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*Some Features of the Internal Structure of Posterior Cord
Roots of the Brachial Plexus in Man*

Niektóre cechy wewnętrznej budowy korzeni pęczka tylnego splotu ramiennego

The internal structure of the posterior cord roots has not been studied yet. Therefore the author decided to investigate some features of its internal texture. The purpose of this study was to determine the number and the thickness of roots, as well as the number of fascicles, the size and the index of their cross-section area.

MATERIAL AND METHODS

The roots of the posterior cord have been examined bilaterally on the bodies of 33 males (♂) and 33 females (♀) who died at the ages between 11th day and 86th year of life. They were free from any nervous system diseases. The cadavers were divided into six age groups. Group I included 5 ♂ and 5 ♀ up to 1st year of life, group II 5 ♂ and 5 ♀ between 1st and 14th year of life, group III — 5 ♂ and 7 ♀ between 15th and 22nd year of life, group IV — 5 ♂ and 6 ♀ between 23rd and 40th year of life, group V — 8 ♂ and 5 ♀ between 41st and 60th year of life, and group VI — 5 ♂ and 5 ♀ above 60th year of life. The roots of the plexus, the trunks and their terminal divisions and the posterior cord were visualized by preparation method. The sections taken from the roots of the posterior cord were fixed in glass frames and then in formalin. Next bearing with the sections, staining of slides and determination of cords thickness and thickness of their fascicles, the number of fascicles and the index of the fascicles area were presented in previous publications (9, 10).

RESULTS

The posterior cord was formed in all the cases by the union of three roots — upper, middle and lower which were the posterior divisions of all three trunks of the plexus. The union of all roots followed on the same level, or the lower root joined somewhere underneath the trunk resulting from junction of the two roots.

THICKNESS OF THE ROOTS OF THE POSTERIOR CORD

In the examined material the thickest root, the medium-thick root and the thinnest root were distinguished. The thickest root was in 89.4% the upper root (ur), in 8.3% the middle root (mr), in 1.5% the cases the lower root (lr). ur and mr had similar thicknesses but greater than lr in 0.8% of the cases. The medium-thick root was in 7.6% ur, in 81.8% mr, in 7.6% lr. mr and lr had similar thicknesses but smaller than that of ur. The thinnest root was in 2.3% ur, in 6.8 mr, and in 88.6% of lr cases.

The discussed value was similar on both sides of the single body in ur in 10.6%, in mr in 6.1% and in lr in 16.7%, and it was greater on the right side respectively in 47.0%, 59.1% and 45.4%, and on the left side in 42.4%, 34.8% and 37.9%.

The average thickness of ur equalled (in sq mm) 7.606 [on the right side (r) 7.737, on the left side (l) 7.475, in males (♂) 7.794, in females (♀) 7.419], of mr 4.604 (r — 4.683, l — 4.524, ♂ — 4.982, ♀ — 4.224), of lr 2.822 (r — 2.364, l — 2.326, ♂ — 2.391, ♀ — 2.299). The values mentioned above in the age groups came out to be: in group I: 3.103, 1.573 and 0.948, in group II: 4.660, 2.958 and 1.699, in group III: 9.377, 4.787 and 2.357, in group IV: 9.581, 5.408 and 2.649, in group V: 9.171, 6.397 and 3.281, in group VI: 8.721, 5.843 and 2.822 respectively.

NUMBER OF FASCICLES

ur was composed of 1 to 23 fascicles, mr — of 1 to 22 fascicles, and lr — of 1 to 14 fascicles. There were 1 to 5 fascicles observed in ur in 40.2%, in mr in 45.5%, and in lr in 87.1%, 6—10 fascicles were found

respectively in 40.2%, 44.7% and 12.1%, and more than 10 fascicles in 19.6%, 9.8% and 0.8% of the cases. The same number of fascicles on both sides of one body was found in 6.1% in ur, in 4.6% in mr, and in 22.7% in lr, and it was greater on the right side respectively in 51.5%, 51.5% and 36.4%, and on the left side in 42.4%, 43.9% and 40.9% of the cases. The number of fascicles had the greatest values in ur in 54.5%, in mr in 31.1%, in lr in 3.8%. The number of fascicles was the same in ur and mr but greater than in lr in 7.5%, the same in ur and lr but greater than in mr in 0.8% and alike in mr and lr but greater than in ur in 2.3% of the cases. It was the lowest in lr in 65.2%, in mr in 9.1%, in ur in 10.6%. The number of fascicles was equal in mr and lr but smaller than in ur in 9.1%, the same in ur and lr but smaller than in mr in 4.5% and alike in ur and mr but smaller than in lr in 1.5% of the cases.

The mean number of fascicles equalled in ur 7.2 (r — 7.4, l — 7.1, ♂ — 6.5, ♀ — 8.0), in mr 6.1 (r — 6.2, l — 6.1, ♂ — 6.1, ♀ — 6.2), and in lr 2.9 (r — 3.0, l — 2.9, ♂ — 2.8, ♀ — 3.0). In the age groups it was: in group I: 6.6, 5.7 and 3.4, in group II: 5.7, 7.1 and 2.9, in group III: 6.2, 4.3 and 2.2, in group IV: 8.7, 7.0 and 2.8, in group V: 8.2, 6.5 and 3.3 in group VI: 7.7, 6.4 and 3.0 respectively.

VALUE OF THE CROSS-SECTION AREA OF FASCICLES (CSAF)

The thickness of the individual fascicles showed the following range of values: 0.004—9.189 sq mm in ur, 0.001—5.748 sq mm in mr, and 0.001—4.035 sq mm in lr. Five groups of fascicles were distinguished on the basis of their cross-section area. They were described in the previous paper (10). Very thin fascicles (vtn) made 17.9% in ur, 25.8% in mr, and 19.4% in lr, thin fascicles (tn) made 26.5%, 29.2% and 29.2% respectively, medium-thick fascicles (mtk) 15.8%, 18.2% and 13.2%, thick fascicles (tk) 19.9%, 14.2% and 18.6%, very thick fascicles (vtk) 19.9%, 12.6% and 19.6%.

The cross-section area of all the fascicles forming ur ranged between 0.169 and 11.227 sq mm, in mr — between 0.501 and 11.742 sq mm, and in lr — between 0.247 and 4.398 sq mm. It showed similar values on both sides of one body in 4.5% in ur, in 6.1% in mr, and in lr in 3.0%, it was greater

on the right side respectively in 47.0%, 60.6% and 45.5%, and greater on the left side in 48.5%, 33.3% and 51.5% of the cases. The csaf had the greatest values in ur in 89.4%, in mr in 6.8%, in lr in 0.8%. It has shown similar values in ur and mr but greater than in lr in 3.0% of the cases. The described sum thicknesses of the fascicles was the lowest in ur in 3.8%, in mr in 9.1%, in lr in 86.3%. It had equal values in mr and lr but smaller than in ur in 0.8% of the cases.

The average value of csaf of ur equalled (in sq mm). 4.885 (r — 4.933, l — 4.836, ♂ — 5.023, ♀ — 4.747), of mr 2.894 (r — 2.920, l — 2.867, ♂ — 3.129, ♀ — 2.658), and of lr 1.579 (r — 1.600, l — 1.557, ♂ — 1.640, ♀ — 1.518). It was different in the age groups: in group I the average value was in ur 1.969, in mr 0.993, and in lr 0.616, in group II respectively: 3.020, 1.738 and 1.170, in group III: 6.266, 3.238 and 1.637, in group IV: 6.479, 3.253 and 1.843, in group V: 5.708, 4.279 and 2.141, in group VI: 5.183, 3.455 and 1.859.

INDEX OF THE CROSS-SECTION AREA OF FASCICLES (IAF)

The value of the index of the fascicle's area was similar on both sides of a single body in 4.5% in ur, in 10.6% in mr, and in 39.4% in lr, greater on the right side in 47.0%, 53.0% and 27.3% respectively, greater on the left side in 48.5%, 35.4% and 33.3% of the cases. The greatest values of IAF were found in ur in 22.0%, in mr in 25.0%, in lr in 42.4%. It was similar in ur and mr but smaller in lr in 2.3%, and similar in ur and lr but smaller in mr in 3.8%, and similar in mr and lr but smaller in ur in 4.5% of the cases. The lowest values of IAF were observed in ur in 31.0%, in mr in 40.2%, in lr in 22.0%. The values were similar in ur and mr but greater in lr in 3.0%, similar in ur and lr but greater in mr in 2.3%, and similar in mr and lr but greater in ur in 1.5% of the cases. The average value of IAF equalled in ur 64.2 (r — 63.8, l — 64.7, ♂ — 64.4, ♀ — 64.0), in mr 62.9 (r — 62.4 — l — 63.4, ♂ — 62.8, ♀ — 62.9), in lr 67.3 (r — 67.7, l — 66.9, ♂ — 68.6, ♀ — 66.0). The value mentioned above in the age groups ranged as follows: in group I the average value was in ur 63.4, in mr 63.1 and in lr 65.0, in group II: 64.8, 58.8 and 68.9, in group III: 66.8, 67.6 and 69.5, in group IV: 67.6, 60.2 and 69.6, in group V: 62.2, 66.9 and 65.3, in group VI: 59.4, 59.1 and 65.9 respectively.

DISCUSSION

The posterior cord appears almost constantly and most often it is formed by the union of three roots — upper, middle and lower — making the posterior divisions of monomial trunks of the plexus (2, 3). The same origin of the posterior cord was observed in all the cases in the present work.

The internal structure of the roots of the posterior cord is characterized by great variability and asymmetry, in contradistinction to their external texture. These observations confirmed the reports of numerous authors who discussed the morphology of peripheral nervous system (1, 4—11). The studies performed recently have shown that the thickness of roots of the posterior cord, number of fascicles, size of the cross-section area of fascicles and index of the fascicle's area were different in the majority of cases not only in people belonging to the same age group and being of the same body height and similar body weight, but also in the same person on both sides of one body. The similar values on both sides of one body for four, three and two features mentioned above were not found in ur and in mr. In lr similar values on both sides of one body for 4 features were recorded in 1.5%, for 3 features — in 1.5% and for 2 features — in 12.1% of the cases. The similar values of a single feature were also rarely observed on both sides of one body: the thickness of ur in 10.6%, of mr in 6.1% and of lr in 9.1%, the size of csaf in 4.5%, 6.1% and 0%, the number of fascicles in 6.1%, 4.6% and 10.6%, and IAF in 4.5%, 10.6% and 27.3% of the cases respectively.

The examined features were greater in a single person on the right than on the left side: the thickness of ur in 47.0%, mr in 59.1% and lr in 45.4%, the size of csaf in 47.0%, 60.6% and 45.4%, the number of fascicles in 51.5%, 51.5% and 36.4% and IAF in 47.0%, 53.0% and 27.3% respectively, and they were greater on the left than on the right side: the thickness of ur in 42.4%, mr in 34.8% and lr in 37.9%, the size of csaf in 48.5%, 33.3% and 51.5%, the number of fascicles in 42.4%, 43.9% and 40.9%, IAF in 48.5%, 36.4% and 33.3% respectively.

The mean values of the examined features differed between the sides of a single body. They were greater on the right side with the exception of IAF in ur and mr which was greater on the left side. They showed, with

the exception of IAF in ur and mr, differences related to the sex, too. In males the following features were greater than in females: the thickness of roots, the size of csaf and IAF, whereas in females the number of fascicles was greater than in males.

The roots of the posterior cord differed between each other in thickness, size of csaf, number of fascicles and size of IAF. The superior root reached the highest average thickness, it was by 65.2% greater than average thickness of mr and by 169.5% greater than average thickness of lr. The highest average value of csaf was also observed in ur. It was by 68.8% greater than in mr and by 209.4% greater than in lr. The highest average number of fascicles, considering also ur, was greater than the corresponding value of mr by 18.0% and of lr by 148.3%. The highest average value of IAF recorded in lr was greater than the corresponding value in ur by 4.8% and in mr by 7.0%. The average values of the examined features clearly distinguished the roots. The superior root has been characterized by the greatest thickness, the greatest csaf and the highest number of fascicles and middle IAF, mr — middle thickness, middle number of fascicles and small IAF, lr — small thickness, small csaf, small number of fascicles and the highest IAF. The participation of the fascicles of different thickness in roots structure was unequal. Very thin fascicles occurred most often in mr, less often in lr and least often in ur, tn — equally in mr and lr, but less often in ur, mtk — most often in mr, less often in ur and least often in lr; tk and vtk appeared most often in ur and least often in mr.

The studied features underwent big changes in postnatal life, mostly up to the 22nd year. The thickness of ur increased 3.1 times, mr 4.1 times and lr 3.5 times. The size of csaf increased 3.3, 4.3 and 3.5 times respectively. The number of fascicles in adults was greater than in children up to 1 year of life by 31.8% in ur and by 22.8% in mr, but in lr it was smaller by 11.8%. IAF in ur and mr decreased by 6.3%, but in lr it increased by 7.0%. The participation of fascicles of different thickness in the roots structure changed in postnatal life, too. In children up to 1 year old the fascicles of the cross-section area up to 0.3 sq mm dominated in the structure of three roots — at the most in lr, at the least in ur. In adults their participation in the structure of roots of the posterior cord decreased, and the part of fascicles with the cross-section area greater than 0.5 sq mm increased greatly.

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STRESZCZENIE

W trzech korzeniach pęczka tylnego — górnym, środkowym i dolnym, odchodzących od jednoimiennych pni splotu, pobranych obustronnie ze zwłok 33 osób płci męskiej i 33 osób płci żeńskiej, badano grubość, wielkość powierzchni poprzecznego przekroju ich pęczków (pppp), liczbę pęczków (lp) i wskaźnik powierzchni pęczków (wpp). Korzeń górny charakteryzują: największa grubość, wielkość pppp i lp oraz średni wpp, korzeń środkowy — średnia grubość, wielkość pppp i lp oraz niski wpp, korzeń dolny — mała grubość, wielkość pppp i lp oraz wysoki wpp. Udział pęczków o różnej grubości był niejednakowy w budowie korzeni pęczka tylnego.

