Variations of nerve roots of the brachial plexus in clinical aspects during foetal period

JOWITA WOŹNIAK¹, ALICJA KĘDZIA¹, KRZYSZTOF DUDEK²

Abstract

Introduction: Brachial plexus is composed of C₅-Th₁ medullary nerves ventral radices. Brachial plexus damages may occur in both perinatal and postnatal period. The goal of the study was brachial plexus nerve radices variability evaluation in prenatal period in clinical aspect. Material and methods: The examinations were carried on the total of 220 brachial plexuses derived from 110 foetuses aged 14-32 weeks including 50 females (45.45%) in CRL: 80-233 mm. The following methods were incorporated in the survey: preparational, anthropological, Image J image digital acquisition computer system, GIMP program and statistical methods. Symmetry and sexual dimorphism were observed. Results: Medullary radices variations were observed in 35 (15.9%) plexuses. C₄ nerve accessory radix occurred most often bilaterally in 26 plexuses. Besides, the following phenomena were found: Th₂ accessory radix, lack of Th₁ radix, accessory anastomoses between C₆-C₇ nerves radices and C₇-C₈ nerves radices. No asymmetry or sexual dimorphism were found in brachial plexus medullar radices variations. Conclusions: Brachial plexus medullary radices most often variability is C₄ nerve fibres presence. Radices variations prevail very often regardless body side or sex. Brachial plexus variations recognition is important in respect of reconstructive surgery and traumatology.

Key words: brachial plexus, anatomy, variations, medullary radices, human foetus

Introduction

Brachial plexus is formed from combined ventral branches of medullar radices of the following nerves: C₅, C₆, C₇, C₈ and Th₁. C₅ and C₆ nerves radices combine to form superior stem, C₇ nerve radix forms middle stem and inferior stem is composed of C₈ and Th₁ nerves radices. Each stem generates anterior and posterior branches which, in turn, combine to form particular bundles. The bundles give away long and short branched of brachial plexus. Peripheral nerves autopsical examinations carried on the adult corpses material were reported already at the turn of 19th and 20th centuries. In 1896, Paterson described both limbs peripheral nerves segmental distribution as well as particular muscles innervation [1]. In 1904, similar paper was published by Harris who examined vertebrate and mammal plexuses morphological variants and distribution [2]. In turn, in 1906, Scott [3] observed brachial plexus variations and structure on the autopsical material composed of 17 adult corpses and 8 foetuses. The most comprehensive paper by Kerr thoroughly described brachial plexus numerous morphological variations on the basis of autopsical examinations carried on in years 1895-1910 on the material consisting of 175 brachial plexuses from adult corpses including 114 plexuses originating from males [4]. Uysal et al. [5] described foetal brachial plexuses variations.

Brachial plexus is an extremely delicate nervous structure. Plexus injuries take place in perinatal period, often in brachial distocia mechanism. It also happens in postnatal period due to injuries, extensive fractures, sprains and other damages of locomotor system. Perinatal injury to brachial plexus is a delivery serious complication and it prevails with the frequency 0.2-5.1 in 1000 live births [6], in Poland with frequency 0.57-1.19% [7, 8]. In brachial plexus perinatal damages, remote results of brachial plexus injury are observed in less than 10% of children although some authors report higher numbers (50% of cases) [9, 10].

In turn, brachial plexus traumatic injuries may co-occur with bruises, sprains, dislocations, fractures as well as be their healing results especially along with cicatrisation or bone fractions improper arrangement. Due to microsurgical techniques development, brachial plexus remedial procedures turn to be more and more efficient. Basic operative techniques include: neurolysis, neurotization, autogenous grafts with the use of fibrin glue [11-13]. Wu et. al [14] described sural nerve grafts in the treatment of brachial plexus nerve radices avulsions. Muscular strength significant improvement was

¹ Department of Normal Anatomy, Medical University of Wroclaw, Poland
² Institute of Machines Design and Operation, Technical University of Wroclaw, Poland
observed in all diseased children in the period 12-24 months after operation. In more serious cases, multi-stage treatment is applied. Matyja et al. [15] described orthopaedic techniques incorporated in surgical treatment of brachial plexus perinatal injuries. Transfers of healthy muscles replacing paralysed ones are noteworthy. These procedures functional effects are not satisfactory, however, limbs function improvement is significant. In USA (especially Houston), such procedures are very popular and they are gradually introduced to European countries.

The goal of the survey was brachial plexus nerve roots evaluation in human foetuses in clinical aspect.

Material and methods

The survey comprised 220 brachial plexuses cutdown from 110 foetuses aged 14-32 weeks, in CRL range: 80-233 mm including 50 females and 60 males. Examined foetuses belonged to the collection of Normal Anatomy Dept., Wroclaw University of Medicine. Examined foetuses did not reveal post mortem autolysis or any visible developmental defects. The following methods were used in the study: anthropological and preparational methods as well as image digital acquisition with the use of high definition digital camera – 12 MP, Image J images transformation system and GIMP program as well as statistical methods (Statistica program package). Optic microscope and microsurgical instruments were used for preparation procedures. Anthropological method was based on the foetal age assessment with the use of CRL length and Scammon – Calkins tables [16]. Brachial plexus morphological variations evaluation was done with 0/1 system where: 0 – no anomalies, 1 – presence of nerve roots morphological variation.

Sexual dimorphism and nerve roots variations symmetry statistical analysis was based on contingency tables and chi-square test. The value: $p < 0.05$ was accepted as the significance level.

Results

No statistically significant difference ($p > 0.05$) in brachial plexus nerve roots morphological variations frequency was observed in male and female foetuses (Tab. 1, Fig. 1). Morphological variations appeared both

Table 1. Numerical amount (percentage) of brachial plexus nerves roots variations on the left and right side in sex subgroups, comparison results

<table>
<thead>
<tr>
<th>Type of nerve root</th>
<th>Left side</th>
<th>Right side</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$F = 50$</td>
<td>$M = 60$</td>
<td></td>
</tr>
<tr>
<td>0 – normal</td>
<td>42 (84%)</td>
<td>52 (87%)</td>
<td>0.693</td>
</tr>
<tr>
<td>1 – morphological variant</td>
<td>8 (16%)</td>
<td>8 (13%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>$F = 50$</td>
<td>$M = 60$</td>
<td></td>
</tr>
<tr>
<td>0 – normal</td>
<td>40 (80%)</td>
<td>51 (85%)</td>
<td>0.491</td>
</tr>
<tr>
<td>1 – morphological variant</td>
<td>10 (20%)</td>
<td>9 (15%)</td>
<td></td>
</tr>
</tbody>
</table>

Fig. 1. Number of observations in subgroups differentiated in respect of nerve root type and sex on the left and right sides, chi-square test results
on the left and right sides with the same frequency (Tab. 2, Fig. 2). Morphological variations of spinal nerves roots occurred in 35 plexuses (15.9%).

Table 2. Numerousness (percentage) of brachial plexus nerve roots variations in subgroups differentiated in respect of the side, comparison results

<table>
<thead>
<tr>
<th>Type of nerve root</th>
<th>Body side</th>
<th>( N = 110 )</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – normal</td>
<td>L</td>
<td>94 (85%)</td>
<td>0.580</td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>91 (83%)</td>
<td></td>
</tr>
<tr>
<td>1 – morphological variant</td>
<td>L</td>
<td>16 (15%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>R</td>
<td>19 (17%)</td>
<td></td>
</tr>
</tbody>
</table>

In 26 cases, \( C_4 \) nerve supernumerary root occurred (Fig. 3) and in 10 foetuses, the anomaly was bilateral. Fig. 4 shows \( T_h \) root presence in 2 cases. We observed also: absence of \( T_h \) nerve root in 4 plexuses (Fig. 5), extra connection between \( C_6 \) and \( C_7 \) (Fig. 6) as well as between \( C_7 \) and \( C_8 \) nerves roots – in two cases (Fig. 7).

**Discussion**

In the examined material, 185 (84.09%) brachial plexuses were formed of \( C_5, C_6, C_7, C_8 \) and \( T_h \) nerves ventral roots. Very often – in 26 (11.81%) of observations, \( C_4 \) nerve supernumerary root was observed and in 10 foetuses it occurred bilaterally. Besides, other anomalies were found: \( T_h \) root presence in 2 plexuses, no \( T_h \) root in 4 plexuses or single accessory connections between \( C_6 \) and \( C_7 \) or \( C_7 \) and \( C_8 \) roots. Similarly to literature reports, in described observations, \( C_4 \) accessory root prevalence was significant in proportion to \( T_h \) nerve root small prevalence [4, 5, 17, 18]. The paper by Lewis [19] points at \( C_4 \) nerve root role in brachial plexus formation in 4th week of early embryonic development. About 5th week, the root gets separated and is not involved in plexus formation. These observations may explain the prevalence of \( C_4 \) nerve roots ventral branches in some plexuses as a persistent feature from early embryonic development. In the paper by Uysal et al. [5] based on the foetal material, plexus roots typical structure was observed in 71.5% of cases. In 25.5% of cases, \( C_4 \) nerve root was found in 25.5% of cases and \( T_h \) nerve root was detected in 2.5% of cases. In one case, both accessory roots were found.
Variations of nerve roots of the brachial plexus in clinical aspects during foetal period


Fig. 5. Th1 root deficiency and accessory connection between the middle trunk (28) and medial cord (18), where: C5-Th1 – brachial plexus roots, 8 – musculocutaneous nerve, 9 – axillary nerve, 10 – radial nerve, 11 – median nerve lateral root, 12 – median nerve medial root, 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

Kerr [4], divided examined plexuses into 3 groups: I – with C₄ nerve root (62.85%), II – without C₄ root but with the whole of C₅ nerve root (29.79%) and III – in which C₅ nerve root takes only fragmentary part in brachial plexus formation – 7.42%. In turn, Th₂ nerve root was observed in 30% of cases.

Matejcek [17] examined 100 brachial plexuses of adult corpses and C₄ nerve accessory root was observed in 24 cases (48%). However, Th₂ was found only in one plexus. He stated some abnormalities similar to those presented in this paper like C₇-C₈ roots connection. Uzun and Bilgic [20] examined 65 brachial plexuses in infants and found that C₄ nerve root took part in 30.77% of plexuses formation. Lee et al. [21] carried on the morphological analysis of 152 brachial plexuses coming from 77 Korean adult corpses. In 21.7% of plexuses, C₄ root was found but also Th₂ as well as C₅ and Th₂ prevailed in single cases. Adebisi and Singh [22] carried their surveys on autopsical material coming from 90 Nigerian adult corpses and observed C₄ nerve root in 20 cases (22.2%). Oliveira-Filho et al. [23] elicited similar results. These anomalies were considered significant from the clinical point of view. The authors lay stress on the clinical importance of brachial plexus variety recognition in reconstructive surgery, hand surgery and traumatology.

Conclusions

1) Nerve root prevalence does not reveal any relationship either with body side or sex.

2) Brachial plexus nerve roots most common variation was C₄ nerve root fibres prevalence.

3) Brachial plexus variations recognition is significant from the reconstructive surgery and traumatology line of approach.

References


Variations of nerve roots of the brachial plexus in clinical aspects during foetal period


Alicja Kędzia
Department of Normal Anatomy
Medical University of Wroclaw
6a Chałubińskiego, 50-368 Wroclaw, Poland
e-mail: jowita_wozniak@yahoo.com