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Terminal Divisions of the Middle Trunk of the Brachial Plexus in Man

Końcowe części pnia środkowego splotu ramiennego u człowieka

The middle trunk, the thinnest among the trunks of the brachial plexus, divides usually into two terminal parts, anterior and posterior, like other trunks of this plexus. Their internal structure has not been studied yet. In the present work the thickness of the terminal divisions of the middle trunk, the size of cross-section area of their fascicles, the number of fascicles and the index of the fascicle's area are described.

The studies were carried out on material obtained bilaterally from cadavers of 34 males (♂) and 34 females (♀) who died at the age between the 11th day and 86th year of life. Six age groups were distinguished. Group I included 5 ♂ and 5 ♀ up to 1 year of life, group II — 5 ♂ and 5 ♀ between the 1st and 14th year of life, group III — 5 ♂ and 8 ♀ between the 15th and 22nd year of life, group IV — 5 ♂ and 6 ♀ between the 23rd and 40th year of life, group V — 9 ♂ and 5 ♀ between the 41st and 60th year of life, and group VI — 5 ♂ and 5 ♀ above the 60th year of life. The methods used to obtain the samples, to stain the slides and to determine the thickness of different parts of peripheral nervous system and their fascicles, the number of fascicles and the index of the fascicle's area, were described in the previous papers (9, 10).

RESULTS

The middle trunk was divided into two parts, anterior and posterior in 130 of cases (95.6%). The posterior part joined with the respective branches of the superior and inferior trunks to form the posterior fascicle. The anterior part in 120 of cases (88.2%) made the lateral fascicle along with the anterior division of superior trunk, and in 10 cases (7.4%) divided into two branches, lateral and medial. The lateral branch was composing the part of lateral fascicle, and the medial branch has joined with the anterior division of inferior trunk to form medial fascicle. In 6 instances (4.4%) the division of middle trunk into three parts, posterior and two anterior parts: lateral and medial, was observed. They participated in the structure of the three fascicles of the brachial plexus by the union with the respective parts of the superior and inferior trunks.

Thickness of the anterior and posterior divisions of the middle trunk

The dimension of the cross-section area of the discussed divisions in males is presented in Fig. 1, and in females in Fig. 2. The age of subjects is marked on the abscissa axis, and the age groups are separated by vertical lines. On the ordinate axis, the cross-section area of the anterior and posterior parts of the middle trunk are plotted (in 6 instances, in which there appeared two anterior parts, lateral and medial, it was presented by the sums of size of their cross-section areas). The thickness of the anterior part ranged between 0.471 and 14.120 sq mm, and of the

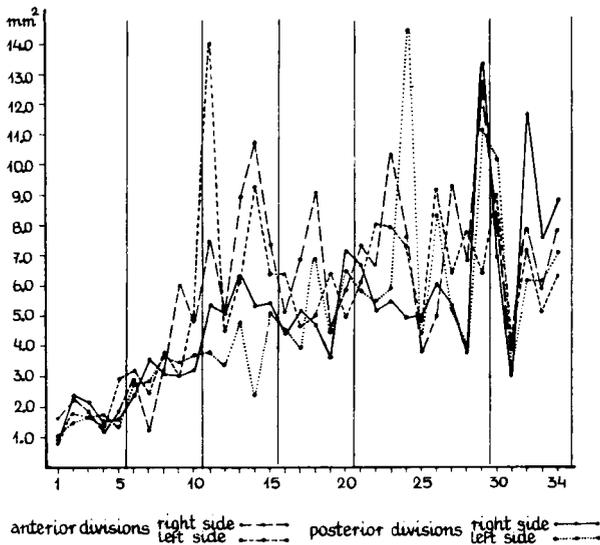


Fig. 1. Thickness of the anterior and posterior division of the middle trunk in males

posterior part between 0.880 and 14.521 sq mm. It was similar on both sides of the single body in the anterior division in 4.4%, and in the posterior division in 5.9% of cases. It was greater on the right side, respectively, in 50.0 and in 58.8%, and it was greater on the left side in 45.6 and in 35.3% of the cases. The thickness of both divisions showed similar values in 5.1% [on the right side (r) — 5.9%, on the left side (l) — 4.4%, in males (♂) — 5.9%, in females (♀) — 4.4%]. The thickness of the anterior division was greater in 69.1% (r — 64.7%, l — 73.5%, ♂ — 63.2%, ♀ — 75.0%), and the thickness of the posterior division was greater in 25.8% of the cases (r — 29.4%, l — 22.1%, ♂ — 30.9%, ♀ — 20.6%).

The average thickness of the anterior division equalled 5.525 sq mm, and of the posterior division 4.630 sq mm, on the right side it equalled, respectively, 5.620 and 4.705 sq mm, on the left side 5.430 and 4.554 sq mm, in males 5.790 and

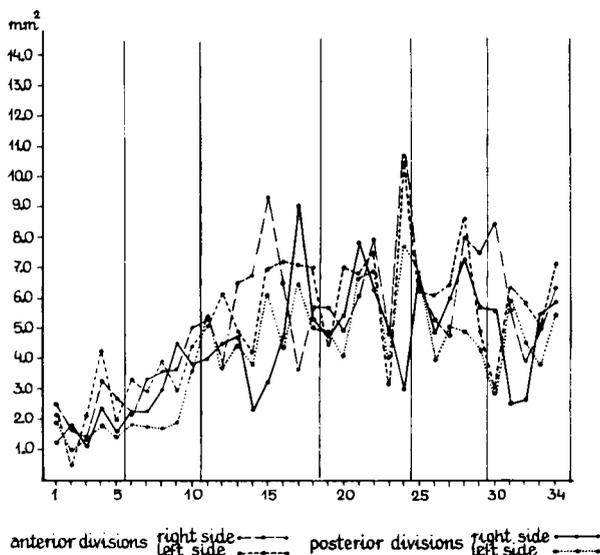


Fig. 2. Thickness of the anterior and posterior division of the middle trunk in females

5.005 sq mm, in females 5.259 and 4.254 sq mm. The values mentioned above in the age groups come out to be: in group I — 1.994 and 1.573 sq mm, in group II — 3.590 and 2.958 sq mm, in group III — 6.814 and 4.821 sq mm, in group IV — 6.365 and 5.408 sq mm, in group V — 7.110 and 6.351 sq mm, in group IV — 6.171 and 5.843 sq mm.

Number of fascicles

The anterior part was composed of 1 to 20 and the posterior part of 1 to 22 fascicles. In both parts most often six fascicles were found: in the anterior part in 13.8%, in the posterior part in 14.0% of the cases. There were 1 to 5 fascicles in the anterior part in 35.3%, and in the posterior part in 45.6%, from 6 to 10 fascicles respectively in 50.0 and in 44.8%, from 11 to 15 fascicles — in 11.0 and in 8.1%, and more than 15 fascicles — in 3.7 and in 1.5% of cases. The same number of fascicles on both sides of a single body was found in 4.4% in the anterior division and 4.4% in the posterior division. The number of fascicles was greater on the right side respectively in 42.7 and in 52.9%, and it was greater on the left side in 52.9 and in 42.7%. The number of fascicles in both parts of the middle trunk was the same in 13.2% (r — 11.8%, l — 14.7%, ♂ — 16.2%, ♀ — 10.3%). The number of fascicles was greater in the anterior part in 46.3% (r — 47.1%, l — 45.6%, ♂ — 41.2%, ♀ — 51.5%), and it was greater in the posterior part in 40.5% of cases (r — 41.2%, l — 39.7%, ♂ — 42.6%, ♀ — 38.2%).

The mean number of fascicles equalled in the anterior part 7.0, and in the posterior part 6.1, on the right side, respectively, 6.8 and 6.1, on the left side 7.1 and 6.1, in males 6.9 and 6.1, in females 7.1 and 6.1. In the age groups it came out as follows: in age group I — 7.1 and 5.7, in age group II — 7.0 and 7.1, in age group III — 6.4 and 4.3, in age group IV — 7.4 and 7.0 in age group V — 6.8 and 6.5, in age group IV — 7.2 and 6.4, respectively.

Dimension of the cross-section area of fascicles

In the examined material the thickness of an individual fascicle showed the following range of values: 0.001 to 5.247 sq mm in the anterior part, and 0.001 to 5.748 sq mm in the posterior part. Five groups of the fascicles were distinguished on the basis of their cross-section area. There were: very thin fascicles with cross-section area up to 0.100 sq mm, thin (from 0.101 to 0.300 sq mm), medium-thick (from 0.301 to 0.500 sq mm), thick (from 0.501 to 1.000 sq mm), and very thick (over 1.000 sq mm). They appeared with different frequency in the anterior and posterior part of the middle trunk. Very thin fascicles made 23.9% in the anterior part (r — 23.2%, l — 24.5%, ♂ — 22.7%, ♀ — 24.9%) and 25.5% in the posterior part (r — 25.1%, l — 25.9%, ♂ — 24.8%, ♀ — 26.2%), thin fascicles made respectively — 28.5% (r — 26.2%, l — 30.7%, ♂ — 25.8%, ♀ — 31.2%) and 28.9% (r — 27.5%, l — 30.3%, ♂ — 28.9%, ♀ — 28.9%), medium-thick fascicles — 17.2% (r — 19.0%, l — 15.5%, ♂ — 18.9%, ♀ — 15.6%) and 18.2% (r — 18.2%, l — 18.2%, o — 15.9%, ♀ — 20.7%), thick fascicles — 17.2% (r — 17.7%, l — 16.7%, ♂ — 18.5%, ♀ — 16.0%) and 14.3% (r — 15.3%, l — 13.3%, ♂ — 16.4%, ♀ — 12.3%), very thick fascicles — 13.2% (r — 13.9% (r — 13.9%, l — 12.6%, ♂ — 14.2%, ♀ — 12.3%) and 13.0% (r — 13.9%, l — 12.1%, ♂ 14.0%, ♀ — 12.0%) of all the fascicles.

The frequency of occurrence of differently thick fascicles in the examined divisions of the middle trunk was unequal in the age groups. The participation of fascicles in the structure of anterior part was as follows: in age group I — very thin fascicles 44.8%, thin 39.9%, medium-thick 8.4%, thick 5.6% and very thick 1.4%, in age group II it was — 23.4, 40.4, 21.3, 12.1 and 2.8% respectively, in age group III — 20.5, 22.9, 16.3, 20.5 and 19.9%, in age group IV — 20.2, 23.9, 18.4, 22.7 and 14.7%, in age group V — 18.4, 20.5, 20.0, 21.6 and 19.7%, in age group IV — 18.7, 27.8, 18.1, 18.1 and 17.4% respectively.

In the posterior part in age group I very thin fascicles made 41.7%, thin fascicles 37.4%, medium-thick fascicles 14.8%, thick fascicles 5.2% and very thick fascicles 0.9%, in age group II respectively — 37.3, 38.0, 16.2, 6.3 and 2.1%, in group III — 13.5, 17.1, 20.7, 21.6 and 27.0%, in group IV — 20.8, 32.5, 18.8, 14.9 and 13.0%, in group V — 18.8, 25.4, 18.8, 19.3 and 17.7%, in group VI — 23.4, 21.9, 20.3, 17.2 and 17.2%.

The size of cross-section area of all the fascicles forming the anterior part of the middle trunk ranged between 0.204 and 7.175 sq mm, and for the posterior part it ranged between 0.501 and 11.742 sq mm. It showed similar values on both sides of a single body in 4.4% in the anterior division, and in 5.9% in the posterior division, greater on the right side, respectively, in 57.4 and in 58.8%, greater on the left side in 38.2 and in 35.3% of cases. The sum of the thickness of the fascicles of the anterior part compared with the respective sum of the posterior part was similar in 6.6% (r — 5.9%, l — 7.4%, ♂ — 4.4%, ♀ — 8.8%). It was greater in 68.4% (r — 64.7%, l — 72.1%, ♂ — 64.7%, ♀ — 72.1%), but it was less in 25.0% (r — 29.4%, l — 20.6%, ♂ — 30.9%, ♀ — 19.1%) of cases.

The average value of the cross-section area of the fascicles of the anterior division equalled 3.431 sq mm, and of the posterior division 2.919 sq mm, on the right side, respectively, 3.480 and 2.939 sq mm, on the left side 3.381 and 2.899 sq mm, in males 3.567 and 3.149 sq mm, in females 3.294 and 2.689 sq mm. It was different in the age groups: in group I in the anterior part 1.204 sq mm, and in the posterior part 0.993 sq mm, in group II respectively — 2.195 and 1.738 sq mm, in group III — 4.349 and 3.275 sq mm, in group IV — 3.917 and 3.253 sq mm, in group V — 4.464 and 4.164 sq mm, in group VI — 3.717 and 3.455 sq mm.

Index of the cross-section area of fascicles (IAF)

The size of the index of the fascicle's area of the anterior division ranged between 43.3 and 84.2, but the one of the posterior division ranged between 43.3 and 88.0. It showed similar values on both sides of one body in 14.7% in the anterior division and in 10.3% in the posterior division, it was greater on the right side respectively in 44.1 and in 51.5%, and it was greater on the left side in 41.2 and in 38.2% of cases. The size of IAF of both parts of the middle trunk was similar in 8.1% (r — 7.4%, l — 8.8%, ♂ — 10.3%, ♀ — 5.9%). It was greater in the anterior part in 41.9% (r — 39.7%, l — 44.1%, ♂ — 41.2%, ♀ — 42.6%), and it was greater in the posterior part in 50.0% (r — 52.9%, l — 47.1%, ♂ — 48.5%, ♀ — 51.5%). The average value of index in the examined material equalled: 62.1 in the anterior division, and 63.1 in the posterior division, 61.9 and 62.5, respectively, on the right side, 62.3 and 63.7 on the left side, 61.6 and 62.9 in males, 62.6 and 63.2 in females. The value mentioned above in the age groups ranged as follows: in group I in the anterior part 60.4, and in the posterior part 63.1, in group II, respectively — 61.2 and 58.7, in group III — 63.8 and 67.9, in group IV — 61.5 and 60.2, in group V — 62.8 and 65.6, in group VI — 60.2 and 59.1.

DISCUSSION

The middle trunk most often divides into two parts, anterior and posterior, which take part in the formation of the lateral and posterior fascicles. Sometimes it gives the branch to the medial fascicle, which arises directly from the trunk or from its anterior part (3). In the presented material terminal divisions of the middle trunk participated in the structure of all fascicles of the brachial plexus in 11.8%, and two fascicles — lateral and posterior — in 88.2% of cases.

The performed investigations of some features of the internal texture of the middle trunk terminal parts have shown a great individual variability and asymmetry. Numerous authors describing the structure of different parts of the peripheral nervous system, have already paid attention to them (1—11). In the examined material identical values for all or three features mentioned above were not found on both sides of a single body, and two identical features were observed only in 1 of the cases. Similar values for a single characteristic of the middle trunk terminal parts on both sides of a body were seldom found: the thickness of the anterior part in 4.4%, and of posterior part in 5.9% of the bodies, the size of the cross-section area of fascicles respectively in 4.4 and in 5.9%, the number of fascicles — in 4.4 and in 2.9%, and the index of the fascicle's area — in 14.7 and in 8.8%.

Out of the examined features in a single person the following were greater on the right side than on the left side: the thickness of the anterior part in 50.0% and of the posterior part in 58.8%, the size of the cross-section area of fascicles respectively in 57.4 and in 58.8%, the number of fascicles — in 42.7 and in 52.9%, the index of the fascicle's area — in 44.1 and in 51.5% of cases. The above features in a single person had greater values on the left side than on the right side: the thickness of the anterior part in 45.6% and of the posterior part in 35.3%, the size of the cross-section area of fascicles respectively in 38.2 and in 35.3%, the number of fascicles — in 52.9 and in 42.7%, the index of the fascicle's area — in 41.2 and in 38.2% of cases.

The mean values of the examined features of the middle trunk terminal divisions differed a little between the sides of a single body and in relation to sex. In the anterior part they were greater on the right than on the left side: the thickness by 3.5% and the size of the cross-section area of fascicles by 2.9%, on the contrary, the mean value of the number of fascicles was greater on the left side than on the right side by 4.4%. The index of the fascicle's area showed similar values on both sides. In males the thickness of the anterior part was greater by 10.1%, and the cross-section area of fascicles by 8.3% than in females, on the contrary, in females the number of fascicles was greater by 2.9%, and the index of the fascicle's area by 1.6% than in males.

In the posterior part the following mean values were greater on the right than on the left side: the thickness by 3.3% and the size of the cross-section area of fascicles by 1.4%, on the contrary, the index of the fascicle's area was greater by 1.9% on the left side than on the right side. The mean number of fascicles was identical on both sides. In males the thickness of the posterior part was greater by 17.6%, and the cross-section area of fascicles by 17.1% than in females. The number of fascicles and the index of the fascicle's area had similar values in both sexes.

The anterior division of the middle trunk compared with its posterior division was thicker by 19.3% (r — 19.4%, l — 19.2%, ♂ — 15.7%, ♀ — 23.6%), the size of its cross-section area of fascicles greater by 17.5% (r — 18.4%, l — 16.6%, ♂ — 13.3%, ♀ — 22.5%), and the number of fascicles greater by 14.0% (r — 10.5%, l — 17.4%, ♂ — 12.3%, ♀ — 15.6%), on the contrary, the index of fascicle's area was smaller by 1.6% (r — 1.0%, l — 2.2%, ♂ — 2.1%, ♀ — 1.0%).

The participation of fascicles of various thickness in the structure of both parts of the middle trunk was different. Thick fascicles were observed in the anterior part more often than in posterior one, but very thin and medium-thick fascicles were found in the anterior part rather rarely. Medium-thick fascicles occurred more often on the right side in the anterior part, and were present equally on both sides of the body in the posterior part. Certain differences in the fascicular structure were observed in relation to the sex: thin fascicles occurred more often in females in the anterior part, and were equally present in the persons of both sexes in the posterior part, but medium-thick fascicles appeared more often in males in the anterior part, and in females in the posterior part.

The examined features of the middle trunk terminal divisions, apart from the number of fascicles, underwent big changes in postnatal life, especially in the age of up to the 22nd year of life. The thickness of the anterior division increased 3.6 times, and of the posterior division 3.3 times, the size of the cross-section area of fascicles increased respectively 3.7 times and 4.2 times, the index of the fascicle's area increased by 5.6 and 7.6%. The participation of fascicles of different thickness in the structure in the discussed divisions changed in postnatal life too. The fascicles of a cross-section area up to 0.3 sq mm constituted about $\frac{4}{5}$ of all in children up to 1 year old in both divisions. At the ages between the 1st and 22nd year of life their participation decreased, while the ratio of fascicles with a cross-section area greater than 0.5 sq mm increased considerably.

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STRESZCZENIE

Część przednią i tylną pnia środkowego badano obustronnie na zwłokach 34 osób płci męskiej i 34 osób płci żeńskiej. Część przednia w porównaniu z częścią tylną była o 19,3% grubsza, miała o 17,5% większą powierzchnię poprzecznego przekroju pęczków oraz o 14,0% większą liczbę pęczków, natomiast o 1,6% mniejszy wskaźnik powierzchni pęczków. W części przedniej występowały częściej niż w tylnej pęczki grube, a rzadziej pęczki bardzo cienkie i średniej grubości. Podczas życia pozapłodowego powiększały się: grubość części przedniej 3,6 razy, części tylnej 4,0 razy, wielkość powierzchni poprzecznego przekroju pęczków części przedniej 3,7 razy, części tylnej 4,2 razy, a wskaźnik powierzchni pęczków części przedniej o 5,6%, części tylnej o 7,6%. Zmieniał się również udział pęczków o różnej grubości w budowie badanych części: zmniejszał się — pęczków o powierzchni poprzecznego przekroju do 0,3 mm², a zwiększał — pęczków o powierzchni poprzecznego przekroju powyżej 0,5 mm². Liczba pęczków nie wykazywała różnic związanych z wiekiem.