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Some Features of the Internal Structure of the Brachial Plexus Trunks in Man

Niektóre cechy wewnętrznej budowy pni splotu ramiennego u człowieka

Studies concerning the brachial plexus trunks morphology are not numerous (3, 5, 11) and lack internal structure analysis. Due to this fact I took an interest in some features of the internal structure of the three trunks of the brachial plexus — superior, middle and inferior during postnatal life in man.

MATERIAL AND METHODS

The study was carried out on the material obtained bilaterally from the cadavers of 33 males and 33 females who died between the 11th day and 86th year of life, and who did not suffer from any disease of the nervous system. Material was divided into 6 age groups. Group I included 5 males and 5 females up to one year of life, group II — 5 males and 5 females between the 14th and 1st year of life, group III — 5 males and 7 females between the 15th and 22nd year, group IV — 5 males and six females between the 23rd and 40th year, group V — 8 males and 5 females between the 41st and 60th year and group VI — 5 males and 5 females over the 60th year of life. The dissection method visualized the brachial plexus roots, trunks and their terminal divisions. The segments of the middle parts of the trunks were excised, fastened to a glass frame and fixed in formalin. Further preparation of the excisions, staining of the slides, the methods of determining the trunks and their fascicles thickness as well as the number of fascicles and the index of fascicles area were described in the previous papers (9, 10).

RESULTS

Three trunks of the brachial plexus — superior, middle and inferior were present in all the examined cases.

Thickness of the trunks

The values of the cross-section area of the trunks in males are presented in Figure 1, and in females in Figure 2. The age of subjects is marked on the

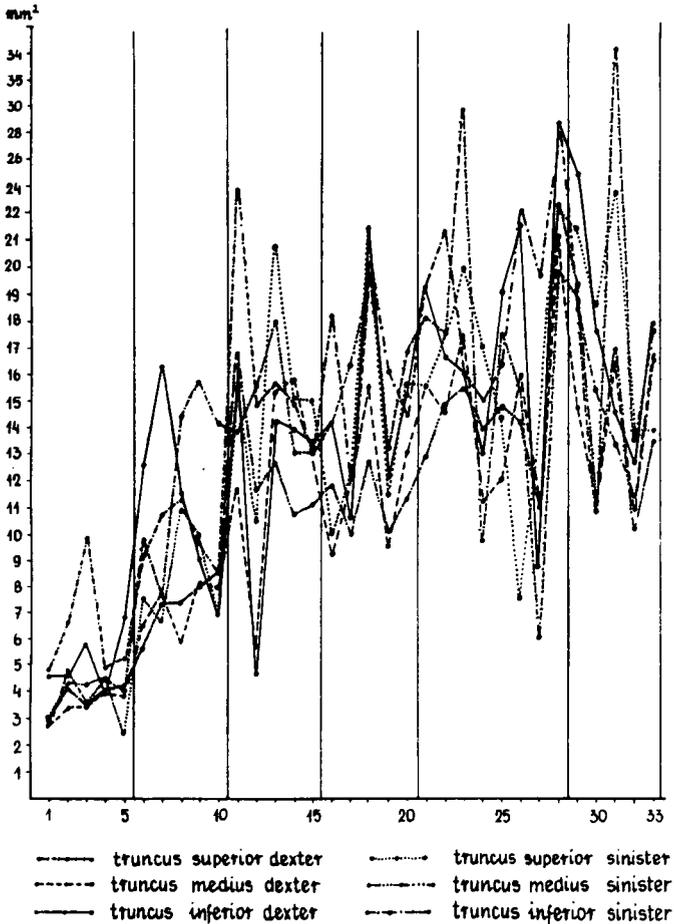


Fig. 1. Thickness of the trunks in males

abscissae axis and the age groups are separated by vertical lines. On the ordinate axis the values of the trunks thickness are plotted. It arose from the figures that the thickness of the trunks in a single person and on the same side of the body was different. Six varieties of superior (s), middle (m), and inferior (i) trunks thickness relations were distinguished. They are presented by the following patterns: 1 — $i > s > m$, 2 — $s > i > m$, 3 — $i > m > s$, 4 — $s > m > i$, 5 — $m > i > s$, 6 — $m > s > i$. The first variety was observed in 37.1%, the second in 31.1%, the third in 15.1%, the fourth in 11.4%, the fifth in 3.8% and the sixth in 1.5% of cases.

The superior trunk was the thickest in 42.4%, the middle in 5.3% and the inferior in 52.3% of cases. They were the thinnest in 18.9, 68.2 and 12.9% of cases respectively.

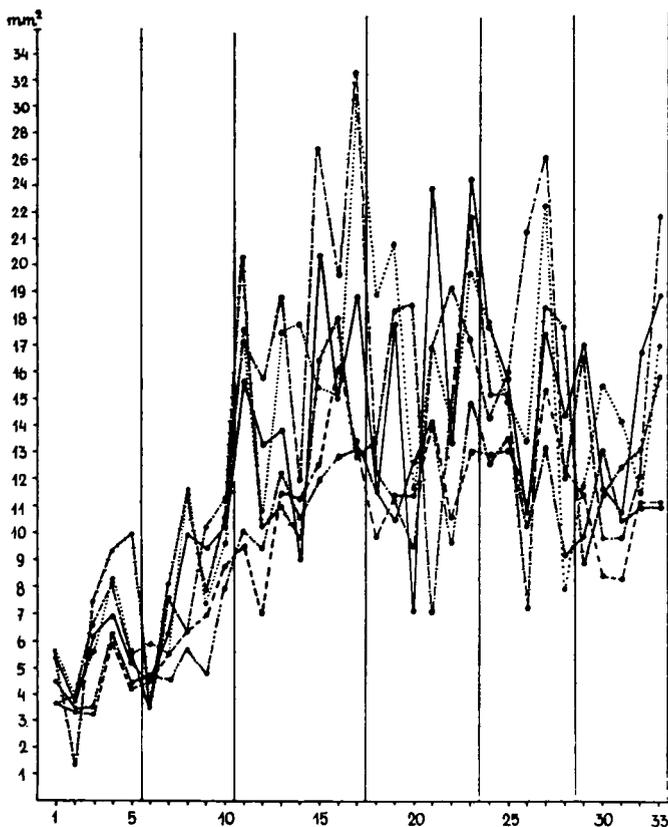


Fig. 2. Thickness of the trunks in females

The discussed value was similar on both sides of the single body in the superior trunk in 4.5%, in the middle trunk in 24.2% and in the inferior trunk in 12.1% of cases. It was greater on the right side in 51.5, 39.4 and 33.4% and it was greater on the left side in 44.0, 36.4 and 54.5% of cases respectively.

The average thickness of the superior trunk was 13.224, of the middle trunk 10.374 and of the inferior trunk 13.701 sq mm. The discussed value came out to be 5.056, 3.944 and 5.633 in group I, 9.289, 6.661 and 9.283 in group II, 15.747, 11.940 and 16.436 in group III, 15.823, 11.791 and 15.451 in group IV, 15.921, 13.970 and 17.979 in group V and 15.934, 12.403 and 15.416 in group VI respectively.

Number of fascicles

The number of fascicles ranged from two to forty one in the superior trunk, from one to twenty five in the middle trunk and from one to thirty four in the

inferior trunk. There were one to five fascicles in the superior trunk in 15.9%, in the middle trunk in 15.9% and in the inferior trunk in 30.3% of cases, from six to ten fascicles in 33.3, 38.6 and 33.3% of cases respectively, from eleven to fifteen fascicles in 28.0, 30.3 and 22.5%, from sixteen to twenty fascicles in 16.7, 11.4 and 9.1% and more than twenty fascicles in 6.1, 3.8 and 4.6% of cases. The same number of fascicles on both sides of one body was found in 9.1% of cases in the superior trunk, in 4.5% in the middle trunk and in 6.1% in the inferior trunk. The number of fascicles was greater on the right side of the body in 39.4, 44.0 and 42.4% of cases respectively and it was greater on the left side in 51.5, 51.5 and 51.5% of cases.

The number of fascicles was similar in all the three trunks on the same side of the body in 2.3% of cases. It had the highest values in the superior trunk in 35.6%, in the middle trunk in 25.0% and in the inferior trunk in 22.0% of cases. It had similar values in the superior and middle trunks and greater than in the inferior trunk in 9.1%, the same values in the superior and inferior trunks and greater than in the middle trunk in 1.5%, and similar values in the middle and inferior trunks and greater than in the superior trunk in 4.5% of cases.

The mean number of fascicles equalled 11.5 in the superior trunk, 10.4 in the middle trunk and 9.3 in the inferior trunk. In the age groups it was as follows: in group I — 9.1, 7.6 and 9.8 respectively, in group II — 12.2, 11.2 and 9.7, in group III — 13.3, 10.7 and 7.2, in group IV — 12.0, 12.0 and 9.6, in group V — 11.4, 10.5 and 11.7 and in group VI — 10.6, 10.1 and 7.7.

Size of the cross-section area of fascicles

In the examined material very thin fascicles with the cross-section area below 0.100 sq mm, thin fascicles (0.101—0.300 sq mm), medium thick fascicles (0.301—0.500 sq mm), thick fascicles (0.501—1.000 sq mm) and very thick fascicles (over 1.000 sq mm) were differentiated. Very thin fascicles formed 19.2% of the superior trunk, 20.1% of the middle trunk and 17.8% of the inferior trunk. Thin fascicles formed 23.8, 28.6 and 22.5% respectively, medium-thick fascicles 14.9, 15.6 and 13.0%, thick fascicles 19.6, 18.5 and 17.4% and very thick fascicles 22.5, 17.2 and 29.3% respectively.

The frequency of occurrence of different size fascicles in the examined trunks was unequal in the age groups. In group I very thin fascicles reached 28.0% in the superior, 31.4% in the middle and 32.5% in the inferior trunk, thin fascicles 31.9, 36.6 and 31.0%, medium-thick fascicles 23.6, 10.5 and 15.7%, thick fascicles 9.3, 13.7 and 13.7% and very thick fascicles 7.1, 7.8 and 7.1% respectively. In group II very thin fascicles made 31.4% in the superior, 31.6% in the middle and 21.0% in the inferior trunk, thin fascicles 26.9, 34.2 and 28.2%, medium-thick 15.1, 13.3 and 14.4%, thick 15.5, 12.0 and 17.9%, very thick fascicles 11.0, 8.9 and 18.5% respectively. In group III the superior trunk involved 15.6%, the middle trunk

14.4% and the inferior trunk 10.4% very thin fascicles, 23.1, 26.6 and 19.7% thin fascicles, 12.8, 16.8 and 9.8% medium-thick fascicles, 20.9, 20.2 and 14.4% thick fascicles and 27.5, 21.9 and 45.7% very thick fascicles respectively. In group IV the superior trunk was in 15.2%, the middle in 17.3% and the inferior trunk in 15.1% composed of very thin fascicles, in 19.8, 29.7 and 21.2% of thin fascicles, in 11.4, 13.9 and 12.3% of medium-thick fascicles, in 25.5, 21.4 and 16.5% of thick fascicles and in 28.1, 17.7 and 34.9% of very thick fascicles respectively. In group V very thin fascicles constituted 15.5% of each trunk, thin fascicles 20.9% of the superior, 23.2% of the middle and 20.1% of the inferior trunk, medium-thick fascicles 16.6, 18.5 and 14.1%, thick fascicles 22.6, 22.9 and 20.1% and very thick fascicles 24.3, 19.9 and 30.2% of the trunks respectively. In group VI very thin fascicles made 13.1% of the superior, 15.8% of the middle and 11.6% of the inferior trunk, thin fascicles 23.5, 24.6 and 13.6%, medium thick fascicles 12.2, 18.7 and 10.2%, thick fascicles 19.7, 17.2 and 20.4% and very thick fascicles 31.5, 23.6 and 44.2% of the trunks respectively.

The sum of cross-section area of all the fascicles showed similar values in the three trunks in 0.8% of cases. It was the greatest in the superior trunk in 36.3%, in the middle in 3.0% and in the inferior trunk in 58.3% of cases. It had similar values in the superior and inferior trunks and greater than in the middle trunk in 0.8% of cases and similar in the middle and inferior trunks and greater than in the superior trunk in 0.8% of cases. It had similar values on both sides of the single body in 16.7% in the middle trunk and in 13.6% in the inferior trunk, greater on the right side in the superior trunk in 50.0%, in the middle in 47.0% and in the inferior trunk in 37.9% and greater on the left side in 50.0, 36.3 and in 48.5% of cases respectively.

The average value of cross-section area of fascicles equalled (in square milimeters) 8.514 in the superior, 6.150 in the middle and 9.117 in the inferior trunk. It was different in the age groups: 3.437, 2.524 and 3.652 in group I, 5.913, 3.976 and 5.749 in group II, 10.087, 7.321 and 11.521 in group III, 10.060, 6.888 and 10.483 in group IV, 10.321, 8.210 and 11.657 in group V, 10.252, 7.056 and 10.260 in group VI respectively.

Index of cross-section area of fascicles (IAF)

The highest values of the index were found in the superior trunk in 34.8%, in the middle in 15.9% and in the inferior trunk in 44.7% of cases. IAF showed similar values in the superior and inferior trunks and greater than in the middle trunk in 3.8% of cases, and similar values in the superior and middle trunks and greater than in the inferior trunk in 0.8% of cases. The IAF value was similar on both sides of one body in the superior trunk in 7.6%, in the middle in 12.1% and in the inferior trunk in 22.7%. It was greater on the right side in 48.5, 45.5 and 43.9% respectively, and greater on the left side in 43.9, 42.4 and 33.4% of cases.

The average values of the index equalled: 64.4 in the superior, 59.3 in the middle and 66.5 in the inferior trunk. The IAF value ranged in the age groups as follows: in group I — 68.3 in the superior, 64.0 in the middle and 64.8 in the inferior trunk, in group II — 63.7, 59.7 and 61.9 respectively, in group III — 63.3, 61.3 and 70.1, in group IV — 63.6, 58.4 and 67.8, in group V — 64.8, 58.8 and 64.8 and in group VI — 64.0, 56.9 and 66.6.

DISCUSSION

Cognition of some features of the internal structure of the three trunks on the same material increases our knowledge on the morphology of the brachial plexus. The investigations performed had shown a great individual variability concerning the internal composition of the trunks (1, 2, 4, 6, 7, 8). The trunks differed between each other in thickness, the number of fascicles, their size as well as the index of their cross-section area.

The inferior trunk reached the highest average thickness; it was by 3.6% greater than the average thickness of the inferior trunk and by 32.1% greater than that of the middle trunk. The highest average value of the cross-section area of fascicles (csaf) was also observed in the inferior trunk. It was by 7.1% greater than in the superior trunk and by 48.2% greater than in the middle trunk. The highest average number of fascicles, considering the superior trunk, was greater from the corresponding value of the middle trunk by 10.6% and of the inferior trunk by 23.7%. The highest average value of IAF recorded in the inferior trunk was greater from the corresponding value in the superior trunk by 3.3% and in the middle trunk by 12.1%. The average values of the examined features distinguished the trunks. The superior trunk has been characterized by the middle thickness, middle csaf, middle IAF and the greatest number of fascicles, the middle trunk — by small thickness, small csaf, small IAF and middle number of fascicles, the inferior trunk — by the highest thickness, the highest csaf, the highest IAF and the smallest number of fascicles.

Different thickness fascicles participation in trunks structure was unequal. Very thin, thin and medium thick fascicles occurred most often in the middle trunk, less often in the superior trunk and least often in the inferior trunk. The thick fascicles — most often in the superior trunk, less often in the middle trunk and least often in the inferior trunk and very thick fascicles — most often in the inferior trunk, less often in the superior trunk and least often in the middle trunk.

The features studied were undergoing big changes in postnatal life, mostly up to the 22nd year of life. The thickness of the superior trunk increased 3.1 times, of the middle trunk 3.5 times and of the inferior trunk 3.2 times. The size of the cross-section area of fascicles increased 3.0, 3.3 and 3.3 times respectively. The index of the fascicles area in the the superior trunk decreased by 6.3% and in the middle trunk by 11.1%, but in the inferior trunk it increased by 8.2%. The

number of fascicles in adults was greater than in children younger than 1 year, by 46.2% in the superior trunk, 59.2% in the middle trunk and 19.4% in the inferior trunk. The participation of fascicles of different thickness in the trunks structure changed in postnatal life too. In children up to one year old the fascicles of the cross-section area smaller than 0.3 sq mm constituted more than 60% and fascicles of the cross-section area over 0.5 sq mm about 20% of all fascicles. In adults these relations were changed. The participation of the fascicles of $csaf < 0.3$ sq mm decreased at least by 33%, and of the fascicles of $csaf > 0.5$ sq mm increased 2—3 times. The greatest changes in fascicles dimensions occurred in the superior trunk and the smallest in the middle trunk.

REFERENCES

1. Балакишев К. А.: Внутренняя топография пучков главных нервных стволов поясничного сплетения. Азербайджанский мед. журн. **25**, 38, 1935.
2. Cotrell L.: Histologic variations with age in apparently normal peripheral nerve trunks. Arch. Neurol. Psychiat. **43**, 1138, 1940.
3. Hirasawa K.: *Plexus brachialis* und die Nerven der oberen Extremität. Arbeiten aus. 3. Abt. Anat. Institut. Kaiserl. Univ. Kyoto, Serie A, H. 2, Kyoto 1931.
4. Йосифов Г. М.: Топография пучков образующих нервные стволы плечевого, поясничного и крестцового сплетения. Русский архив. Anat. Гистол. Эмбриолог. **7**, 207, 1928.
5. Kerr A. T.: The brachial plexus of nerves in man, the variations in its formation and branches. Am. J. Anat. **23**, 285, 1918.
6. Mustafa G. Y., Gamble H. J.: Observations on the development of the connective tissues of developing human nerve. J. Anat. **127**, 141, 1978.
7. Sunderland S., Cossar D. F.: The structure of the facial nerve. Anat. Rec. **116**, 147, 1953.
8. Sunderland S., Swaney W. E.: The intraneural topography of the recurrent laryngeal nerve in man. Anat. Rec. **114**, 411, 1952.
9. Urbanowicz Z.: Femoral nerve fascicles in the human postfetal life. Folia Morphol. (Warszawa) **39**, 283, 1980.
10. Urbanowicz Z.: Fascicular structure of the root of the brachial plexus from C₆ in man. Ann. Univ. M. Curie-Skłodowska, Lublin, Sectio D **47**, 61, 1992.
11. Walsh J. F.: The anatomy of the brachial plexus. Am. J. Med. Sc. **74**, 387, 1877.

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STRESZCZENIE

Grubość pni splotu ramiennego — górnego, środkowego i dolnego, wielkość powierzchni poprzecznego przekroju ich pęczków (pppp), liczbę pęczków i wielkość wskaźnika powierzchni pęczków (pp) badano obustronnie na zwłokach 33 osób płci męskiej i 33 osób płci żeńskiej. Pień górny charakteryzowały: średnia grubość, wielkość pppp i wskaźnik pp oraz największa liczba pęczków, pień środkowy — mała grubość i wielkość pppp, niski wskaźnik pp i średnia liczba pęczków, pień dolny — największa grubość i wielkość pppp, wysoki wskaźnik pp i najmniejsza liczba pęczków. W życiu pozapłodowym, głównie do 22 roku, badane cechy ulegały dużym zmianom.

