Analysis of variability of brachial plexus cords in human fetuses

JOWITA WOŹNIAK1, ALICJA KĘDZIA2, KRZYSZTOF DUDEK3

Abstract

Cords of brachial plexus are created by combination of divisions of individual trunks. Brachial plexus nerves originate from cords of brachial plexus. Anomalies of cords can be one of the causes of vascular-nerve conflict. The purpose of this study was assessment of variability of brachial plexus cords during fetal period. The examinations was carried on the total of 110 fetuses aged 14-32 weeks, including 50 females and 60 males (in CRL range: 80-233 mm). The following methods were incorporated in the study: dissection, anthropological as well as statistical methods. Symmetry and sexual dimorphism was observed. Cords variations were observed in 40 (18.18%) cases, more often on the left side, regardless of gender. There was no variation of the medial cord. Lateral cord anomalies occurred in 35 (15.9%) cases. The most common abnormality of lateral cord was additional connection between the cord and the medial root of the median nerve forming a double or triple lateral root of the median nerve – in 21 (9.54%) cases. Posterior cord variants were observed in only 5 plexuses. Anatomic variants of cords occurred in nearly every fifth of assessed plexuses, more often on the left side of the body. Lateral cord was the most variable. Knowledge of the anomalies of the brachial plexus is important in reconstructive surgery.

Key words: brachial plexus, cord, anatomy, variability, human fetus, vascular-nerve conflict

Introduction

Development of the nervous system occurs in the prenatal period. Development of the brachial plexus as an important element of the peripheral nervous system is the subject of a small number of publications in the open literature. The early embryonic development of this structure is described by Lewis [10] and Shinohara et al. [16]. Research on the fetal material was conducted by Wozniak et al. [20-21] and Uysal et al. [17]. Knowledge of the variability of the brachial plexus is important from a clinical point of view, because its damage can occur in the perinatal period. As a result of these injuries paralysis of upper limb function occurs, disrupting normal psychomotor development of the child. Reconstrucive surgery of the brachial plexus is a microsurgical procedures such as neurolysis, neurotization procedure and nerve autografts [13]. The first nerve transplant were performed back in the 50’s of the last century. There are reports of sural nerve grafts using fibrin glue [3, 14]. Nerve autografts are currently the main method of reconstruction. Wu et al. [22] described sural nerve grafts in the treatment of preganglionic avulsions of nerve roots of the brachial plexus, a significant improvement in muscle strength was observed in all patients, children in the control studies conducted in the period from 12 to 24 months after surgery. In more severe cases, multi-stage treatment was used. Particularly noteworthy is the method of transfer of healthy muscles, which replace the affected muscles, such procedure was presented by Burge et al. [4], Davis et al. [6], Lusskin et al. [11], Waters et al. [19] as well as Gosk et al. [7]. Reported the use of fibrin glue in microsurgical reconstruction of the brachial plexus. Nerve anastomosis done with fibrin glue was considered as atraumatic, which did not cause inflammation and granulomas. This can also reduce treatment time and integrate damaged nerves in difficult technical conditions, despite the anatomical complexity of this structure. Another problem is clinical replantation of limbs amputated at the level of shoulder. The area of damaged limb is then very large, prognosis is unfavorable, and the patient’s condition is generally heavy. Jablecki et al. [8] reported 9 replantation of shoulder. In 6 patients reconstruction of large nerve trunks by direct suture was performed, the remaining further stump of median nerve was joined by the use of available

1 Department of Neurosurgery, Academic Clinical Hospital in Wroclaw, Poland
2 Department of Normal Anatomy, Wroclaw Medical University, Poland
3 Institute of Machines Design and Operation, Wroclaw Technical University, Poland
nerve fragments with less critical functions: radial or ulnar. In the operated material achieved 100% survival reconstructed limbs. Due to the complex anatomy authors concluded that it is the stage of reconstruction of the nerves of the brachial plexus is a major problem in the surgery treatment. Therefore, it appears that knowledge of the anatomy and anatomical variations of the brachial plexus is needed in surgical procedures on this structure. The aim of this study was to analyze the anatomical variability of brachial plexus cords in the prenatal period as well as assessment of symmetry and sexual dimorphism.

Material and methods

The investigation comprised 220 brachial plexuses obtained from 110 fetuses aged 14-32 weeks (between IV-VII months) in CRL range: 80-233 mm, 50 females and 60 males. Examined fetuses belonged to the collection of Department of Normal Anatomy, Wroclaw Medical University as well as did not reveal any visible genetic defects. The following methods were used in the study: dissection, anthropological method, digital acquisition with the use of high definition digital camera – 12 MP and statistical methods by Statistica 8.0 software. Optical microscope and microsurgical instruments were used for dissection procedures. Anthropological method was based on an assessment of fetal age by somatic measures: CRL (crown-rump length) and V-Pl (vertex-plan tare length). Brachial plexus cords morphological variations evaluation was done with 0/1 system, where: 0 – no anomalies, 1 – presence of cord variation. Sexual dimorphism as well as symmetry statistical analysis was based on contingency tables and chi-square test. The value $p < 0.05$ was accepted as the significance level.

Results

There was no statistically significant difference between the incidence of abnormalities of cords in male and female ($p > 0.05$), while asymmetry was observed more often on the left side (24%) than the right (13%) – Figure 1.

Cords anomalies were dissected in 40 cases, which was 18.18% of all assessed brachial plexuses. Lack anomalies of the medial cord was observed. The vast majority of anomalies was observed in lateral cord – 35 cases (15.9%). In 8 cases lateral cord was created only by the anterior division of the upper trunk. However, in five cases there was a variant in which there is a lack typical lateral cord, because anterior division of upper trunk goes directly to the musculocutaneous nerve, and does not give lateral root of the median nerve – Figure 2.

In one case lateral cord was dissected which was supported by nerve fibers from root of spinal nerve $C_4$ – Figure 3.

The most common abnormality was the presence of lateral cord in 20 cases (9.09%) additional connection between it and the medial root of the median nerve – creating a dual lateral root of the median nerve – Figure 4, and in 1 plexus double connection between lateral cord and the medial root of median nerve – forming a triple lateral root of the median nerve in Figure 5. Posterior cord variants were observed in only 5 cases. In 4 cases it was built by posterior divisions of the upper and middle trunk, while the posterior division of the lower trunk joined the radial nerve – Figure 6. In single case two additional branches of posterior cord were observed which joined to the medial and lateral root of the medial nerve – Figure 7.

Fig. 1. Assessment of symmetry and the result of chi-square test
Analysis of variability of brachial plexus cords in human fetuses

Fig. 2. Lack of typical lateral cord, anterior division of upper trunk (21) goes directly to the musculocutaneous nerve (8), and does not give lateral root (11) of the median nerve (13), where: C5 – Th1 – 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 (ADMT), 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

Fig. 3. Lateral cord was supported by nerve fibers from root of spinal nerve C4, where: C4 – Th1 – brachial plexus roots, 20 – lateral cord

Fig. 4. Additional connection between lateral cord (20) and the medial root (12) of the median nerve – creating a “dual lateral root” of the median nerve (13), where: C5 – Th1 – brachial plexus roots, 11 – lateral root of median nerve, 12 – medial root of median nerve, 13 – median nerve, 20 – lateral cord

Fig. 5. Double connection between lateral cord (20) and the medial root (12) of median nerve – forming a “triple lateral root” of the median nerve (13), where: C5 – Th1 – brachial plexus roots, 11 – lateral root of median nerve, 12 – medial root of median nerve, 13 – median nerve, 20 – lateral cord
Fig. 6. Posterior cord (19) was built by posterior divisions of the upper (22) and middle (24) trunk, while the posterior division of the lower trunk (25) joined the radial nerve (10), as well as presence of C4 brachial plexus roots, where: C5 – Th1 – 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 (ADMT), 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.

Fig. 7. Two additional branches of posterior cord (19) were observed which joined to the medial (12) – red stars and lateral root (11) of the medial nerve – green stars, where: C5 – Th1 – 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 (ADMT), 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.

Discussion

Anatomic variants of cords occurred in nearly every fifth of assessed plexuses, more often on the left side of the body. Interestingly there were no anomalies in the medial cord. Due to the large number of cases examined (220 plexuses) observation can be regarded as an inborn and inter-individual feature of the studied population of fetuses. In recent scientific reports variants of the medial cord assessed on the material of the dead adults Matejcik [12] and on newborns Uzun and Bilgic [18] have been reported. Lateral cord created the vast majority of anomalies – in almost every sixth assessed plexuses, other anomalies were related to posterior cord. Uysal et al. [17] studied the variation of the brachial plexus in human fetuses. The authors described a lateral cord formed by the anterior division of the upper trunk which was observed in 2.5% of cases, an additional connection between the lateral cord and the medial root of the median nerve was observed in 5% of cases. While Kerr [9] observed lack of lateral cord in 7 cases out of 175 assessed plexuses, no typical posterior cord (formed
only by the radial nerve) in 36 plexuses. In 99.46% of cases medial cord was formed by the anterior division of the lower trunk as well as medial cord anomalies occurred in only two cases, when this cord was co-created by posterior division of the middle trunk. Matejcik [12] found 22 anomalies of cords, which were often related to the lateral cord. The Uzun and Bilgic [18] described cord variants in the newborn, in 4 (3.07%) cases a lateral cord was created only by the anterior division of the upper trunk. However, Bhat and Girijavallabhan [2] discussed case of the neuro-vascular conflict in which participated posterior cord. The authors found that posterior cord divided into two branches, which compressed and shut the subclavian artery. Then the branches united and formed the radial nerve. A similar anomaly is also presented in this paper, as illustrated in figure 7.

The clinical role of neuro-vascular conflict was highlighted by the Satyanarayana et al. [15], who described the compression of profunda brachial artery which was located between the roots of the median nerve. The occurrence of double or triple lateral root of the median nerve, formed by the nerve fibers of lateral cord can be an additional risk factor for profunda brachial artery compression. It should be noted that this type of anomaly is not rare, because it was observed in 21 assessed plexuses – almost every tenth case. The Abhaya et al. [1] observed one sided branch extending from lateral cord penetrating into the coracobrachialis muscle. Das and Paul [5] reported additional connection between the lateral cord and median nerve. The study of brachial plexus variation are important in reconstructive surgery as well as in assessment of vascular-nerve conflict, which, as shown in available literature can co-create posterior cord or roots of the median nerve.

Conclusions
Anatomic variants of cords occurred in nearly every fifth of assessed plexuses, more often on the left side of the body. Lateral cord was the most variable. Knowledge of the anomalies of the brachial plexus is important in reconstructive surgery.

Conflict of interest – none

References


Jowita Woźniak
Department of Neurosurgery
Academic Clinical Hospital in Wroclaw
Borowska 213, 50-556 Wroclaw, Poland
e-mail: jowita_wozniak@yahoo.com