THE IMPORTANCE OF THE ANATOMIC RELATION OF THE SPINAL PEDICLE WITH THE NERVOUS ROOTS AT THE THORACIC LEVEL FOR VERTEBROPLASTY

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Cuvinte cheie: *vertebroplastia, fractura osteoporotică, pediculul vertebrei toracice*

Rezumat: *Lucrarea evaluează relaţia dintre rădăcinile nervilor spinali si pediculii vertebrali la nivel toracic, şi importanţa acestor relaţii în abordul transpedicular pentru efectuarea vertebroplastiei. Material si Metodă: studiul s-a efectuat pe patru cadavre adulte. S-a efectuat abordul mediospinal dorsal, după care am măsurat distanţele dintre pediculul superior şi inferior cu rădăcinile nervoase, şi diametrele pediculilor vertebrali. Cunoaşterea acestor distanţe permiţând un abord transpedicular sigur cu reducerea complicaţiilor neurologice. Concluzii: Distanţa dintre pediculul şi rădăcina nervului spinal nu prezintă o evoluţie clară crecătoare sau descrecătoare a valorilor în funcţie de nivelul vertebrei. Distanţa dintre pediculul inferior şi radăcina nervoasă prezintă o scădere progresivă a acesteia în sens cranio-caudal. În ceea ce priveşte diametrele transvers şi sagital al pediculilor se observă o creştere progresivă în dimensiuni a pediculilor toracici de la nivelul lui T4 la T12. Complicaţile abordului pediculilor vertebrelor toracale pot fi prevenite dacă se respectă tehnica chirurgicală.*

Keywords: *vertebroplasty, osteoporotic fractures, Thoracic vertebral pedicle*

Abstract: *The study asses the relations between the roots of the spinal nerves and the spinal pedicles at a thoracic level, as well as the importance of these relations in the transpedicular approach for vertebroplasty. Material and Method: the study was conducted on four adult human cadaver spines. We measured the distances between the superior and inferior pedicle with the nervous roots and the diameters of the spinal pedicles. Knowing these values allow a safe transpedicular approach, with reduced complications. Conclusions: The distance between the superior pedicle and the root of the spinal nerve presents no clear evolution of values in connection to the level of the vertebra. The distance between inferior pedicle and the nervous root shows a progressive reduction of the values in the craniocaudal direction. When referring to the transverse and sagittal diameter of the pedicles we observe a progressive growth in size of the thoracic pedicles from the level T4 to T12. The complications can be prevented when surgery techniques are respected and the surgeon is familiar with the Spinal Anatomy.*

INTRODUCTION

The transpedicular approach is used in vertebroplasty, kyphoplasty, transpedicular fixation or spinal biopsy. Vertebroplasty it was first used by Galibert in 1987, in the case of hemangioma at the level of C2. (1) Transpedicular fixation of the spine by means of posterior approach is regarded as a stable and versatile fixation method even in the case of osteoporotic vertebras. (6) The main concern when introducing the trocar in vertebroplasty is not to damage the cortex of the medial side pedicle. (11) Besides the anatomic studies done by dissecting the cadavers there are also studies assessing the vertebral morphometry using imagistic means (frontal and profile radiography, CT), in order to determine with precision the best area to enter and the path the needle has to follow inside the vertebral pedicle. (2,3,4,5) The main purpose of the vertebroplasty is to reinforce and stabilize the affected vertebra. Nowadays the vertebroplasty is used in the case of osteoporotic fractures, vertebral metastasis, and vertebral hemangioma. Percutaneous vertebroplasty implies injecting polymethyl methacrylate mixed with barium sulphate (to obtain the necessary radioopacity while injecting the cement) in the vertebral fracture, by means of one-pedicle or 2-pedicle approach (or extrapedicular in the high thoracic area), using a needle. This technique can be done using radiological surveillance, the patient being laid in the ventral position. Along time this procedure proved its efficiency by significantly reducing the pain, stabilizing the fracture and granting the possibility of fast functional recovery of the patient.

THE AIM OF THE STUDY

The study wants to show the importance of the anataomical relations of the vertebral pedicle in vertebroplasty.

MATERIAL AND WORK METHOD

For this study four human cadavers were dissected, two female and two male bodies, aged 45 to 57. It is important to mention that the subjects died of natural causes and presented no spine malformations or trauma. The study was done with the help of the Anatomy Department within "Victor Papilian" Faculty of Medicine of Sibiu, „Lucian Blaga" University. The cadavers were positioned in prone position, and posterior approached was conducted. Later on bilateral skeletonization

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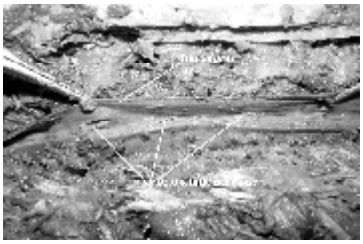
with subperiosteal dissection of the paravertebral muscles was done; then there was a laminectomy from the level of T4 to T12 removing the spinal processes and the yellow ligaments (the costovertebral articulations were preserved undamaged). In order to have a better identification and visualization of the nervous roots a medial longitudinal incision of the dura mater was made along the entire laminectomy area. The electronic morphometric measurements were determined by means of an electronic caliper, with a deviation of 0.01 mm. The final image of the dissection is presented in Figures 1 below, where the posterior elements of the thoracic spine are presented.

Figure no. 1. Final image of the dissection after the incision of the dura mater



The sagittal and transversal diameters of the pedicle were measured, as well as the distance between the lower end of the superior pedicle and the nervous root and the upper end of the inferior pedicle as compared to the nervous root, also the transversal and sagittal diameters of the vertebral pedicle.

RESULTS AND DISCUSSIONS

The registered values are presented within Table 1, below, presenting the average means (left and right side) for each individual level, followed by the mean of the four cases. These values are expressed in millimeters.

The gender can have an important position when describing pedicle morphometry, thus, generally due to the fact that female subjects are shorter, the dimensions of the pedicles and the interpedicular distances are smaller than the ones registered with male subjects.(7)

When measuring the distance between the lower end of the superior pedicle and the nervous root (Table 1) the mean values ranged between 1.19 to 1.24 mm. No clear evolution of the values based on the level of the vertebras could be seen, neither ascendant nor descendent. Thus, we can conclude that the distance between the lower end of the sub-adjacent pedicle and the nervous root between T4 to T11 is relatively constant, without significant differences.

When measuring the distance between the upper end of the sub-adjacent pedicle and the nervous root (Table 1) we can notice that the distance reduces from an average value of maximum 14.36 mm at the level of T4 to a minimum value of 12.68 mm at T12. This is due to the emergence angle of the nervous root which becomes horizontal starting with T4 to T12, varying from 60 to 140 degrees.(11) Thus, the distance between the upper end of the pedicle and the nervous root reduces, which involves reducing the distance as well.

The transversal diameter of the thoracic pedicle ranged between a minimum value of 3.90 at T4 and a maximum value of 9 mm at the level of T12 (Table 2). The sagittal diameter of the studied vertebras ranged between 9.5 mm at T4 and 18.25 at T12. Thus we can notice a progressive growth of the dimensions of the thoracic pedicles at the level of T4 to T12. The results registered align with the information found in the specialized literature, where values of 4.8 to 8.7 mm are mentioned for the transversal diameter, and values of 11.8 mm to 18.7 mm are presented for the sagittal diameter of the pedicle.(6) The differenced are reduced, varying according to the population type, for the Asian populations these values being slightly smaller. (6,7,8)

Table no. 1. The distance between the lower end of the pedicle and the nervous root may be consulted in the following table:

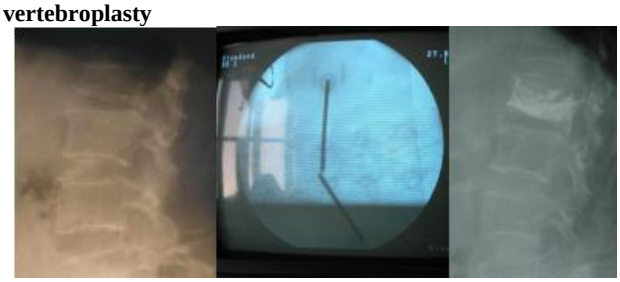
The distance between the lower end of the pedicle and the nervous root (mm)						The distance between the upper end of the pedicle and the nervous root (mm)				
Pedicle	Case I	Case II	Case III	Case IV	Mean	Case I	Case II	Case III	Case IV	Mean
T4	1,19	1,20	1,21	1,22	1,20	13,45	14.32	14,55	15,12	14,36
T5	1,20	1,22	1,21	1,22	1,21	13,8	14,38	14,59	15,3	14,51
T6	1,22	1,23	1,22	1,24	1,22	13,12	13,40	13,53	13,61	13,41
T7	1,17	1,20	1,23	1,29	1,22	12,7	13,23	13,40	13,45	13,19
T8	1,19	1,20	1,23	1,31	1,23	13,0	13,10	13,25	13,45	13,2
T9	1,17	1,26	1,22	1,31	1,24	12,71	13,00	13,20	13,22	13.03
T10	1,18	1,25	1,24	1,30	1,24	12,62	12,9	12,86	13,1	12,87
T11	1,17	1,19	1,20	1,22	1,19	12,5	12,67	12,76	13,00	12,73
T12	1,19	1,20	1,19	1,25	1,20	12,45	12,60	12,78	12,9	12,68

Table no. 2. The sagital and transversal diameter of the thoracic pedicles

	Sagittal diameter (mm)					Transversal diameter (mm)				
	Case I	Case II	Case III	Case IV	Mean	Case I	Case II	Case III	Case IV	Mean
T4	9,5	9,4	9,6	9,8	9,57	3,90	3,80	3,95	4,00	3,91
T5	9,7	9,7	9,8	10	9,8	4,00	4,25	4,60	4,70	4,38
T6	11,10	11,12	11,15	11,30	11,16	4,35	4,45	4,85	4,90	4,63
T7	11,20	11,30	11,68	11,70	11,46	4,70	4,63	4,74	4,84	4,72
T8	11,35	11,40	11,70	11,90	11,58	5,10	5,25	5,33	5,40	5,27
T9	12,57	12,86	13,20	13,95	13,14	5,70	5,85	6,00	6,20	5,93
T10	14,90	15,40	15,50	15,70	15,37	6,70	6,86	7,15	7,20	6,97
T11	16,35	16,50	17,20	17,70	16,93	7,52	7,83	8,24	8,35	7,98
T12	17,40	17,58	18,15	18,25	17,82	8,52	8,65	8,87	9,00	8,76

The dimensions of the pedicles have a direct influence on the size of the transpedicular trocar. The size of the trocar varies from one manufacturer to another with values from 9 to 14 gauge. Thus, for the superior vertebra a thinner trocar shall be used and for the inferior ones a thicker trocar can be used, as the size of the pedicle increases from the proximal to the distal. When leaning the needle in a sagittal direction, special care shall be paid to the lower end of the pedicle in order not to damage the cortex, due to the close position of the nervous root (1.19 – 1.24 mm), as well as to the median side due to the close position of the dura mater..

Figure no. 2. Vertebral fracture of T 12 treated with vertebroplasty



The thoracic spine is formed of twelve vertebras and its caudal and cranial ends comprise two individual morphofunctional entities with biomechanics differing from the rest of the thoracic spine: the thoracic-lumbar junction and cervical-thoracic junction. This is the reason why we examined the thoracic vertebras at the level of T4 to T12. It is also known the fact that the root of the spinal nerve exits below the pedicle of the corresponding vertebra, for example T5 root exits below the pedicle of the T5 vertebra. The thoracic spine is considered the most stable spinal segment, being reinforced by the ribs and the thoracic cage. The foramen in the thoracic area has a smaller diameter than the ones in the lumbar area and the root covers almost completely the foramen being closely connected to the spinal pedicles. Thus, when approaching the thoracic pedicle it is important to remain inside the pedicle, as breaking its cortical area can result in radicular, medular, vascular or pleural lesions. At the thoracic level the spinal body can be approached extrapedicular, as well, between the end of the rib and the pedicle, but there is a greater risk to damage the pleura and cause pneumothorax. To this end it is extremely important that the surgeon is familiar with the anatomy of the spine and be able to form a 3D image, although the image offered by the image amplifier is only a 2D one.

When measuring using CT and radiological of the thoracic pedicles several studies shown that their value is smaller than the values measured directly on the cadaver. (6).

CONCLUSIONS

With regard to the distance between the lower end of the superior pedicle and the root of the spinal nerve there is no clear evolution of the values based on the level of the vertebra, neither ascendant nor descendent. When measuring the distance between the upper end of the sub-adjacent pedicle and the nervous root, there is a progressive reduction in the craniocaudal direction. The transversal and the sagittal diameters of the thoracic pedicles present a progressive growth in size from the level of T4 to T12. The possible complications can be prevented when doing the vertebroplasty if the surgery norms and techniques are respected, and the surgeon is familiar with spine's anatomy.

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