

## Accuracy of Anatomical Markers in Numbering Spine Vertebrae in A Full Spine MRI

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### Abstract

**Background:** Because of Lumbosacral Transitional Vertebra (LSTV), which is a common variant, the numbering of spinal vertebrae could be inaccurate. In this study, the potential role of paraspinal anatomical structures was assessed for exact numbering of spinal vertebrae.

**Methods:** In this cross-sectional study, 51 MRI images were studied. MRI machine in this study was Siemens 1.5 T MRI with the following specifications: T2 TSE sag TR3660 TE95 and T1 TSE sag TR645 TE11 with 4 mm slice thickness. The anatomical distribution of the thoracic and lumbar paraspinal structures of the spine was assessed.

**Results:** The mean age of cases was 46.9 years (range=20-76). In the cervical region, all subjects showed the widest spinous process in C2 vertebra and the longest one in C7. In the thoracic and abdominal regions, there were few or considerable anatomical variations in each landmark; carina was adjacent to T5 or T5-T6 intervertebral disc in 57% of subjects, left pulmonary artery was adjacent to T5 or T5-T6 intervertebral disc in 55% of subjects and upper ridge of manubrium was adjacent to T2-T3 intervertebral disc or T3 in 55% of subjects. In the low back area of all patients with normal lumbosacral segmentation, the iliolumbar ligament was placed at L5 level (94%), at L4 in L5 sacralization cases (4%) and S1 in S1 Lumbarization cases (2%).

**Conclusion:** Some paraspinal anatomical structures could be helpful in numbering vertebrae but is challenging and full spine MRI is a better alternative.

**Keywords:** Magnetic resonance imaging, Spinal diseases, Vertebrae

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## Introduction

Pain and morbidity related to the spinal disease are one major cause of in-person patient-doctor visits (1). Magnetic Resonance Imaging (MRI) is one of the best modalities in evaluation of spinal stenosis, which can assess the vertebral body, intervertebral disc, ligaments, spinal canal, and neural foramen accurately. Also, it is a good method for diagnosis of tumors, infections, and degenerative diseases (2-4).

In MRI, the accurate number of the cervico-thoracolumbar and sacral vertebrae is an important factor in treating abnormalities in this area especially before any surgical intervention; therefore, incorrect numbering leads to complications, which is the main reason for patients to complain (5-9). In lumbar MRI, a radiologist usually evaluates the lumbar vertebrae level based on the morphology of vertebral body, lumbosacral angle in the sagittal view, and situation of intervertebral discs. Choosing the exact location of lumbar vertebrae when using lumbar radiography or MRI alone can be incorrect, because the occurrence of Lumbosacral Transitional Vertebra (LSTV), a common type, is 30% (5-7)

In this study, the anatomical position of paraspinal anatomical structures in the vicinity of thoracolumbar vertebrae was examined and the potential role of paraspinal anatomical structures was assessed for exact numbering of spinal vertebrae.

## Materials and Methods

In this descriptive cross-sectional study, 51 patients were enrolled for full spine MRI including cervical, thoracic, and lumbosacral spines.

The patients with spinal anomalies, deformities, severe scoliosis, kyphosis, and lordosis, congenital anomalies, vertebrae collapse, compression fracture, metastatic infectious diseases, age under 18, trauma and previous spinal surgery were excluded. The study was approved by the ethical committee of Tehran University of Medical Sciences.

MR imaging: MRI machine was Siemens 1.5 T MRI with the following specifications: T2 TSE sag TR 3660 TE 95 and T1 TSE sag TR 645 TE 11 with 4 mm slice thickness in sagittal, axial, and coronal MR images of the whole spine. The anatomical distribution of the thoracic and lumbar paraspinal structures to the spine including carina, left pulmonary artery, upper ridge of

the manubrium of the sternum, aortic artery arch, right pulmonary artery, superior mesenteric artery, celiac trunk, aortic artery bifurcation, right renal artery, psoas muscle origin, the tip of conus medullaris and iliolumbar ligament were assessed. The widest and longest spinous processes of the cervical vertebrae were determined and vertebrae were counted caudally from C2 to S1.

## Results

Our patients were 51 cases among which 33 were female (64.7%) and 18 males (35.3%). Mean age was  $46.9 \pm 6.7$  years old, with a range of 20-76. From 51 MR images, 47 had a normal lumbosacral spine (92.2%), and 4 had lumbosacral transitional vertebra (LSTV) (7.8%) in which 3 had sacralization of L5 (5.9%) and 1 had lumbarization of S1.

In the cervical region, the C2 vertebra had the widest spinous process (100% of patients) and C7 had the longest one (100% of patients).

In the thoracic region, the most precise paravertebral anatomical structure for numbering was carina and left pulmonary artery together; the location of the carina was adjacent to T5 or T5-T6 intervertebral disc in 29 patients (57%). The left pulmonary artery was adjacent to T5 or T5-T6 intervertebral disc in 28 patients (55%). The location adjacent to the upper ridge of the manubrium of the sternum was T2-T3 intervertebral disc or T3 in 28 patients (55%) (Figure 1).

Aortic artery arch was adjacent to T3 or the underneath



Figure 1. Sternum tip, pointed by an arrow.

disc (28 patients, 55%) and the right pulmonary artery was adjacent to T6 or the underneath disc (26 patients, 51%).

In the thoracolumbar region, the more frequent spinal anatomical location adjacent to the superior mesenteric artery was T12-L1 intervertebral disc or L1 vertebra (39 patients, 76.5%) while the celiac trunk was adjacent to T12 or the beneath disc in 36 patients (72%).

In the lumbar region, the most precise paraspinal anatomical structure was aortic bifurcation in 42 patients adjacent to L4 or the above disc (82.3%); it is shown in figure 2 and the next precise structure was the right renal artery that was adjacent to L1 or the beneath disc in 41 patients (80.5%) which is shown in figure 3. The psoas muscle origin was adjacent to T12 or the beneath disc in 73% of patients and the tip of conus medullaris in 35 patients (68.5%) was adjacent to L1 or the above disc (Figure 4).

Paraspinal lumbar structures of S1 lumbarization were located more toward the caudal location, while paraspinal structures of L5 sacralization were located more toward the cephalic location.

Among all patients with normal lumbosacral segmentation, the iliolumbar ligament was located at L5 level (94%), at L4 in L5 sacralization cases (4%) and S1 in S1 lumbarization cases (2%).

## Discussion

This study evaluated 12 paraspinal anatomical markers in numbering of vertebrae together.

It was found that superior mesenteric artery was located at T12-L1 intervertebral disc (23.5%) or L1 vertebra (52.9%) and celiac trunk adjacent to T12 (52%) or the beneath disc (20%); in the studies

conducted by Lee *et al* and Pennington *et al*, the same results were found (6,10).

Aortic bifurcation was located adjacent to L4 (64.7%) or the above disc (17.6%) which was in line with the findings of Lee *et al*'s, Varney *et al*'s and Chithraki *et al*'s studies (6,11,12).

Right renal artery was adjacent to L1 (56.9%) or the beneath disc (31.4%) similar to Lee *et al*'s and Pennington *et al* findings (6,10).

Psoas muscle origin was adjacent to T12 (61.5%) or the beneath disc (11.5%) and Jagannathan *et al* observed that psoas muscle origin was from T12 or T12-L1 in most patients in the normal and sacralization groups (13).

Tip of conus medullaris was adjacent to L1 (51%) or the above disc (17.6%); Aria *et al* and Lee *et al* revealed the same results (6,14).

Generally, the last vertebral body with squared shape was considered to be L5, and the first vertebral body with a rhombus shape was considered to be S1 vertebra (6), but they were different in transitional vertebra.

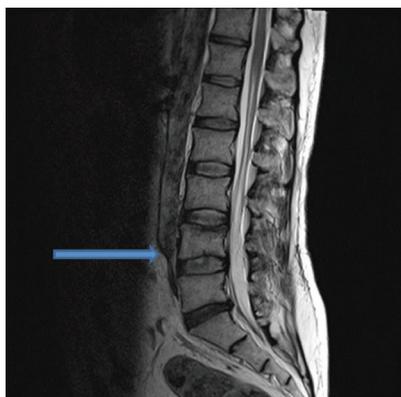
Aortic artery bifurcation location was the most accurate paraspinal marker and the right renal artery was the second one in the lumbar region in our study.

## Conclusion

In conclusion, the numbering of vertebral columns regarding the paraspinal structures is challenging and full spine MRI is the most accurate method for exact numbering and determining the pathology level.

## Conflict of Interest

There is no conflict of interest in this study.



**Figure 2.** Aortic bifurcation, pointed by an arrow.



**Figure 3.** Right renal artery, pointed by an arrow.



**Figure 4.** Conus, pointed by an arrow.

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