MORPHOMETRIC STUDY OF THE AREOLAR SPACE BETWEEN THE GREAT VESSELS AND THE LUMBAR SPINE

ABSTRACT

Objective: This work aims to study the areolar space anterior to the lumbar spine, and also the positioning of the large vessels focusing a lateral approach. Methods: This is a morphometric study of 108 cases based on T2 weighted-MRI images in the supine position. The following measurements were performed: lumbar and segmental lordosis; anteroposterior disc diameter; space between the disc/vertebral body and the vessels; bifurcation between the abdominal aorta and the common iliac veins confluence in relation to the lumbar level. Results: The areolar space with respect to the iliac veins, and with the vena cava increased cranially (p < 0.001), starting from average 0.6mm at L4-L5 and reaching 8.4mm at L2, while the abdominal aorta showed no increase or decrease pattern across the different levels (p = 0.135) ranging from 1.8 to 4.6mm. The diameter of the discs increased distally (p < 0.001) as well as the lordosis (p < 0.001). The disc diameter was 11% larger when compared to the adjacent vertebral bodies (p < 0.001) and that resulted in a smaller distance of the vessels in the disc level than in the level of the adjacent vertebral bodies (p < 0.001). The aortic bifurcation was generally ahead of L4 (52%) and less frequently at L3-L4 (28%) and L4-L5 (18%). The confluence of the veins was usually at the L4-L5 level (38%) and at L5 (37%), and less frequently at L4 (26%). Conclusions: There is an identifiable plane between the great vessels and the lumbar spine which is particularly narrow in its distal portion. It is theoretically feasible to reach this plan, handle the anterior complex disc/ALL and protect the great vessels by lateral approach, however, it is challenging.

Keywords: Blood vessels; Aorta; Vena cavae; Lumbosacral region; Lordosis; Orthopedics; Magnetic resonance imaging; Radiology.

RESUMO

Objetivo: Estudar o espaço areolar localizado anteriormente à coluna lombar e também o posicionamento dos grandes vasos com enfoque em abordagem lateral. Métodos: Estudo morfométrico com 108 casos com base em exames de ressonância magnética com ponderação T2 em posição supina. Foram realizadas as seguintes medidas: lordose lombar e segmentar; diâmetro discal anteroposterior; espaço entre o disco/corpo vertebral e os vasos; bifurcação da aorta abdominal e confluência das veias ilíacas comuns em relação ao nível lombar. Resultados: O espaço areolar com relação às veias ilíacas e à veia cava aumentou no sentido cranial (p < 0.001), partindo de média de 0.6 mm em L4-L5 e chegando em 8.4 mm em L2, e a artéria aorta abdominal não apresentou padrão ao longo dos diferentes níveis (p = 0.135), variando de 1.8-4.6 mm. O diâmetro dos discos aumentou distalmente (p < 0.001), assim como a lordose (p < 0.001). O diâmetro discal foi 11% superior ao dos corpos vertebrais adjacentes (p < 0.001) e isso refletiu na menor distância dos vasos no nível discal do que no nível dos corpos vertebrais (p < 0.001). A bifurcação aórtica estava geralmente à frente de L4 (52%) e com menos frequência, em L3-L4 (28%) e L4-L5 (18%). A confluência das veias foi, em geral, no nível de L4-L5 (38%) e de L5 (37%), e menos frequentemente em L4 (26%). Conclusões: Existe um plano identificável entre os grandes vasos e a coluna lombar, que é especialmente estreito em sua porção distal. Até com acesso lateral é teoricamente factível, porém desafiador, atingir este plano, manipular o complexo anterior do disco/ILLA e proteger os grandes vasos.

Descritores: Vasos sanguíneos; Aorta; Venea cavae; Lumbosacral region; Lordosis; Ortopedia; Imagem por ressonância magnética; Radiologia.

RESUMEN

Objetivo: El trabajo tiene como objetivo estudiar el espacio areolar situado anteriormente a la columna lumbar y también el posicionamiento de los grandes vasos con enfoque de abordaje lateral. Métodos: Estudio morfométrico de 108 casos basados en RM con ponderación T2 en posición supina. Se realizaron las siguientes mediciones: lordosis lumbar total y segmentaria; diámetro anteroposterior del disco; espacio entre disco/cuerpo vertebral y los vasos; bifurcación de la aorta abdominal y la confluencia de las venas ilíacas comunes en relación con el nivel lumbar. Resultados: El espacio areolar con respecto a las venas ilíacas y la vena cava inferior aumentó cranealmente (p < 0.001), a partir de un promedio de 0.6 mm en L4-L5, llegando a 8.4 en L2, y la aorta abdominal no ha presentado un patrón a lo largo de los diferentes niveles (p = 0.135) que van desde 1.8 a 4.6 mm. El diámetro de los discos aumentó distalmente (p < 0.001) así como la lordosis (p < 0.001). El diámetro del disco fue 11% mayor que el diámetro de los cuerpos vertebrales adyacentes (p < 0.001) y esto resultó en la distancia más corta de los vasos en el nivel del disco que en el nivel de los cuerpos vertebrales (p < 0.001). La bifurcación aórtica fue en general por delante de L4 (52%) y con menor frecuencia en L3-L4 (28%) y L4-L5 (18%). La confluencia de las venas fue generalmente en L4-L5 (38%) y L5 (37%), y menos frecuentemente en L4 (26%). Conclusiones: Hay un plano identificable entre los grandes vasos y la columna vertebral lumbar que es especialmente estrecho en su parte distal. En teoría, es posible alcanzar este plan, manejar el complejo anterior disco/ILLA y proteger los grandes vasos por abordaje lateral, sin embargo, es un desafío.

Descritos: Vasos sanguíneos; Aorta; Venas cavae; Región lumbosacra; Lordosis; Ortopedia; Imagen por resonancia magnética; Radiología.
INTRODUCTION

Although iatrogenic vascular lesions do not occur very often during lumbar spine surgery (0.017% to 0.14%), they can be considered the most devastating complication arising from intervertebral disc surgery, and have a very significant mortality rate, reaching as high as 65%.\(^1\)

The major vessels include the abdominal aorta, the inferior vena cava, and the common iliac arteries and veins located immediately anterior to the lumbar spine. These structures, especially the veins in a position in front of and juxtaposed to the lumbar spine, are vulnerable to lacerations during surgeries that involve the intervertebral discs.

As is well-documented in the literature,\(^2\)–\(^4\) discectomy and intervertebral fusion performed on the lumbar spine via lateral transpsoas approach preserves the complex in front of the apophyseal ring/ anterior longitudinal ligament. As a result, it does not require manipulation, and generally does not place at risk the large vessels located immediately in front of this disc/ligament complex. However, a new indication was recently incorporated into lateral access approaches: reconstruction in the sagittal plane using hyperlordotic spacers.\(^5\),\(^6\) According to the reports, it is necessary to mobilize the vertebral segment through resection of the anterior discal complex, in order to gain segmental angulation.

The vascular anatomy anterior to the lumbar spine has been studied in terms of its implications mainly in relation to an anterior\(^7\) or posterior\(^8\) approach. In the area of the lateral transpsoas approach, despite partial analyses or case reports including the great vessels,\(^9\)–\(^14\) the most studied anatomy is that of the lumbar plexus in relation to the lumbar discs.\(^15\)–\(^20\) However, there is no study of the distribution of the great vessels relating the space between them to the anterior aspect of the lumbar spine.

The objective of this article is to study the placement of the great vessels and the distribution of the areolar space in the lumbar spinal region, with a focus on the safety of a lateral approach to the anterior disc complex.

METHODS

We studied sagittal and axial slices of T2-weighted magnetic resonance imaging (MRI) exams of the lumbar spine, selected from the DICOM archive of our institution. Exclusion criteria: arthrodesis of the lumbar spine, more or less than five lumbar vertebrae, deformities like scoliosis (angle greater than 10°); hyperkyphosis, spondylolisthesis, collapsed intervertebral discs or extruded herniated disc, poor image quality (impossible to distinguish the vessels), and exams with slices spaced greater than 3 mm. 108 test cases were selected. The average age was 51 years (standard deviation 16, confidence interval 48 – 54) and 60% of the subjects were male.

The measurements were determined using the OsiriX (Pixmeo, Switzerland) program. To reduce interobserver variability, the measurements were reviewed by two authors. Because lateral access to the lumbar spine is only performed between the thoracolumbar discs and have a very significant mortality rate, reaching as high as 65%.\(^1\)

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This study was approved by the Institutional Review Board where it was developed and following approval, was assigned number 0360/11.

The statistical tests were performed using the SPSS program (version 10.0, Chicago, IL) with alpha values equal to 0.05. The Student’s t test, ANOVA, and Pearson correlation test were performed.

RESULTS

First, we studied the location of the bifurcation/confluence of the great vessels by lumbar vertebral levels. The results are shown in Table 1. The bifurcation of the abdominal aorta had a normal distribution varying from the vertebral body of L3 to the body of L5, with 52% of the cases splitting at the level of vertebral body L4 and with decreasing proportions at both the more cranial and caudal positions. The distribution of occurrences of the confluence of the common iliac veins was concentrated between L4 and L5.

Table 1. Lumbar level of the bifurcation/confluence of the great vessels.

<table>
<thead>
<tr>
<th></th>
<th>L2</th>
<th>L3</th>
<th>L3L4</th>
<th>L4</th>
<th>L4L5</th>
<th>L5</th>
<th>L5L6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal aortic artery</td>
<td>0 (0%)</td>
<td>2 (2%)</td>
<td>30 (28%)</td>
<td>56 (52%)</td>
<td>19 (18%)</td>
<td>1 (1%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Inferior vena cava</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td>28 (26%)</td>
<td>41 (38%)</td>
<td>39 (37%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

Values are displayed as total occurrences (total percent).

The results of the distance between the vessels and the anterior aspect of the lumbar spine (intervertebral disc or vertebral body) are shown in Table 2. The results for the inferior vena cava show that the areolar space increases in the cranial direction (p<0.001), starting from a minimum average of 0.6 mm (54% of the cases with 0 mm) at the L4-L5 level and reaching an average of 8.4 mm at the level of the L2 vertebral body. The values for the abdominal aorta show that it reaches its lowest average value (1.8 mm) at the level of the L3-L4 disc. At the L4-L5 and L4 levels, the right iliac artery was located in a superimposed position in front of the right common iliac vein in 58% and 88% of the cases, respectively. In contrast, the left iliac artery was only superimposed in front of the left common iliac vein in 9% of the cases at the L4-L5 level and in 6% of the cases at the L4 level. At the L3-L4 level and above, there was no overlapping of vessels. Table 2 shows one value per great vessels, and when there are two arteries or two veins, the average of the two values is displayed. The right and left vessel data at level L4-L5 follow (shown in millimeters, average ± standard deviation, 95% confidence interval): LIA, 2.5 ± 2.4, 2.0-3.0; DIA, 4.8 ± 4.0, 4.0-5.6; LCIV, 0.4 ± 0.7, 0.2-0.6; RCIV, 0.8 ± 0.9, 0.6-0.4; and at level L4: LIA, 3.5 ± 1.8, 3.1-3.9; RIA, 6.9 ± 3.4, 6.1-7.7; LCIV, 0.8 ± 1.0, 0.4-1.2; RCIV, 2.3 ± 1.6, 1.5-3.1.

Table 2. Lumbar level of the bifurcation/confluence of the great vessels.

<table>
<thead>
<tr>
<th></th>
<th>Abdominal aortic artery</th>
<th>Inferior vena cava</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>average (sd)</td>
<td>95% CI</td>
<td>Average (sd)</td>
</tr>
<tr>
<td>L2</td>
<td>3.6 (2.1)</td>
<td>3.2-4.0</td>
<td>8.4 (3.9)</td>
</tr>
<tr>
<td>L2L3</td>
<td>2.2 (2.1)</td>
<td>1.8-2.6</td>
<td>4.2 (3.2)</td>
</tr>
<tr>
<td>L3</td>
<td>3.4 (2.3)</td>
<td>3.0-3.8</td>
<td>3.8 (2.6)</td>
</tr>
<tr>
<td>L3L4</td>
<td>1.8 (1.9)</td>
<td>1.4-2.2</td>
<td>1.6 (1.8)</td>
</tr>
<tr>
<td>L4</td>
<td>4.6 (3.3)</td>
<td>4.0-5.2</td>
<td>2.1 (1.9)</td>
</tr>
<tr>
<td>L4L5</td>
<td>3.3 (3.3)</td>
<td>2.7-3.9</td>
<td>0.6 (0.9)</td>
</tr>
</tbody>
</table>

Values are shown in millimeters as average (standard deviation), and the lower and upper limits of the interval of the 95% confidence interval. *statistically significant.

DISCUSSION

Among the lumbar discs, the areolar space for the abdominal aorta showed no tendency to either increase or decrease in the cranial direction (p=0.135). However, the areolar space of the cava became larger in the cranial direction (p<0.001), and the space in front of the discs was smaller than the space in front of the adjacent vertebral bodies (p<0.001).

The results of the maximum anteroposterior dimension of the discs and vertebrae are shown in Table 3. In the pairwise comparison of the dimension of the disc versus the adjacent vertebrae (ex. L4-L5 versus L4), it was possible to confirm that the discs are on average 11% larger than the adjacent vertebrae (p=0.007). The AP disc diameter values were higher than those of the adjacent vertebral bodies, reflecting a shorter distance and narrower areolar space between the vessels and the discs along the vertebral bodies (p=0.001; Table 3 and Figure 4).

Table 3. Anteroposterior dimension of the anterior spine.

<table>
<thead>
<tr>
<th></th>
<th>Average (sd)</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>L2</td>
<td>35 (3)</td>
<td>35-36</td>
</tr>
<tr>
<td>L2L3</td>
<td>39 (5)</td>
<td>38-40</td>
</tr>
<tr>
<td>L3</td>
<td>37 (5)</td>
<td>36-38</td>
</tr>
<tr>
<td>L3L4</td>
<td>40 (4)</td>
<td>39-41</td>
</tr>
<tr>
<td>L4</td>
<td>36 (4)</td>
<td>35-37</td>
</tr>
<tr>
<td>L4L5</td>
<td>41 (4)</td>
<td>40-42</td>
</tr>
</tbody>
</table>

Values are shown in millimeters as average (standard deviation), and the lower and upper limits of the interval of the 95% confidence interval.
REFERENCES


CONCLUSION

Although small, there is a space between the great vessels and the lumbar spine, this space being especially narrow in its distal portion. Therefore, via lateral access it is theoretically feasible to find the plane between these structures in order to protect the vessels and manipulate the complex in front of the disc and the ALL. Caution and thorough investigation of the anatomical position of the vessels are indispensable for the planning and verification of anatomical variations.

CONFLICTS OF INTEREST

Author LP has conflicts of interest with NuVasive, LLC: consultant, royalties, and shares. The other authors declare no conflicts of interest.


