction and fusion for adult lumbar degenerative scoliosis: a technique and feasibility study. J Spinal Disord Tech 21:459–467.
4. Ozgur BM, Aryan HE, Pimenta L, Taylor WR (2006) Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion. Spine J 6:435–443.
5. Dakwar E, Cardona RF, Smith DA, Uribe JS (2010) Early outcomes and safety of the minimally invasive, lateral retroperitoneal transpsoas approach for adult degenerative scoliosis. Neurosurg Focus 28: E8.
6. Eck JC, Hodges S, Humphreys SC (2007) Minimally invasive lumbar spinal fusion. J Am Acad Orthop Surg 15:321–329.
7. Fantini GA, Pappou IP, Girardi FP, Sandhu HS, Cammisa FP Jr (2007) Major vascular injury during anterior lumbar spinal surgery: incidence, risk factors, and management. Spine 32:2751–2758.
8. Regev, G. J., Chen, L., Dhawan, M., Lee, Y. P., Garfin, S. R., & Kim, C. W. (2009)."Morphometric analysis of the ventral nerve roots and retroperitoneal vessels with respect to the minimally invasive lateral approach in normal and deformed spines."Spine (Phila Pa 1976) 34(12): 1330-1335.
9. Hasegawa T, Mikawa Y, Watanabe R, An HS (1996) Morphometric analysis of the lumbosacral nerve roots and dorsal root ganglia by magnetic resonance imaging. Spine 21:1005–1009.
10. Dakwar E, Cardona RF, Smith DA, Uribe JS (2010) Early outcomes and safety of the minimally invasive, lateral retroperitoneal transpsoas approach for adult degenerative scoliosis. Neurosurg Focus 28: E8.
11. Ozgur, B. M., Aryan, H. E., Pimenta, L., & Taylor, W. R. (2006). "Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique for anterior lumbar interbody fusion."Spine J 6(4): 435-443.
12. Benglis, D. M., Elhammady, M. S., Levi, A. D., & Vanni, S. (2008). "Minimally invasive anterolateral approaches for the treatment of back pain and adult degenerative deformity." Neurosurgery 63(3 Suppl): 191-196.