

Variations in the formation of the trunks of brachial plexus

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Abstract

Background: The brachial plexus is a complex network of nerves that innervates the upper limbs. Variations in brachial plexus are common, as well as its relationships with other anatomical structures, gaining thus clinical and surgical importance. The aim of this study was to report variations in the formation of the trunks of brachial plexus. **Material and Methods:** Forty upper limbs from 20 human fetuses were used, fixed and kept in 10% formol solution. Fetal age was estimated from the hallux-calcaneus length and ranged from 20 to 37 weeks of gestation, with a mean of 25.63 weeks. The plexus were dissected without the aid of optical instruments, and the access route for dissection began 2 cm below the mastoid process, followed the posterior border of the sternocleidomastoid muscle until the medial third of the clavicle, and then went through the deltopectoral groove until the arm. **Results:** Of the 40 plexuses investigated, 37 (92.5%) had the usual trunk formation, and 3 (7.5%) showed variation in its formation. Among these, in 2 (5%) plexuses of a single fetus, the upper trunk was formed by the C5, C6 and C7 roots, the middle trunk by the C8 root, and the lower trunk by the T1 root, both on left and right sides. In 1 (2.5%) plexus of another fetus, there was the formation of four trunks on the left side: the first trunk was formed by the C4 and C5 roots, the second by the C7 root, the third by the C8 root, and the fourth by the T1 root. **Conclusion:** Studies on variations in brachial plexus should continue to draw the attention of different healthcare professionals who work directly or indirectly with this plexus in their daily routine.

Keywords: anatomic variations, anatomy, trunk formation.

1 Introduction

The brachial plexus is characterized by having a complex anatomical formation since its origin in the neck and also by establishing relationships with other anatomical structures throughout its path. These relationships are of great clinical and surgical importance, especially when there are anatomical variations of the plexus (FAZAN, AMADEU, CALEFFI et al., 2003).

The brachial plexus is usually described as being formed by primarily by the union of the anterior ventral branches of the fifth, sixth, seventh and eighth cervical nerves (C5 to C8) and the first thoracic nerve (T1), with the possible contribution of the fourth cervical nerve (C4) and the second thoracic nerve (T2) (BOLLINI, 2004; JOHNSON, VEKRIS, ZOUBOS et al., 2006). According to Costabeber, Almeida, Becker et al. (2010) the plexus is located between the anterior and middle scalene muscles and is organized throughout its path in five distinct portions: roots, trunks, divisions, cords, and terminal branches (peripheral nerves).

In the organization of the brachial plexus, several types of variations have been described with regard to the formation of its upper, middle and lower trunks (AGGARWAL, PURI, AGGARWAL et al., 2010; MATEJCIK, 2003; SINGHAL, RAO and RAVINDRANATH, 2007; UYSAL, SEKER, KARABULUT et al., 2003; VILLAMERE, GOODWIN, HINCKE et al., 2009). Shetty, Nayak, Madahv et al. (2011) described that the middle trunk would be formed by the union of C7 and C8 roots and pointed out that this type of variation has not been reported in the literature yet. Given

the importance of knowing the anatomy of the brachial plexus, emphasized recently by Orebaugh and Williams (2009), the present study aimed to examine the variations that occur in the formation of the trunks of brachial plexus.

2 Materials and Methods

Forty upper limbs from 20 human fetuses were used for this study. These had been fixed and were being kept in 10% formol solution. The fetuses belonged to the anatomy laboratory of the Federal University of Sergipe and had been obtained in accordance with Law 8,501 of November 30, 1992, which deals with the use of unclaimed cadavers for studies and research purposes. The age of the fetuses were estimated from the hallux-calcaneus length and ranged from 20 to 37 weeks of gestation, with a mean of 25.63 weeks. The brachial plexuses were dissected without the aid of optical instruments, the cadaver was placed in the supine position, with the head extended and facing the side opposed to that which was being explored. The access route began 2 cm below the mastoid process, followed the posterior border of the sternocleidomastoid muscle until the medial third of the clavicle, and then went through the deltopectoral groove until the arm. Each finding was drawn and recorded taking into account the side where the variations occurred. The study was approved by the Research Ethics Committee of the Federal University of Sergipe, under protocol number 1497.0.000.107.

3 Results

Out of the 40 brachial plexuses dissected, 37 (92.5%) had the usual anatomical formation of the trunks: the upper trunk was formed by C5 and C6 roots, the middle trunk by the C7 root, and the lower trunk by the C8 and T1 roots, and three (7.5%) plexuses presented variations in trunk formation. In two brachial plexuses of a single fetus, the upper trunk was formed by the C5, C6 and C7 roots, the middle trunk was formed by the C8 root and the T1 root formed the lower trunk, both on left and right sides (Figure 1). In another fetus, there was the formation of four trunks on the left side: the first trunk (I) was formed by the C4 and C5 roots, the second (II) by the C7 root, the third (III) by the C8 root, and the fourth (IV) by the T1 root

(Figure 2). In this last plexus, the posterior cord was formed by the posterior divisions of the upper and middle trunks (first and second trunks respectively) and by the posterior divisions of C8 (third trunk) and T1 (fourth trunk), and the medial cord was formed by the anterior divisions of C8 (third trunk) and T1 (fourth trunk).

4 Discussion

The variations in the origin of trunks, divisions and cords of brachial plexus have been reported by several authors (BALLESTEROS and RAMIREZ, 2007; FAZAN, AMADEU, CALEFFI et al., 2003; MILLER, 1934). In the present study, three plexuses had anatomical variations in the formation of their trunks.

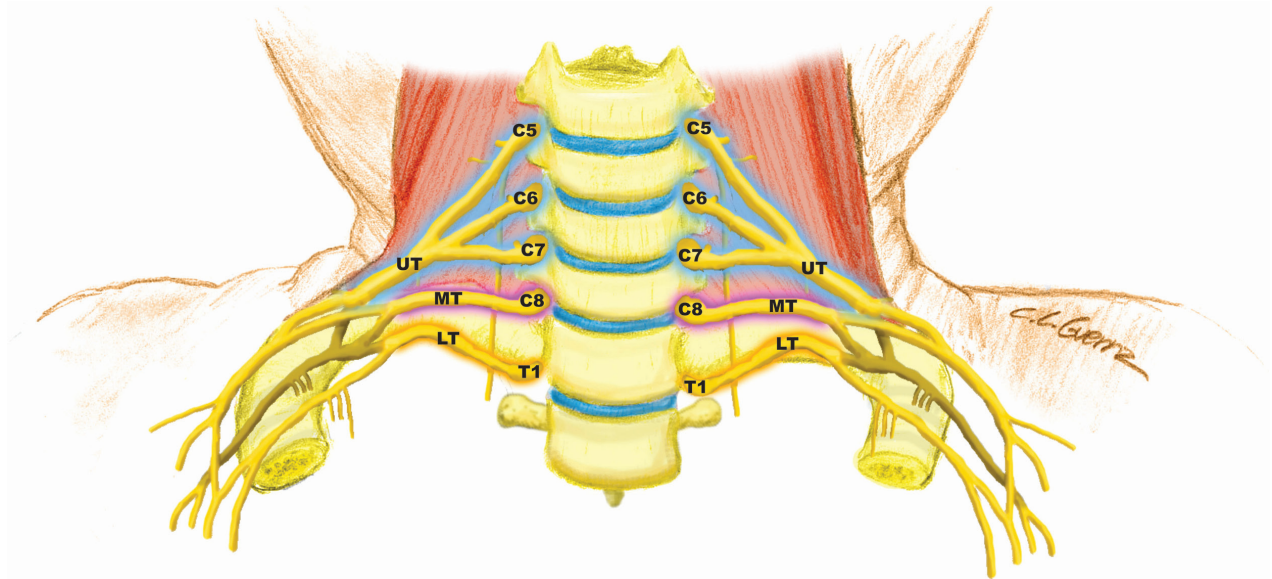


Figure 1. Upper trunk formed by C5, C6 and C7 roots. UT- Upper trunk; MT – Middle trunk; LT – Lower trunk; C4, C5, C6, C7, C8 and T1 – Nervous roots.

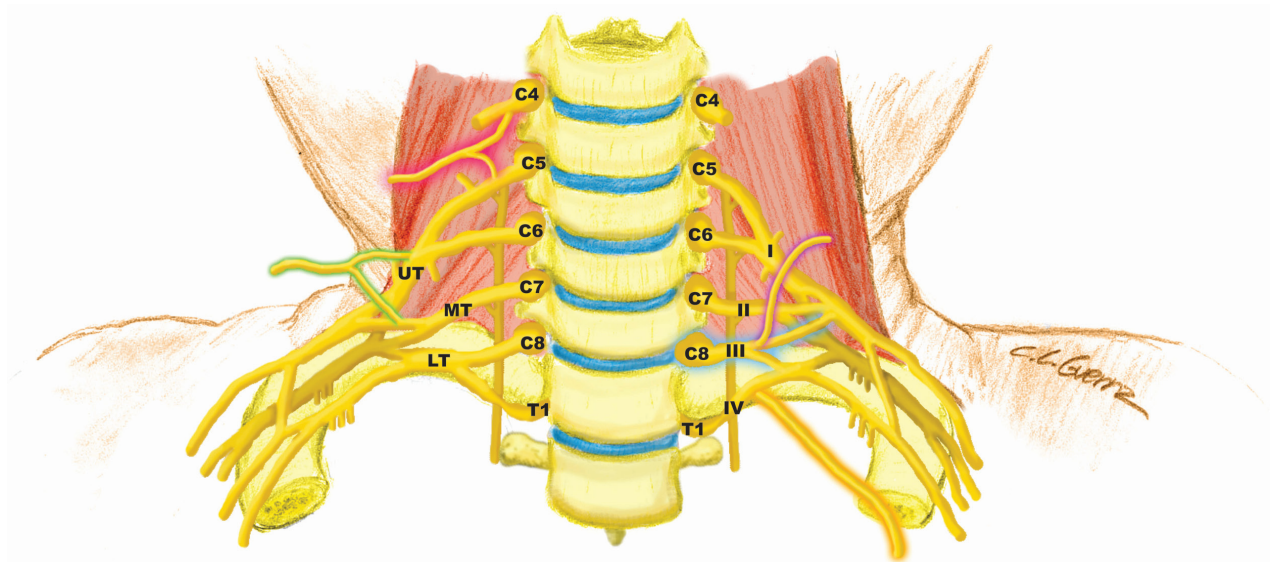


Figure 2. Formation of four brachial trunks in the left upper limb. UT – Upper trunk; MT – Middle trunk; LT – Lower trunk; I – First trunk; II – Second trunk; III – Third trunk; IV – Fourth trunk; C4, C5, C6, C7, C8 and T1 – Nervous roots.

The anterior ventral roots of the brachial plexus are almost equal in size, but they vary in the form of union. The C5 and C6 roots join close to the lateral border of the medial scalene muscle to form the upper trunk, C7 alone forms the middle trunk, and C8 and T1 roots join to form the lower trunk (BOLLINI, 2004; COSTABEBER, ALMEIDA, BECKER et al., 2010; JOHNSON, VEKRIS, ZOUBOS et al., 2006). This formation of origin of the brachial plexus occurred in 92.5% of the cases from the present study. These three trunks descend laterally in the axilla, passing over the first rib, behind the subclavian artery and between the scale muscles. This space is known as interscalene groove and should be acknowledged when performing interscalene and supraclavicular blocks (BOLLINI, 2004).

In our study, the variations in the formation of trunks of brachial plexus occurred in 7.5% (BOLLINI, 2004) of the cases. In 5% (BALLESTEROS and RAMIREZ, 2007), the anterior ventral roots of C5, C6 and C7 joined to form the upper trunk on the left and right sides of the same fetus. This variation was also found by different authors (MATEJCIK, 2003; PRAKASH, PRABHU, KUMAR et al., 2006). According to Shetty, Nayak, Madahv et al. (2011), this type of formation of upper trunk of brachial plexus by C5, C6 and C7 roots is considered very rare by most authors and would be often associated with anatomical absence of the middle trunk or fusion of upper and middle trunks.

In 2.5% (AGGARWAL, PURI, AGGARWAL et al., 2010) of the cases, there was the formation of four trunks on the left side of the fetus, which were craniocaudally numbered as I – IV. The first trunk was formed by the union of C5 and C6 (Trunk I) and the second, third and fourth trunks were a continuation of C7, C8 and T1 roots respectively. A similar finding was also described by Chaudhary, Singla, Kalsey et al. (2012), although differing with regard to the divisions for the formation of lateral, medial and posterior cords.

The presence of anatomical variations in brachial plexus can make it more vulnerable to injuries during the performance of procedures such as: radical neck dissections and surgical interventions for the treatment of breast carcinoma and neural complications in anesthetic injections. Therefore, knowing these variations is important for anatomists, radiologists, anesthetist, and surgeons and, more relevant, for use in computer graphics for diagnostic purposes (CORNISH and GREENFIELD, 1997).

5 Conclusion

We believe that the present findings with regard to anatomical variations of brachial plexus should continue to draw the attention particularly of different healthcare professionals who work directly or indirectly with this plexus in their daily routine.

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References

AGGARWAL, A., PURI, N., AGGARWAL, AK., HARJEET, K. and SAHNI, D. Anatomical variation in formation of brachial plexus and its branching. *Surgical and Radiologic Anatomy*, 2010, vol. 32,

n. 9, p. 891-894. PMID:20521147. <http://dx.doi.org/10.1007/s00276-010-0683-8>

BALLESTEROS, LE. and RAMIREZ, LM. Variations of the origin of collateral branches emerging from the posterior aspect of the brachial plexus. *Journal of Brachial Plexus and Peripheral Nerve*, 2007, vol. 2, n. 2, p. 14.

BOLLINI, CA. Revisión anatómica del plexo braquial. *Revista Argentina de Anestesiología*, 2004, vol. 62, n. 6, p. 386-398.

CHAUDHARY, P., SINGLA, R., KALSEY, G. and ARORA, K. A four trunked brachial plexus and a post fixed brachial plexus: a conjunction or a co-incidence? Report of three cases. *Clinical Anatomy*, 2012, vol. 25, n. 5, p. 593-600. PMID:22025416. <http://dx.doi.org/10.1002/ca.21287>

CORNISH, PB. and GREENFIELD, LJ. Brachial plexus anatomy. *Regional Anesthesia*, 1997, vol. 22, n. 1, p. 106-107. [http://dx.doi.org/10.1016/S1098-7339\(06\)80067-2](http://dx.doi.org/10.1016/S1098-7339(06)80067-2)

COSTABEBER, I., ALMEIDA, GM., BECKER, M., SILVEIRA, AF. and MARTINI, DT. Fascículos do plexo braquial: um estudo morfológico. *Revista Brasileira de Anestesiologia*, 2010, vol. 60, n. 6, p. 617-619.

FAZAN, VPS., AMADEU, AS., CALEFFI, AL. and RODRIGUES FILHO, OA. Brachial plexus variations in its formation and main branches. *Acta Cirúrgica Brasileira*, 2003, vol. 18, Suppl. 5, p. 14-18. <http://dx.doi.org/10.1590/S0102-86502003001200006>

JOHNSON, EO., VEKRIS, MD., ZOUBOS, AB. and SOUCACOS, PN. Neuroanatomy of the brachial plexus: the missing link in the continuity between the central and peripheral nervous systems. *Microsurgery*, 2006, vol. 26, n. 4, p. 218-229. PMID:16628658. <http://dx.doi.org/10.1002/micr.20233>

MATEJCIK, V. Aberrant formation and clinical picture of brachial plexus from the point of view of a neurosurgeon. *Bratislavské Lekárske Listy*, 2003, vol. 104, n. 10, p. 291-299. PMID:15055727.

MILLER, RA. Comparative studies upon the morphology and distribution of the brachial plexus. *American Journal of Anatomy*, 1934, vol. 54, n. 1, p. 143-175. <http://dx.doi.org/10.1002/aja.1000540106>

OREBAUGH, SL. and WILLIAMS, BA. Brachial plexus anatomy: normal and variant. *ScientificWorldJournal*, 2009, vol. 9, p. 300-312. PMID:19412559. <http://dx.doi.org/10.1100/tsw.2009.39>

PRAKASH, S., PRABHU, LV., KUMAR, J. and SINGH, G. Brachial plexus with two trunks and double axillary veins: applied importance and clinical implications. *Firat Tip Dergisi*, 2006, vol. 11, n. 4, p. 210-212.

SHETTY, SD., NAYAK, BS., MADAHV, V., BRAGANZA, CS. and SOMAYAJI, SN. A study on the variations in the formation of the trunks of brachial plexus. *International Journal of Morphology*, 2011, vol. 29, n. 2, p. 555-558. <http://dx.doi.org/10.4067/S0717-95022011000200042>

SINGHAL, S., RAO, VV. and RAVINDRANATH, R. Variations in brachial plexus and the relationship of median nerve with the axillary artery: a case report. *Journal of Brachial Plexus and Peripheral Nerve Injury*, 2007, vol. 2, p. 21. <http://dx.doi.org/10.1186/1749-7221-2-21>

UYSAL, II., SEKER, M., KARABULUT, AK., BÜYÜKMUMUCU, M. and ZIYLAN, T. Brachial plexus variations in human fetuses. *Neurosurgery*, 2003, vol. 53, n. 3, p. 676-684. PMID:12943583. <http://dx.doi.org/10.1227/01.NEU.0000079485.24016.70>

VILLAMERE, J., GOODWIN, S., HINCKE, M. and JALALI, A. A brachial plexus variation characterized by the absence of the superior trunk. *Neuroanatomy*, 2009, vol. 8, p. 4-6.

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