

RESULTS

Five mixed nerves which arise from the brachial plexus cords were present in all the cases. The musculocutaneous nerve (mc) arose from the lateral cord, the median nerve (med.) was formed by the union of two roots from the lateral and medial cords, and the ulnar nerve (uln) – left and medial cord. The radial nerve (rad) and the axillary nerve (ax) made the terminal branches of the posterior cord.

THICKNESS OF MIXED NERVES OF THE BRACHIAL PLEXUS

The size of the cross-section area of the nerves in males is presented in Figures 1 and 2, and in females in Figures 3 and 4. The age of subjects is marked on abscissa axis, and the age groups are separated by the vertical lines. On the ordinate axis the cross-section area of nerves is plotted. The discussed value was similar on both sides of one body in 11.3% in the mc, in 15.0% in the med, in 16.3% in the uln, in 20.0% in the rad and in 6.3% in the ax, it was greater on the right side in 38.7%, 48.8, 46.2, 45.0 and 55.0, and greater on the left side in 50.0, 36.3, 37.5, 35.0 and 38.7% of the cases respectively.

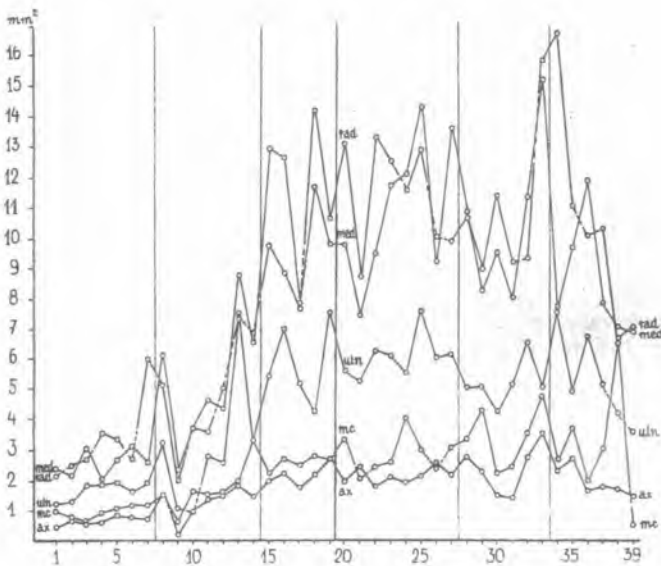


Fig. 1. Thickness of right mixed nerves in males; mc – musculocutaneous nerve, med – median nerve, uln – ulnar nerve, rad – radial nerve, ax – axillary nerve

In the examined material the thickest nerve, thick nerve, medium-thick nerve, thin nerve and the thinnest nerve were distinguished. The thickest was in 56.9% rad, in 35.0% med. In 7.5% rad and med, and in 0.6% of the cases rad and mc had similar thicknesses, but greater than the medium-thick nerve. The thick nerve was represented in 52.5% by med, in 33.8% by rad, in 3.1% by uln and

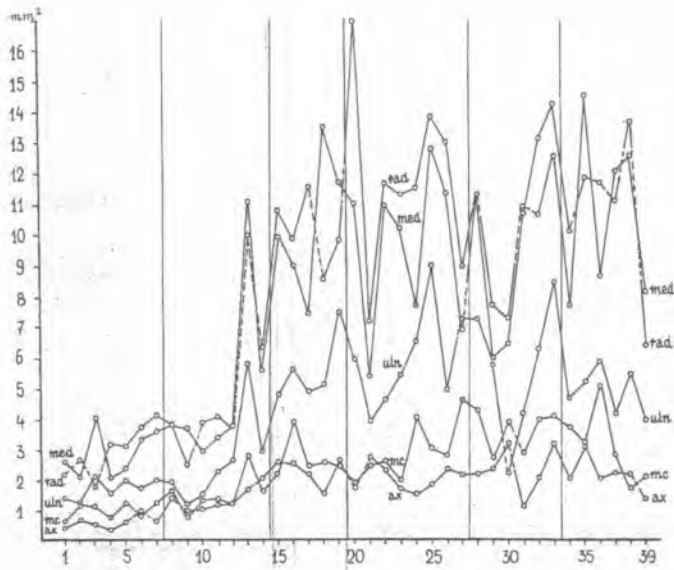


Fig. 2. Thickness of left mixed nerves in males; for explanation see Fig. 1

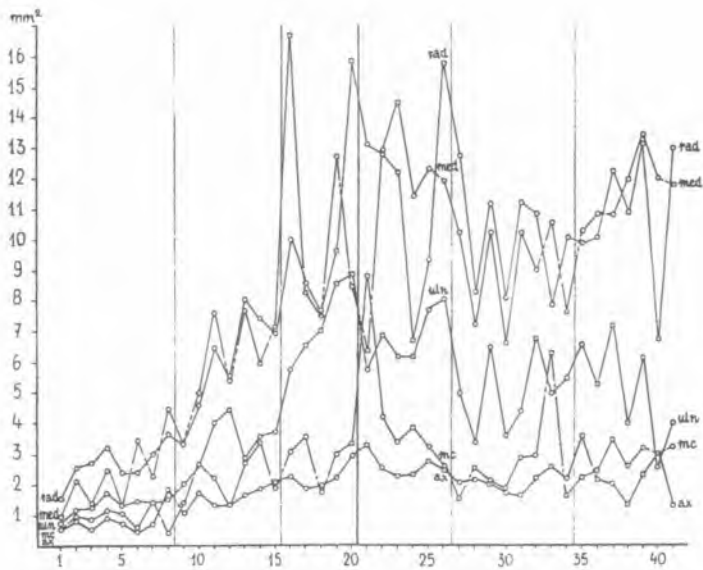


Fig. 3. Thickness of right mixed nerves in females; for explanation see Fig. 1

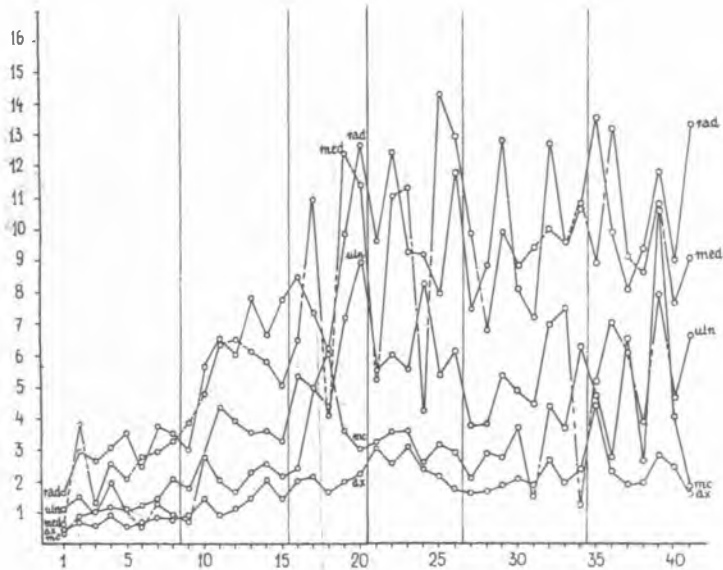


Fig. 4. Thickness of left mixed nerves in females; for explanation see Fig. 1

in 0.6% by mc. In 0.6% rad and uln, in 0.6% med and uln, and in 0.6% med and mc had similar thicknesses, but greater than the thin nerve. The medium-thick nerve was in 85.0% uln, in 5.6% mc, in 3.1% med, in 0.6% rad and in 0.6% ax. In 2.5% uln and mc, and in 0.6% mc and ax had similar thicknesses, but greater than the thinnest nerve. The thin nerve was in 74.4% mc, in 13.1% ax, in 5.6% uln and in 0.6% med. In 2.5% mc and ax, and in 0.6% uln and ax had similar thicknesses, but smaller than the medium thick nerve. The thinnest nerve was in 82.5% ax, in 12.5% mc and in 1.9% uln.

The average thickness of the mc equalled (in sq mm) 2.605 [on the right side (r) 2.492, on the left side (l) 2.719, in males (δ) 2.438, in females (♀) 2.764], of the med 7.881 (r – 8.095, l – 7.666, δ – 7.945, ♀ – 7.819), of the uln 4.459 (r – 4.512, l – 4.406, δ – 4.419, ♀ – 4.498), of the rad 8.259 (r – 8.364, l – 8.154, δ – 8.404, ♀ – 8.121), of the ax 1.788 (r – 1.791, l – 1.786, δ – 1.749, ♀ – 1.826). The discussed values come out to be 0.942, 2.547, 1.533, 2.975 and 0.697 in group I, 1.892, 5.420, 3.093, 5.513 and 1.385 in group II, 3.077, 10.294, 6.259, 9.917 and 2.170 in group III, 3.282, 10.461, 6.208, 11.298 and 2.292 in group IV, 3.272, 9.659, 5.116, 10.186 and 2.184 in group V and 3.272, 10.134, 5.332, 10.60 and 2.220 in group VI respectively.

NUMBER OF FASCICLES

The number of fascicles ranged from 1 to 14 in mc, from 1 to 26 in med, from 1 to 22 in uln, from 2 to 31 in rad, and from 1 to 9 in ax. There were up to 5 fascicles observed in 69.4% in mc, in 15.6% in med, in 47.5% in uln, in 3.1% in rad, and in 90.0% in ax, from 6 to 10 fascicles in 25.0, 40.6, 40.0, 14.4 and 10.0%, from 11 to 15 fascicles in 5.6, 25.0, 11.2, 26.9 and 0% respectively, and

more than 15 fascicles in 18.8 in med, in 1.2 in uln and in 55.6% in rad. The same number of fascicles on both sides of one body was found in 15.0% in mc, in 8.8% in med, in 17.5% in uln, in 7.5% in rad and in 31.3% in ax, and it was greater on the right side in 45.0, 51.2, 42.5, 55.0 and 36.2%, and greater on the left side in 40.0, 40.0, 40.0, 37.5 and 32.5% of the cases respectively. The number of fascicles was the greatest in 75.6% in rad, in 18.8% in med and in 1.3% in uln. The number of fascicles was the same in two nerves in 3.1% (in rad and med in 2.5%, in rad and uln in 0.61%), and in three nerves in 1.2% (in rad, med and uln in 0.6%, in rad, med and ax in 0.6%), but greater than in the remaining nerves. It was the lowest in 53.2% in ax, in 13.1 in mc, in 6.3% in uln and in 0.6% in med. The number of fascicles was equal and the lowest in two nerves in 22.5% (in mc and ax in 11.9%, in uln and ax in 6.9%, in mc and uln in 1.9% and in 0.6% equally in med and ax, med and mc, med and uln), and in three nerves in 4.3% (in mc, uln and ax in 3.1%, in mc, med and uln in 0.6%, in med, uln and ax in 0.6%).

The mean number of fascicles equalled in mc 4.5 ($r = 4.7, 1 - 4.4, \delta - 3.9, \eta - 5.1$), in med 10.7 ($r = 10.6, 1 - 10.8, \delta - 9.5, \eta - 11.8$) in uln 6.2 ($r = 6.1, 1 - 6.3, \delta - 5.3, \eta - 7.1$), in rad 16.0 ($r = 16.1, 1 - 16.0, \delta - 15.1, \eta - 16.9$), in ax 2.7 ($r = 2.8, 1 - 2.6, \delta - 2.4, \eta - 3.0$). In the age groups it was: in group I - 4.9, 7.4, 5.6, 17.0 and 3.1, in group II - 4.2, 8.2, 5.1, 15.3 and 2.7, in group III - 4.4, 11.3, 7.8, 15.6 and 3.3, in group IV - 4.6, 12.7, 7.5, 15.8 and 2.2, in group V - 4.1, 12.4, 6.0, 15.9 and 2.6, in group VI - 5.0, 12.6, 5.7, 16.6 and 2.5 respectively.

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

There were differentiated: very thin fascicles (up to 0.1 sq mm), thin fascicles (0.101-0.3 sq mm), medium-thick fascicles (0.301-0.5 sq mm), thick fascicles (0.501-1 sq mm) and very thick fascicles (over 1 sq mm). Very thin fascicles (vtn) made 34.8% in mc, 16.1% in med, 20.6% in uln, 31.6% in rad and 24.2% in ax, thin fascicles (tn) 32.4, 37.9, 33.7, 34.5 and 30.7%, medium-thick fascicles (mtk) 12.8, 23.0, 17.8, 17.8 and 14.6%, thick fascicles (tk) 9.5, 16.9, 16.9, 12.9 and 13.4%, very thick fascicles (vtk) 10.5, 6.1, 11.2, 3.2 and 17.1% respectively.

The frequency of occurrence of differently thick fascicles in nerves was unequal in the age groups. In group I vtn were present in 65.3% in mc, in 30.8 in med, in 45.2 in uln, in 61.9% in rad and in 53.3 in ax, tn - in 29.3, 49.8, 42.9, 34.2 and 25.0%, mtk - in 2.7, 12.2, 6.5, 2.4 and 12.0%, tk - in 2.7, 5.0, 3.0, 1.6 and 9.8%, vtk - in 0, 2.2, 2.4, 0 and 0% respectively. In group II vtn consisted of 43.7% in mc, 14.7% in med, 20.4% in uln, 29.8% in rad and 28.0% in ax, tn - 32.8, 37.2, 38.0, 44.8 and 34.7%, mtk 9.2, 28.1, 19.0, 15.2 and 9.3%, tk - 3.4, 12.6, 12.6, 9.8 and 14.7%, vtk - 10.9, 7.4, 9.9, 0.5 and 13.3% respectively. In group III vtn formed 15.9% in mc, 10.6% in med, 10.2% in uln, 19.2% in rad and 16.6% in ax, tn - 40.9, 33.0, 33.1, 34.0 and 36.4%, mtk 19.3, 23.8, 28.0, 25.0 and 18.2%, tk - 11.4, 24.2, 18.5, 17.6 and 10.6%, vtk - 12.5, 8.4, 10.2, 4.2 and 18.2% respectively. In group IV vtn were present in 25.6% in mc, in 12.6% in med, in 13.7% in uln, in 20.8% in rad and in 9.7% in ax, tn - in 31.8, 37.0, 30.8, 21.0 and 22.6%, mtk - in 17.0, 24.4, 19.4, 21.5 and 17.7%, tk - in 10.1, 19.3, 26.1, 18.8 and 16.1%, vtk - in 15.5, 6.7, 10.0, 7.9 and 33.9% respectively. In group V vtn were present in 17.5% in mc, in 11.8% in med, in 18.3% in uln, in 21.1% in rad and in 15.3% in ax, tn - in 36.8, 36.3, 32.0, 31.5 and 30.5%, mtk - in 15.8, 25.6, 13.6, 24.9 and 16.7%, tk - in 12.3, 19.9, 19.5, 19.6 and 15.3%, vtk - in 17.5, 6.4, 16.6, 2.9 and 22.2% respectively. In group VI vtn were present in 29.4% in mc, in 19.2% in med, in 16.2% in uln, in 28.3% in rad and in 10.6% in ax, tn - in 26.4, 36.3, 25.7, 32.0 and 36.3%, mtk - in 16.3, 21.9, 20.9, 22.5 and 15.2%, tk - in 18.6, 17.1, 18.3, 13.0 and 15.2%, vtk - in 9.3, 5.5, 18.9, 4.2 and 22.7% respectively.

The size of cross-section area of all the fascicles (csaf) was similar on both sides of a single body in 16.2% in me, in 17.5% in med, in 21.2% in uln, in 20.0% in rad and in 15.0% in ax. It was greater on the right side in 33.8, 43.8, 45.0, 36.3 and in 45.9% respectively, greater on the left side in 50.0, 37.5, 33.8, 43.7 and in 40.0%. It had the greatest values in 48.1% in rad and in 40.0% in med. The sum of the csaf have shown equal values in rad and med but greater than in the remaining nerves in 11.9% of the cases. The described sum was the lowest in 67.5% in ax, in 22.5% in mc and in 1.2% in uln. It had equal values in mc and ax but smaller than in remaining nerves in 8.8% of the cases.

The average value of csaf was (in sq mm) in mc 1.704 ($r = 1.636$, $l = 1.772$, $\delta = 1.635$, $\varphi = 1.770$), in med 4.419 ($r = 4.502$, $l = 4.337$, $\delta = 4.458$, $\varphi = 4.382$), in uln 2.788 ($r = 2.871$, $l = 2.706$, $\delta = 2.810$, $\varphi = 2.767$), in rad 4.461 ($r = 4.473$, $l = 4.448$, $\delta = 4.502$, $\varphi = 4.421$), in ax 1.339 ($r = 1.346$, $l = 1.332$, $\delta = 1.338$, $\varphi = 1.340$). It was different in the age groups: in group I the average value was in the mc 0.586, in the med 3.437, in the uln 1.008, in the rad 1.741 and in the ax 0.521, in group II – 1.270, 3.437, 2.054, 3.376 and 1.077, in group III – 2.147, 5.751, 3.766, 5.585 and 1.687, in group IV – 2.167, 5.659, 3.754, 6.183 and 1.779, in group V – 2.207, 5.508, 3.291, 5.281 and 1.612, in group VI – 2.082, 5.102, 3.297, 5.161 and 1.495 respectively.

INDEX OF THE CROSS-SECTION AREA OF FASCICLES

The greatest values of IAF were found in 58.1% in ax, in 16.3% in mc, in 8.1% in med and in 6.3% in uln. It was similar in two nerves (in ax and mc in 2.5%, in ax and med in 2.5%, in ax and uln 2.5%, in ax and rad in 0.6%, in mc and uln in 1.9%, in mc and med. in 0.6%, in uln and med. in 0.6%) but greater than in the remaining nerves in 11.2% of the cases. The lowest value of IAF were observed in 39.4% in rad, in 28.1% in med, in 8.8% in uln, in 6.3% in mc and in 0.6% in ax. It was similar in two nerves (rad and mc in 3.1%, rad and med in 5.6%, rad and uln in 1.9%, rad and ax in 0.6%, med and uln in 1.9%, med and ax in 0.6%, mc and uln in 1.9%, mc and ax in 0.6%) in 16.2%, and in three nerves (mc, med and uln) in 0.6% but smaller than in remaining nerves.

The IAF showed similar values on both sides of one body in 10.0% in mc, in 8.7% in med, in 8.7% in uln, in 6.2% in rad and in 21.2% in ax. It was greater on the right side in 42.5, 43.8, 56.3, 41.3 and 37.5%, and it was greater on the left side in 47.5, 47.5, 35.0, 52.5 and 41.3% of the cases respectively.

The average value of IAF equalled: 65.8 in mc ($r = 65.5$, $l = 66.1$, $\delta = 66.5$, $\varphi = 65.1$), 56.1 in med ($r = 55.6$, $l = 56.6$, $\delta = 56.1$, $\varphi = 56.0$), 62.5 in uln ($r = 65.6$, $l = 61.4$, $\delta = 63.6$, $\varphi = 61.5$), 54.0 in rad ($r = 53.5$, $l = 54.5$, $\delta = 53.6$, $\varphi = 54.4$), 74.9 in ax ($r = 75.2$, $l = 74.6$, $\delta = 76.5$, $\varphi = 73.4$). The discussed values in the age groups ranged as follows: in group I the average value was 62.3 in mc, 66.1 in med, 65.8 in uln, 58.5 in rad and 74.7 in ax, in group II – 64.9, 63.4, 66.6, 61.2 and 77.8, in group III – 69.5, 55.9, 60.2, 56.3 and 77.7, in group IV – 66.4, 54.1, 60.5, 54.7 and 77.6, in group V – 67.6, 57.0, 64.3, 51.8 and 73.8, in group VI – 61.7, 50.3, 61.8, 48.3 and 67.3 respectively.

DISCUSSION

The study of some features of the internal structure of all mixed nerves of the brachial plexus in the material derived from the same human corpses increases our knowledge of the brachial plexus morphology. They are important both from theoretical and practical points of view (2, 7). The studies performed recently have shown the great individual variability and asymmetry. Numerous au-

thors, who examined the structure of various nerves, have already paid attention to it (1, 3–6, 8–16). The represented studies showed that thickness of nerves, number of fascicles, size of their cross-section area and index of the fascicle's area are usually different even in the same person on both sides of his body. The similar values on both sides of one body for 4 examined features were observed only in 1.2% in uln, for 3 features only at a time 1.2% in mc, med, uln and rad, for 2 features in 6.2% in mc, in 3.7% in med, in 11.2% in uln, in 6.2% in rad and in 17.5% in ax. The same or similar values of a single feature were found also rare on both sides of one body: the thickness of mc in 6.2%, of med in 11.2%, of uln in 6.2%, of rad in 12.5% and of ax in 3.7%, the size of csaf in 13.7%, 12.5, 12.5, 13.7 and 11.2%, number of fascicles in 10.0, 7.5, 11.2, 6.2 and 16.2%, and IAF in 6.2, 7.5, 2.5, 5.8 and 8.7% respectively.

The mean size of nerves were different on both sides of each body with the exception of thickness of ax, size of csaf of rad and ax, number of fascicles of rad and IAF of mc and ax. The greater on the right than on the left side were: thickness of med by 5.6, uln by 2.4%, rad by 2.8%, size of csaf of med by 3.8%, uln by 6.1%, number of fascicles of mc by 6.8%, ax by 7.7%, and IAF of uln by 3.6%. The above mentioned features were greater on the left than on the right side: thickness of mc by 9.1%, size of esaf of mc by 8.3%, number of fascicles of med by 1.0%, uln by 3.3%, IAF of med by 1.8, rad by 1.9%. They showed, with the exception of csaf in ax and IAF in med, the differences related to the sex. In males were greater than in females: thickness of med by 1.6%, rad by 3.5%, size of csaf of med by 1.7%, uln by 1.6% and rad by 1.8%, IAF in mc by 2.2%, uln by 3.4% and ax by 4.2%. In females were greater than in males: thickness of mc by 13.4%, uln by 1.8% and ax by 4.4%, size of csaf of mc by 8.3%, number of fascicles of mc by 30.8%, med by 24.2%, uln by 34.0%, rad by 11.9% and ax by 25.0 and IAF in rad by 1.5%.

The nerves differed between each other in thickness, size of csaf, number of fascicles and value of IAF.

The rad reached the highest average thickness; it was greater than the respective value of med by 4.8%, uln by 85.2%, mc by 217.0% and ax by 362.0%. The highest average value of csaf was also observed in rad. It was greater than the respective value of med by 0.9%, uln by 60.0%, mc by 161.8% and ax by 233.2%. The highest average number of fascicles, considering also rad, was greater from the corresponding value of med by 49.5%, uln by 159.1%, mc by 255.6% and ax by 492.6%. The highest average value of IAF, recorded in ax, was greater from corresponding value in mc by 13.8%, uln by 19.8%, med by 33.5% and rad by 38.7%. The average values of the examined features clearly distinguished the nerves. The mc has been characterized by: small thickness, small size of csaf, small number of fascicles and high IAF, the med – great thickness, great size of csaf, great number of fascicles and small IAF, the uln – middle sizes of 4 features, the rad – the greatest thickness, the greatest csaf, the highest number of fascicles and smallest IAF, the ax – the smallest thickness, smallest csaf, smallest number of fascicles and the highest IAF.

The participation of the different thickness fascicles in nerves structure was unequal. Vtn and tn occurred more often in mc and rad, less often in med, uln and ax, mtk – most often in med, less often in uln and rad, least often in me and ax, tk and vtk more often in ax and uln, less often in med and mc and least of ten in rad.

The studied features underwent big changes in postnatal life, mostly up to 22nd year of life. The thickness of nerves increased: of mc 3.5 times, med 4.1 times, uln 4.1 times, rad 3.8 times and ax 3.3 times. The size of csaf increased 3.8 times, 3.4 times, 3.7 times, 3.6 times and 3.4 times respectively. The number of fascicles in adults was smaller than in children up to 1 year of life by about 8% in mc, by over 5% in rad and by over 20% in ax, but in med it was greater by 70% and in uln by 15%. The

index of the fascicle's area had the greatest values in children up to 14 years old, with the exception of mc in which case the greatest value is attained in the period up to 22nd year of life. Above the 60th year of life IAF had the lowest values in all nerves. The decrease of the index is mainly a result of the increase in the area occupied by the connective tissue being a part of the nerve, observed in older subjects. The participation of fascicles of different thickness in the structure of nerves changed in postnatal life, too. In children up to 1 year of life vtn made, with the exception of med, the biggest group, which with the increase of age decreased considerably in all nerves. The percentage of tn, made in children also a big group, decreased with the increase of age the most in uln and med, not much in rad, but increased a little in mc and ax. Mtk, observed in children more rarely than vtn and tn, with the increase of age increased the participation in the structure of nerves, especially of mc, uln and rad. However, the percentage of fascicles with the cross-section area greater than 0.5 sq. mm increased the most: tk on average 4 times, and vtk, which did not occur in children up to 1 year of life in mc, rad and ax at all, did not reach even 2.5% in med and uln, and in adults they made 13% of all the fascicles.

REFERENCES

1. Bałakiszje K.: Wnutriennaja topografia puczkw głównych nierwnych stwołów pojasnicznego spletenja. Azerbajdzanski Med. Żurn., 38–39, 25, 1935.
2. Faworskij B. A.: Praktičeskoje značenje wnutristwołno go strojenja pieriferičeskich nierwow. Newropat. Psychiat., 20, 65, 1951.
3. Goldberg I.: The internal architecture of the tibial, peroneal and obturator, nerves. Am. J. Anat. 32, 447, 1923/24.
4. Iosifow G.: Topografia puczkw obrazujuszczich nierwnyje stwoły pleczewogo, pojasnicznego i krestcowogo spletenja. Arch. Anat. Gistol. Embriol., 7, 207, 1928.
5. McKinley J.C.: The intraneural plexus of fasciculi and fibers in the sciatic nerve. Arch. Neurol. Psychiat. 6, 377, 1921.
6. Michajłow S.S.: Wnutristwołnoje puczkwowe strojenje nierwow wierchniej koniecznosti. [in:] Wnutristwołnoje strojenje pieriferičeskich nierwow (A. N. Maksymienkow Red). Gos. Izd. Mied. Lit., Leningrad 1963.
7. Schady V., Ochoa J.L., Torebjörk H.E., Chen L.S.: Peripheral projections of fascicle's in the human median nerve. Brain 106, 745, 1983.
8. Stefaniak–Wojtasik H.: Wewnętrzna budowa nerwu pośrodkowego w przebiegu życia pozapłodowego człowieka. Doctoral thesis, Lublin 1979.
9. Sunderland S.: The intraneural topography of the radial, median and ulnar nerves. Brain 68, 243, 1945.
10. Sunderland S., Ray L.J.: The intraneural topography of the sciatic nerve and its popliteal divisions in Man. Brain 71, 242, 1948.
11. Sunderland S., Swaney W.E.: The intraneural topography of the recurrent laryngeal nerve in man. Anat. Rec. 114, 411, 1952.
12. Stelmasiak M. (Jun.): Pęczki nerwu mięśniowo–skórnego w przebiegu życia pozapłodowego człowieka. Ann. Univ. Mariae Curie–Skłodowska, sectio D, vol. 39, Lublin 1984.
13. Szczepańska–Sobutka J.: Budowa wewnętrzna nerwu łokciowego w życiu pozapłodowym człowieka. Doctoral thesis, Lublin 1979.

14. Triumfow A.: Über den inneren Bau des Nervus medianus. Z. Ges. Neurol. Psychiat., 126, 520, 1930.
15. Urbano wicz Z.: Budowa pęczkowa nerwu pachowego u człowieka. Ann. Univ. Mariae Curie-Skłodowska, sectio D, vol. 39, Lublin 1984.
16. Załuska S.: Pęczki nerwu promieniowego w przebiegu życia pozapłodowego człowieka, Ann. Univ. Mariae Curie-Skłodowska, Sectio D, vol. 36, Lublin, 1981.

Otrz.: 1999.03.30

STRESZCZENIE

W nerwach mieszanych splotu ramiennego, pochodzących z 80 zwłok ludzi zmarłych w wieku od 1 dnia do 87 lat, badano grubość, liczbę pęczków (lp) i wielkość powierzchni ich poprzecznego przekroju (pppp) oraz wskaźnik powierzchni pęczków (wpp). Przeciętne wartości badanych cech wyróżniały nerwy. N. mięśniowo-skinny charakteryzowały: mała grubość, wielkość pppp i lp oraz wysoki wpp, n. pośrodkowy – duża grubość, wielkość pppp i lp oraz niski wpp, n. łokciowy – średnie wielkości 4 cech, n. promieniowy – najwyższa grubość, wielkość pppp i lp oraz najniższy wpp, n. pachowy – najmniejsza grubość, wielkość pppp i lp oraz najwyższy wpp. Udział pęczków o różnej grubości był niejednakowy w budowie nerwów mieszanych splotu ramiennego.

