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ARS Medica Tomitana - 2012; 2(69): 62-65
DOI 10.2478/v10307-012-0012-z

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Morphology of the intervertebral foramen: a direct relation with low back pain

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ABSTRACT.
Low back pain is today a remarkably serious problem, not only in terms of health, but also socially and populationally, and it is, in most developed countries, a leading cause of disability. By its morphological features, the intervertebral foramen turns out to be the key in trying to manage the pathology of lumbar spinal region.
We evaluated morphometrically the lumbar intervertebral foramen on 70 isolated lumbar vertebrae and 11 spinal blocks; the latter were sectioned to obtain easy access to components and dimensional values able to provide additional results, considered statistically and compared with literature. The results, presented in tables and graphics, are discussed in relation with actual literature.

Key words: intervertebral foramen, low back pain

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Introduction

The lumbar intervertebral foramen act, by its conformation, as a real tunnel [1] of variable depth – approx. 10mm – which contains: the vertebral nerve of Luschka [2], a nerve widely discussed since longtime within the low back pain etiology [3], the anterior and posterior roots of the spinal nerve covered by the dural sheath and accompanied by the corresponding arteries and the posterior radicular vessels. This vasculo-nervous bundle is covered by fatty tissue (approx. 2 thirds of the foramen) with a significant role of mechanical protection.

Through their content, their shape and dimensions, the intervertebral foramen shows a significant importance and attention within the literature that covers the subject of low back pain, both in statics and dynamics. Thus, during the movements within the sagittal plane (flexion and extension), the most significant variation occur in what concerns the position and the tilt of the vertical axis, without real dimensional modifications, especially for a normal vertebral column [4]. Also, the arrangement of the contained structures within the intervertebral foramen leads to a higher approach of the anterior (motor) root of the spinal nerve towards the intervertebral joint while the posterior root (sensorial) is closer to the zygapophyseal joint, all of these becoming vital anatomical features of the vertebral column related to the low back pain [5,6].

Material and method

We evaluated morphometrically the lumbar intervertebral foramen on 70 isolated lumbar vertebrae and 11 spinal blocks (22 sectioned hemi-blocks).

We measured: a. the longitudinal diameter (height of the intervertebral foramen), b. the superior antero-posterior diameter (maximal depth of the intervertebral foramen), c. the inferior antero-posterior diameter (minimal depth of the intervertebral foramen) (Figure 1); we evaluated the shape of the intervertebral foramen and its occupation by the vasculo-nervous bundle. The measurements are performed with a 0.01mm digital caliper.

Figure 1 - Diameters of the intervertebral foramen

Results and discussions

The longitudinal diameter (intervertebral foramen height) presented a sinuous evolution from L1 to L5 but, in the same time, the most uniform evolution compared right to left. The left side showed, constantly, greater values than the right one. This was the only diameter with this type of evolution all along the lumbar level (Figure 2).

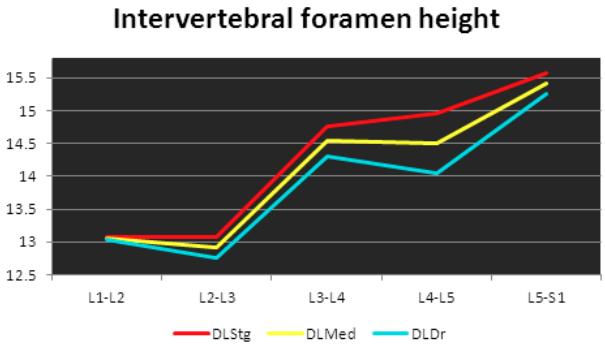


Figure 2

The maximal antero-posterior diameter (Figure 3) showed the largest amount of variation compared left to right (up to 7% larger on the right). The most significant difference is at L1 - L2 level. From here, the right diameter tends to decrease, thus showing a dimensional reverse at L4 - S1 levels.

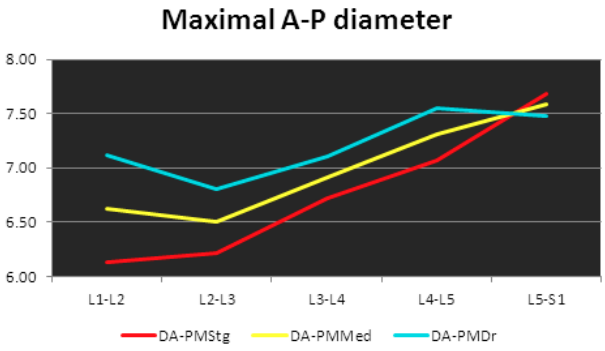


Figure 3

The maximal antero-posterior diameter is the "key" element of the region as long as it represents the main dimension of the space for the vasculo-nervous bundle within the intervertebral foramen. Also, the discal degeneration and backward protrusion directly influences this diameter.

The minimal antero-posterior diameters progressively increased on the right up to L3 - L4, were the reversing process occurs (Figure 4). On the left side, the minimal antero-posterior diameter shows a more abrupt increase above this level

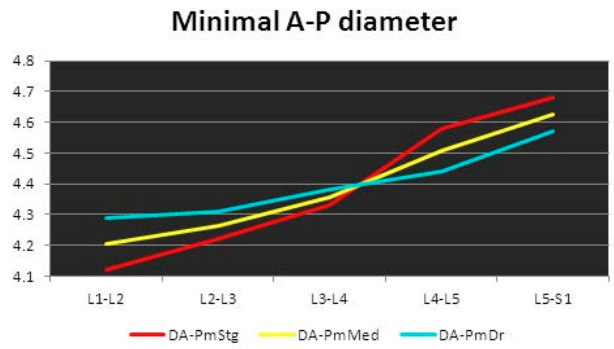
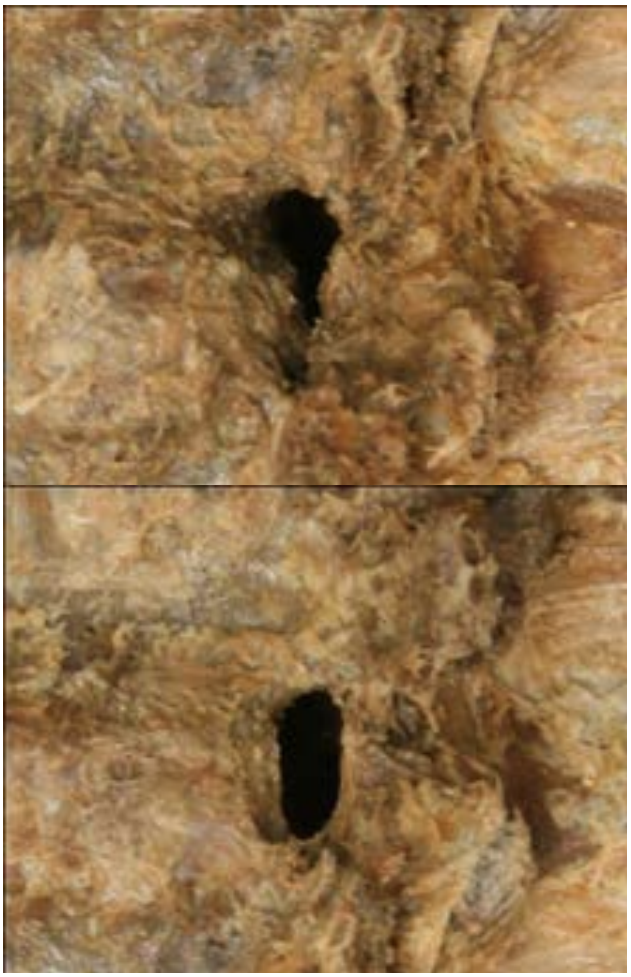


Figure 4

The shape of the intervertebral foramen, although extremely variable, may be distributed upon three main patterns: the "classic" pear shape, the oval shape and the rounded shape (Figure 5).

Figure 5 – Different shapes of the intervertebral foramen



The predominance is represented by the "classic" pear shape (76%), followed by the oval shape (16%) and the rounded one (8%) (Figure 6).

Apparently, an oval or a rounded shape may offer a larger space for the vasculo-nervous bundle but the pear shape is the result of the morphometrical peculiarities of the region, a structural compromise between the stability and the dynamics of the region.

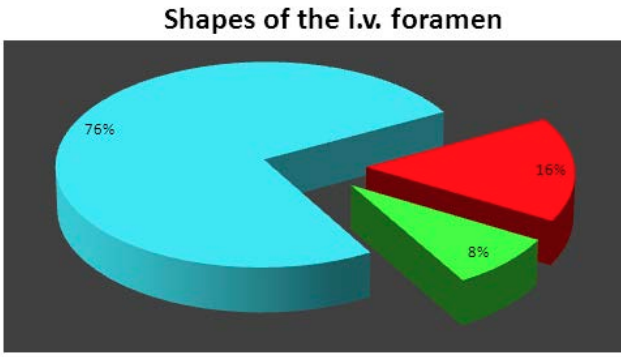


Figure 6

The vasculo-nervous bundle occupies 20 to 60% of the upper part of the intervertebral foramen. In our study, the predominance was approx. 40%, almost double than the rest of the values (Figure 7).

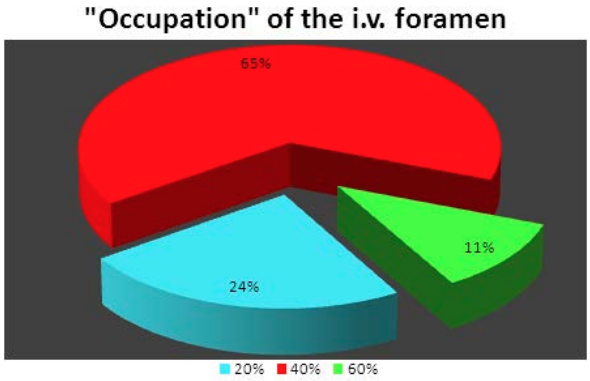


Figure 7

In 8% of the cases, the vasculo-nervous bundle descended into the lower part of the intervertebral foramen, a situation when any displacement of the zygapophyseal joint will directly influence and even injure these structures.

The foraminal index (the ratio between the longitudinal and the antero-posterior diameters) is presented in table I.

Table nr. I - foraminal index

	Maximal foraminal index			Minimal foraminal index		
	Right	Left	Average	Right	Left	Average
L_1-L_2	54.60%	46.94%	50.77%	32.92%	31.53%	32.22%
L_2-L_3	53.33%	47.58%	50.42%	33.80%	32.30%	33.04%
L_3-L_4	49.65%	45.49%	47.53%	30.63%	29.32%	29.97%
L_4-L_5	53.74%	47.22%	50.37%	31.60%	30.60%	31.09%
L_5-S_1	49.07%	49.30%	49.19%	29.97%	30.03%	30.00%
Average	51.96%	47.33%	49.61%	31.69%	30.69%	31.19%

The foraminal index is a key element of the region. The longitudinal diameter is directly influenced by the position of the pedicles and by the thickness of the intervertebral disk, while the antero-posterior diameters are influenced by the protrusion of the disk.

All the diameters of the intervertebral foramen showed significant dimensional correlations with the elements of the region (Table II).

Table nr. II - dimensional correlations with the elements of the region

	I.V. foramen height	Maximal A-P diameter	Minimal A-P diameter
Thickness of the pedicle	0.93621	0.96575	0.97195
Height of the pedicle	0.55712	0.72303	0.72389
Transvers angle of the pedicle	0.91229	0.88430	0.94827
Sagittal angle of the pedicle	0.73064	0.75339	0.87623
Axial length of the pedicle	-0.14708	-0.11839	-0.04022
Interpedicular distance	0.89387	0.98791	0.98126

Conclusions

Low back pain is today a remarkably serious problem, not only in terms of health, but also socially and populationally, and it is, in most developed countries, a leading cause of disability. By their position, the structures that define the relations and, not least, its content, the intervertebral foramen turns out to be the key in trying to manage the pathology of lumbar spinal region. Due to its vital content, the dimensions and the shape of the intervertebral foramen represent the major morphological characteristics of the region that will influence the occurrence and the above mentioned disease

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