ORIGINAL PAPERS

Adv Clin Exp Med 2012, **21**, 6, 735–742
ISSN 1899–5276

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Anatomical Variability of Median Nerve Formation in Human Foetuses in Clinical Aspect

Zmienności anatomiczne powstawania nerwu pośrodkowego u płodów ludzkich w aspekcie klinicznym

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A – research concept and design; **B** – collection and/or assembly of data; **C** – data analysis and interpretation; **D** – writing the article; **E** – critical revision of the article; **F** – final approval of article; **G** – other

Abstract

Background. The median nerve is an important nerve leaving the brachial plexus. Median nerve damages may result from tunnel syndromes or injuries. The nerve anatomical variants are of great clinical importance in hand surgery.
Objectives. Clinical evaluation of median nerve divergence from brachial plexus morphological variability in foetal period.
Material and Methods. The material consisted of 220 brachial plexus sections derived from 110 foetuses aged 14–32 weeks of foetal life (50 females and 60 males, in CRL: 80–233 mm). The survey incorporated the following methods: dissection, anthropological, image digital acquisition, Image J computer transformation system, GIMP programme and statistical methods. Typology assessment was based on 0/1 system. Sexual dimorphism and symmetry were examined.
Results. Median nerve left directly lateral cord in 5 cases. In 59 (26.81%) plexuses, anterior division of middle trunk co-created median nerves anomalies. The total of 9 types of anterior division of middle trunk as well as of median nerve were distinguished. Median nerve double root leaving lateral cord was observed in 10 (9.09%) cases, whereas triple lateral root was seen in one case. In 1/3 of the examined plexuses, median nerve roots combined to form the nerve beneath humeral bone head and even in ½ of the bone distal length (type II and III). Type II prevailed more often on the left side.
Conclusions. Median nerve roots as well as the median nerve itself are characteristic for significant morphological variability. Nerve roots low junction into median nerve is clinically favourable as it can prevent nerve damage during injuries (**Adv Clin Exp Med 2012, 21, 6, 735–742**).

Key words: brachial plexus, anatomy, variations, median nerve, prenatal period.

Streszczenie

Wprowadzenie. Nerw pośrodkowy jest ważnym nerwem, odchodzącym od splotu ramiennego. Uszkodzenie nerwu może wystąpić w wyniku urazów oraz zespołów tunelowych. Warianty anatomiczne nerwu mają znaczenie kliniczne w chirurgii ręki.
Cel pracy. Ocena zmienności morfologicznej odejścia nerwu pośrodkowego od splotu ramiennego w okresie prenatalnym, w aspekcie klinicznym.
Materiał i metody. Do badań włączono 220 preparatów splotów ramiennych pochodzących od 110 płodów między 14. a 32. tygodniem życia płodowego, w tym 50 płci żeńskiej oraz 60 płci męskiej, w przedziale *v-tub*: 80–233 mm. W pracy zastosowano metody: preparacyjną, antropologiczną, cyfrową akwizycję obrazów, komputerowy system przetwarzania obrazu Image J, program GIMP, a także metody statystyczne. Do oceny typologii zastosowano system 0/1. Zbadano symetrię i dymorfizm płciowy.
Wyniki. Nerw pośrodkowy odchodził bezpośrednio od pęczka bocznego w 5 przypadkach. W 59 (26,81%) splotach anomalie korzeni nerwu pośrodkowego współtworzyła gałąź przednia pnia środkowego. Wyróżniono 9 typów anomalii gałęzi przedniej pnia środkowego i korzeni nerwu pośrodkowego. Podwójny korzeń boczny nerwu pośrodko-

wego, odchodzący od pęczka bocznego zaobserwowano w 10 (9,09%) przypadkach, potrójny korzeń boczny w jednym. W 1/3 badanych splotów korzenie nerwu pośrodkowego łączyły się w nerw poniżej głowy kości ramiennej, nawet w ½ dystalnej długości kości (typ II i III). Typ II występował częściej po stronie lewej.
Wnioski. Korzenie nerwu pośrodkowego oraz nerw pośrodkowy charakteryzuje duża zmienność morfologiczna. Niskie połączenie korzeni nerwu w nerw pośrodkowy jest korzystne klinicznie, gdyż może zapobiec uszkodzeniu nerwu podczas urazów (**Adv Clin Exp Med 2012, 21, 6, 735–742**).

Słowa kluczowe: splot ramienny, anatomia, warianty, nerw pośrodkowy, okres prenatalny.

Median nerve is formed from lateral root and median nerve medial root into common stem. Lateral root is lateral cord extension whereas medial root rises from medial cord. Median nerve (C_6–Th_1) undergoes damages due to ulnar joint injuries. Clinical image reveals: impaired fingers flexion in interphalangeal joints, atrophy of thumb abduction, flexion and opposition, fingers flexion impairment in proximal interphalangeal joints, hand backtrack and abduction disorder. In hand bending action, only IV, V and partly III fingers bend (blessing hand) and thenar muscle atrophy begins. This nerve can also undergo impairment in the humeral segment.

Autopsical studies of peripheral nerves and brachial plexuses were carried out as early as in the 19th century. In 1896, Paterson described peripheral nerves segmental distribution in both limbs as well as particular muscles innervation [1]. In 1904, Harris examined mammals and vertebrates plexuses morphological variants and distribution [2]. In turn, Kerr presented numerous morphological variants of brachial plexus elaborated on the basis of autopsical examinations made in the period 1895–1910 which comprised 175 brachial plexuses originating from adult corpses [3]. Brachial plexus and terminal nerves variability were examined in adults by Matejcik [4], in newborns by Uzun and Bilgic [5] and foetuses by Uysal et al. [6]. Available literature does not provide much information concerning brachial plexus surveys on the foetal material. The goal of this study was filling this subject gap namely the assessment of variability of median nerve divergence from brachial plexus in human foetuses in clinical aspect.

Material and Methods

The analysis comprised 220 brachial plexus sections from 110 foetuses aged 14–32 weeks of foetal life in CRL range 80–233 mm, including 50 females and 60 males. The survey exploited the foetuses which did not reveal post mortal autolysis or any other external developmental deficiencies. The material came from the collection of Normal Anatomy Dept. of Wroclaw Medical University. In the survey, the following methods were incorporated: anthropological method, dissection, image digital acquisition with the use of digital camera of 12 MP resolution, Image J software, GIMP software as well as statistical methods (Statistica software package). Microsurgical instruments as well as optic microscope were used to prepare and magnify the sections. Morphology assessment of median nerve divergence was made with the use of Image J v.1.41 and GIMP software. The height of lateral and medial roots combination into median nerve in relation to humeral bone was evaluated with "0/1" system, where: 0 – stood for roots into nerve combination in axillary fossa, 1 – stood for combination in ½ of humeral bone proximal length and 2 – stood for combination in ½ of humeral bone distal length.

Results

The survey initial stage was based on defining the height of lateral and medial roots nerves combination into median nerve. The following 3 morphological types were distinguished: type I (regular one) – in which the roots combined in axillary fossa, type II – in which the roots combined into nerve beneath axillary fossa and type III – in which the combination took place at ½ of humeral bone distal length. Fig. 1 presents each type. Fig. 2 and table 1 present the percentage of male and female foetal nerves roots combinations. No sexual dimorphism was found in the frequency of nerves roots combinations into median nerve. However, type II asymmetry was detected on the left side – Fig. 3, Table 2.

Median nerve divergence variant devoid of the nerve root was observed in 5 cases – Fig. 4. In 59 (26.81%) plexuses, median nerve roots anomalies were found and they were co-created by anterior division of middle trunk. The total of 9 types of anomalies were observed in anterior division of middle trunk (ADMT) and median nerve roots (Fig. 5A–I): Fig. 5A – ADMT combination with lateral root of median nerve which was present in 3 cases; Fig. 5B – the division combination directly with median nerve observed in 4 plexuses; Fig. 5C – combination with medial root of median nerve found in 1 plexus; Fig. 5D – ADMT gives off accessory fibres to median nerve – 1 case; 5E: the ADMT forms lateral root of median nerve and not joining

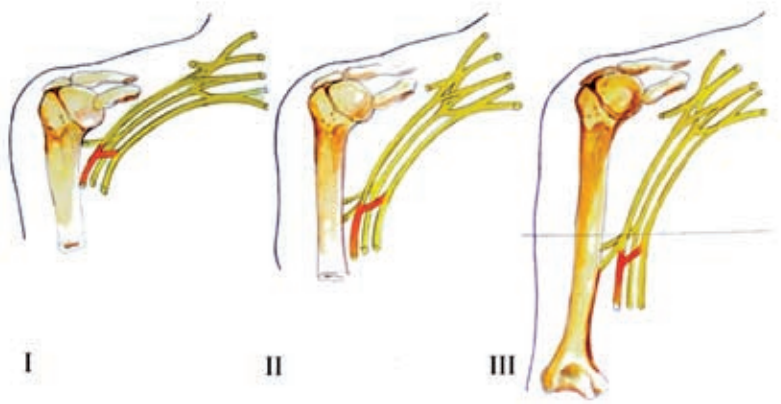

Fig. 1. Median nerve roots combination types in relation to axillary fossa and humeral bone, type I – nerve roots combine in axillary fossa, type II – nerve roots combine in median nerve in ½ of humeral bone proximal length, type III – nerve roots combine into median nerve in ½ of humeral bone distal length

Ryc. 1. Typy połączenia korzeni nerwu pośrodkowego względem dołu pachowego i kości ramiennej, typ I – korzenie nerwu łączą się w nerw w dole pachowym, typ II – korzenie nerwu łączą się w nerw pośrodkowy w ½ proksymalnej długości kości ramiennej oraz typ III – korzenie nerwu łączą się w nerw pośrodkowy w ½ dystalnej długości kości ramiennej

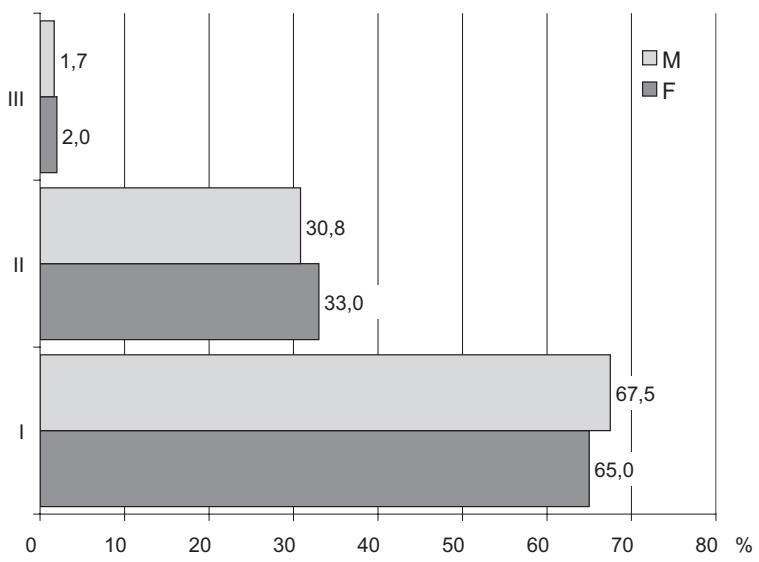

Fig. 2. Nerve roots combinations percentage in male and female foetuses (on both sides collectively): I – medial and lateral roots combination in axillary fossa or at the humeral head height; II – nerve roots combination in ½ of humeral bone proximal length; III – median nerve roots combination in ½ of humeral bone distal length

Ryc. 2. Odsetek rodzajów połączeń korzeni nerwu u płodów żeńskich i męskich (łącznie po obu stronach): I – połączenie korzenia bocznego i przyśrodkowego w dole pachowym, lub na wysokości głowy kości ramiennej; II – połączenie korzeni nerwu w proksymalnej 1/2 długości kości ramiennej; III – połączenie korzeni nerwu pośrodkowego w 1/2 dystalnej długości kości ramiennej

with lateral cord, which is formed only by anterior division of upper trunk – found in 4 plexuses; 5F: similarly to E, but the division gives off accessory combination to medial root of median nerve – observed in 1 plexus; 5G: in 3 cases, the division joined lateral cord, giving off two accessory parts to medial root of median nerve and median nerve; 5H: in 10 plexuses, the ADMT bifurcated joining median nerve two roots. Type I was most often observed. It presented division combination with medial root of median nerve and was observed in 32 (14.54%) plexuses (Fig. 5I).

Besides, roots variants were observed in the form of: median nerve double lateral root leaving lateral bundle as observed in 20 (9.09%) cases (Fig. 6) and triple lateral root observed in 1 plexus (Fig. 7). In turn, in one plexus, anastomosis between median nerve and musculocutaneous nerve took place (Fig. 8).

Discussion

Significant variability was characteristic for median nerve roots structure and median nerve itself. Median nerve leaved from lateral cord directly without roots formation in 5 plexuses. Median nerve roots combination height was observed and 3 types were distinguished. In 32.82% of cases, nerve roots combination took place in ½ of bra-

Table 1. Observations percentage of roots combination into nerve types on the left and right in sex subgroups, comparison results

Tabela 1. Liczności (odsetek) obserwacji typu połączenia korzeni w nerw pośrodkowy po stronie lewej i prawej w podgrupach różniących się płcią i wynik porównań

Type of roots combination into nerve (Typ połączenia korzeni w nerw pośrodkowy)	Left side (Strona lewa)			Right side (Strona prawa)		
	F N = 50	M N = 60	P	F N = 50	M N = 60	P
I – in a axillary fossa (w dole pachowym)	30 (60%)	36 (60%)	0.540	35 (70%)	45 (75%)	0.698
II – in ½ of proximal humerus length (w ½ proksymalnej długości kości ramiennej)	20 (40%)	23 (38%)		13 (26%)	14 (23%)	
III – in ½ of distal humerus length (w ½ dystalnej długości kości ramiennej)	0 (0%)	1 (2%)		2 (4%)	1 (2%)	

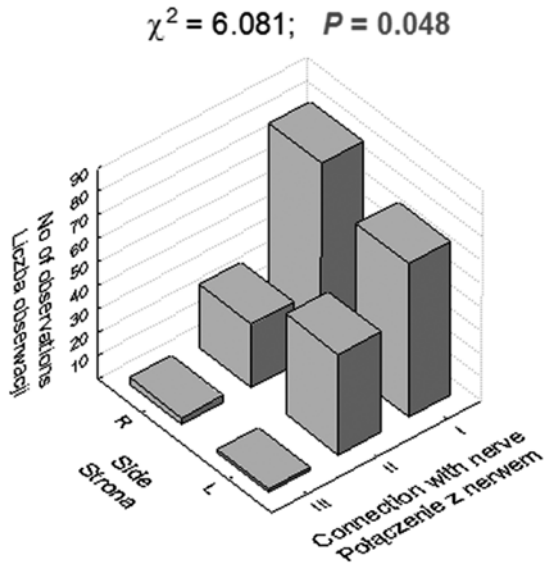

Fig. 3. Observations number in subgroups differentiated with reference to median nerve roots combination height and position on the left or right and χ^2 test result

Ryc. 3. Liczba obserwacji w podgrupach różniących się typem określającym wysokość połączenia korzeni nerwu pośrodkowego i położeniem po stronie lewej i prawej oraz wynik testu χ^2

Table 2. Percentage of observations diverse in respect of median nerve roots combination height in side subgroups, comparison result

Tabela 2. Liczności (odsetek) obserwacji różniących się typem określającym wysokość połączenia korzeni nerwu pośrodkowego w podgrupach różniących się stroną i wynik porównań

Median nerve roots combination height type (Typ wysokości połączenia korzeni nerwu pośrodkowym)	Body side (Strona ciała)		
	L N = 110	R N = 110	P
I – in axillary fossa (w dole pachowym)	66 (60%)	80 (73%)	0.048
II – in ½ of proximal humerus length (w ½ proksymalnej długości kości ramiennej)	43 (39%)	27 (25%)	
III – in ½ of distal humerus length (w ½ dystalnej długości kości ramiennej)	1 (1%)	3 (3%)	

chium proximal length. Beneath axillary fossa and in ½ brachium distal length, the roots combined in 4 cases (1.82%). Type II (combination in ½ of humeral bone proximal length but beneath axillary fossa) prevailed more often on the left side.

The significant number of median nerve anomalies is strictly connected to the anterior division of middle trunk variability. Besides, very often, a double and triple root of median nerve formed by lateral cord has been observed. These observations are of great clinical importance in reconstruction surgery, hand surgery and traumatology. The prevalence of nerve roots into nerve low combination – types II and III may prevent nerve damage during injuries. Such variants appear in every third plexus and they are regarded clinically favourable. In available literature, such a variation has been described but with smaller observation percentage. In turn, only in one plexus, the junction between median and musculocutaneous nerves was observed.

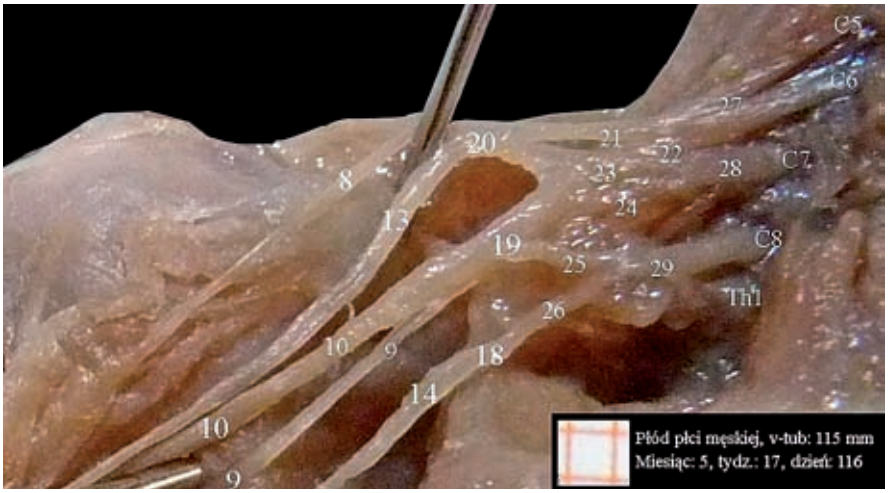

Fig. 4. Median nerve (13) leaves directly lateral cord (20), where: C_5 – Th_1 – brachial plexus roots, 8 – musculocutaneous nerve, 9 – axillary nerve, 10 – radial nerve, 11 – lateral root of median nerve, 12 – medial root of median nerve, 13 – median nerve, 14 – ulnar nerve, 16/17 – brachium and antebrachium medial cutaneous nerves, 18 – medial cord, 19 – posterior cord, 20 – lateral cord, 21 – anterior division of upper trunk, 22 – posterior division of upper trunk, 23 – anterior division of middle trunk, 24 – posterior division of middle trunk, 25 – posterior division of lower trunk, 26 – anterior division of lower trunk, 27 – upper trunk, 28 – middle trunk, 29 – lower trunk

Ryc. 4. Nerw pośrodkowy (13) odchodzi bezpośrednio od pęczka bocznego (20), gdzie: C_5 – Th_1 – korzenie splotu ramiennego, 8 – nerw mięśniowo-skórny, 9 – nerw pachowy, 10 – nerw promieniowy, 11 – korzeń boczny nerwu pośrodkowego, 12 – korzeń przyśrodkowy nerwu pośrodkowego, 13 – nerw pośrodkowy, 14 – nerw łokciowy, 16/17 – nerwy skórne przyśrodkowe ramienia i przedramienia, 18 – pęczek przyśrodkowy, 19 – pęczek tylny, 20 – pęczek boczny, 21 – gałąź przednia pnia górnego, 22 – gałąź tylna pnia górnego, 23 – gałąź przednia pnia środkowego, 24 – gałąź tylna pnia środkowego, 25 – gałąź tylna pnia dolnego, 26 – gałąź przednia pnia dolnego, 27 – pień górny, 28 – pień środkowy oraz 29 – pień dolny

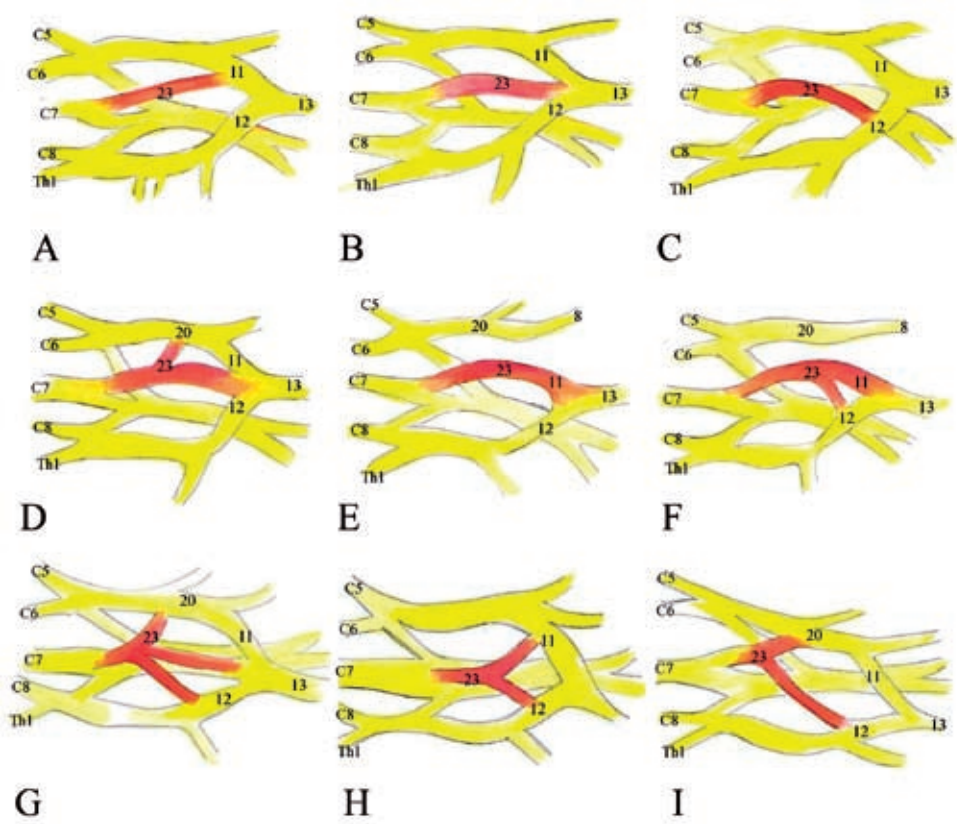

Fig. 5. Median nerve roots variants concreated by anterior division of middle trunk where: C_5 – Th_1 – brachial plexus roots, 8 – musculocutaneous nerve, 11 – lateral root of median nerve, 12 – medial root of median nerve, 13 – median nerve, 20 – lateral cord, 23 – anterior division of middle trunk

Ryc. 5. Warianty korzeni nerwu pośrodkowego współtworzone przez gałąź przednią pnia środkowego, gdzie: C_5 – Th_1 – korzenie splotu ramiennego, 8 – nerw mięśniowo-skórny, 11 – korzeń boczny nerwu pośrodkowego, 12 – korzeń przyśrodkowy nerwu pośrodkowego, 13 – nerw pośrodkowy, 20 – pęczek boczny oraz 23 – gałąź przednia pnia środkowego

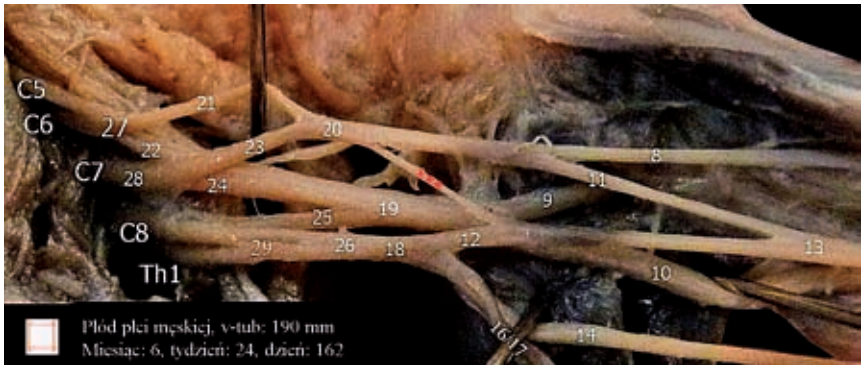

Fig. 6. Double lateral root of median nerve – accessory combination between lateral cord (20) and medial root (12) of median nerve, where: C_5 – Th_1 – brachial plexus roots, 8 – musculocutaneous nerve, 9 – axillary nerve, 10 – radial nerve, 11 – lateral root of median nerve, 12 – medial root of median nerve, 13 – median nerve, 14 – ulnar nerve, 16/17 – brachium and antebrachium medial cutaneous nerves, 18 – medial cord, 19 – posterior cord, 20 – lateral cord, 21 – anterior division of upper trunk, 22 – posterior division of upper trunk, 23 – anterior division of middle trunk, 24 – posterior division of middle trunk, 25 – posterior division of lower trunk, 26 – anterior division of lower trunk, 27 – upper trunk, 28 – middle trunk, 29 – lower trunk

Ryc. 6. Podwójny korzeń boczny nerwu pośrodkowego – dodatkowe połączenie między pęczkiem bocznym (20) a korzeniem przyśrodkowym (12) nerwu pośrodkowego, gdzie: C_5 – Th_1 – korzenie splotu ramiennego, 8 – nerw mięśniowo-skórny, 9 – nerw pachowy, 10 – nerw promieniowy, 11 – korzeń boczny nerwu pośrodkowego, 12 – korzeń przyśrodkowy nerwu pośrodkowego, 13 – nerw pośrodkowy, 14 – nerw łokciowy, 16/17 – nerwy skórne przyśrodkowe ramienia i przedramienia, 18 – pęczek przyśrodkowy, 19 – pęczek tylny, 20 – pęczek boczny, 21 – gałąź przednia pnia górnego, 22 – gałąź tylna pnia górnego, 23 – gałąź przednia pnia środkowego, 24 – gałąź tylna pnia środkowego, 25 – gałąź tylna pnia dolnego, 26 – gałąź przednia pnia dolnego, 27 – pień górny, 28 – pień środkowy oraz 29 – pień dolny

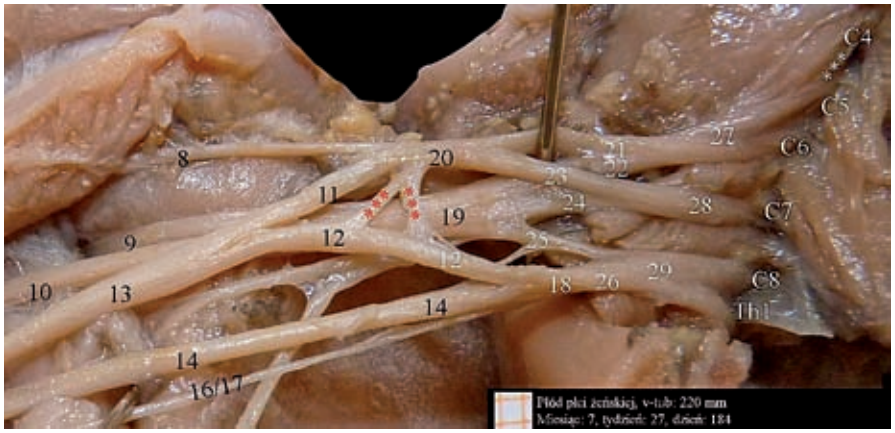

Fig. 7. Median nerve lateral triple root – nerve double fibres (red stars) leaving lateral cord (20) and reaching medial root (12) of median nerve (13), where: C_5 – Th_1 – brachial plexus roots, 8 – musculocutaneous nerve, 9 – axillary nerve, 10 – radial nerve, 11 – lateral root of median nerve, 12 – medial root of median nerve, 13 – median nerve, 14 – ulnar nerve, 16/17 – brachium and antebrachium medial cutaneous nerves, 18 – medial cord, 19 – posterior cord, 20 – lateral cord, 21 – anterior division of upper trunk, 22 – posterior division of upper trunk, 23 – anterior division of middle trunk, 24 – posterior division of middle trunk, 25 – posterior division of lower trunk, 26 – anterior division of lower trunk, 27 – upper trunk, 28 – middle trunk, 29 – lower trunk

Ryc. 7. Potrójny korzeń boczny nerwu pośrodkowego – podwójne włókna nerwowe (czerwone gwiazdki) odchodzące od pęczka bocznego (20) do korzenia przyśrodkowego (12) nerwu pośrodkowego (13), gdzie: C_5 – Th_1 – korzenie splotu ramiennego, 8 – nerw mięśniowo-skórny, 9 – nerw pachowy, 10 – nerw promieniowy, 11 – korzeń boczny nerwu pośrodkowego, 12 – korzeń przyśrodkowy nerwu pośrodkowego, 13 – nerw pośrodkowy, 14 – nerw łokciowy, 16/17 – nerwy skórne przyśrodkowe ramienia i przedramienia, 18 – pęczek przyśrodkowy, 19 – pęczek tylny, 20 – pęczek boczny, 21 – gałąź przednia pnia górnego, 22 – gałąź tylna pnia górnego, 23 – gałąź przednia pnia środkowego, 24 – gałąź tylna pnia środkowego, 25 – gałąź tylna pnia dolnego, 26 – gałąź przednia pnia dolnego, 27 – pień górny, 28 – pień środkowy oraz 29 – pień dolny

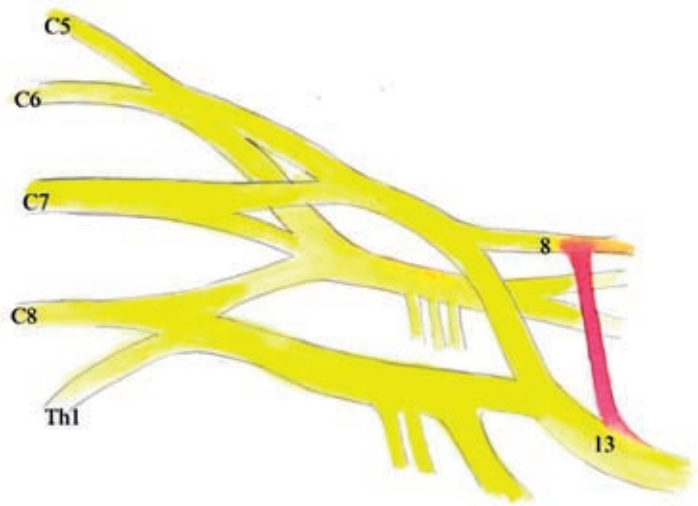

Fig. 8. Musculocutaneous nerve and median nerve anastomosis, where: C_5 – Th_1 – brachial plexus roots, 8 – musculocutaneous nerve, 13 – median nerve

Ryc. 8. Anastomoza między nerwem mięśniowo-skórnym a pośrodkowym, gdzie: C_5 – Th_1 – korzenie splotu ramiennego, 8 – nerw mięśniowo-skórny, 13 – nerw pośrodkowy

Matejcik [4] observed terminal nerve anomalies in 60 cases. Median nerve roots combined in the brachium inferior part in 9 out of 110 examined plexuses – 8.18%. In their surveys carried out on new-born babies, Uzun and Bigic [5] described the prevalence of median nerve triple root in 4 out of 130 examined plexuses. Terminal ramifications anomalies prevailed quite often and they were described in the paper by Uysal et al. [6]. Median nerve roots combined in brachium distal part in 8.5% of cases. Kocabiyik et al. [7] discussed the case of median and musculocutaneous nerves accessory combination in brachium distal part. Also Pandey and Shukla [8], Kaus and Wójtowicz [9], Uzun et al. [10], Singhal et al. [11] as well as Badawoud [12] presented prevalence of combining branch between median and musculocutaneous nerves. The combination of musculocutaneous and median nerves was mentioned by Aktan et al. [13]. According to the authors, knowledge concerning brachial plexus anatomical variations is of great importance in collar surgery and axillary area surgery [14]. Such a big number of brachial plexus morphological variants may result in posttraumatic diverse clinical conditions. Hence, it seems to be reasonable to make brachial plexus visual examinations prior to surgical procedures.

The authors concluded that median nerve roots as well as median nerve itself are characteristic for morphological variability. Median nerve roots low combination in a nerve beneath axillary fossa (type II and III) seems clinically favorable as on brachium injury, the nerve part may stay free from damage. Type II – median nerve roots combining into the nerve in 1/2 of brachium proximal length appeared on the left.

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Conflict of interest: None declared

Received: 29.12.2011
Revised: 18.01.2012
Accepted: 12.12.2012