

# *Brachial plexus variants: an anatomic study*

Jamary Oliveira-Filho<sup>1</sup>

Vital F. Araujo

Rodolfo S. Queiroz

Luanna S. Nunes

Telma S. Masuko

## **Abstract**

*The brachial plexus is a frequent site of traumatic, inflammatory and neoplastic diseases. Anatomic variants are known to occur in up to 48% of cases, depending on the population being studied and imaging technique. Our objective was to describe the main anatomic variants in our specimens and to compare these with other populations. Ten side-matched anatomic specimens of unknown age and gender were preserved in formol. These specimens were dissected from the nerve roots at the cervical spine level to the axillary region, identifying each root, trunk and fascicle. In all specimens studied, the brachial plexus was of a classic type, originating from the fifth cervical to first thoracic roots. Anatomic variants described in the literature were reviewed. No anatomic variants were found in the present specimens. In conclusion, anatomic variants of the brachial plexus in our population seem to be rare; however, larger samples need to be studied before these results can be generalized to our population.*

**Keywords:** *Brachial plexus - Dissection - Anatomic variants.*

## **INTRODUCTION**

*The brachial plexus is a complex structure formed by nerve roots derived from the fifth cervical through the first thoracic spinal segments<sup>1</sup>. It is a frequent site of injury due to traumatic, inflammatory and neoplastic diseases. In surgeries of the superior limb, anesthetic blockade of the brachial plexus is applied based on known anatomic landmarks<sup>2,3</sup>. Thus, knowledge of common anatomic variants is important to plan surgical and anesthetic procedures in the upper limb.*

*The prevalence of anatomic variants of the brachial plexus varies in different populations up to 48%<sup>1,4,5,6,7</sup>. However, there are few studies of brachial plexus anatomy in our population. Thus, our objective was to describe the main anatomic variants in our specimens and to compare these with other populations.*

## **METHODS**

*The Health Sciences Institute of the Federal University of Bahia maintains human anatomical*

---

<sup>1</sup> Jamary Oliveira-Filho - MD, PhD.; Biomorphology Department - Health Sciences Institute of the Federal University of Bahia.

### **Correspondência para / Correspondence to:**

Jamary Oliveira-Filho

Instituto de Ciências da Saúde, sala 415.

Av. Reitor Miguel Calmon, s/n. - Vale do Canela. Salvador, BA.

40110-100 Salvador - Bahia - Brazil.

Tel./Fax: +55-71-3247-7291.

E-mail: jamaryof@ufba.br

specimens for teaching students from various health-related professions such as medicine, phonoaudiology, nursing, physical education, veterinary medicine and odontology. During the period of January to December, 2007, these formol-preserved specimens were catalogued and recovered with the purpose of creating an anatomical museum. In this setting, ten specimens of the superior limb (four of each side) were recovered and dissected searching specifically for the brachial plexus. Each cervical root and first pair of thoracic roots were carefully identified and dissected from proximal to distal, reaching the axillary region, where the trunks and fasciculae were individualized.

We classified potential anatomic variants by three individual locations: variants of root composition (prefixed type – originating from C4, and post-fixed type – originating from T2), trunk and fasciculae. Normal brachial plexus formation was termed of a “classic type”. Documentation of final dissection specimens were photographed with a digital 3.2-pixel Canon camera.

## RESULTS

Ten adult superior limb specimens were suitable for complete dissection of the brachial plexus. Final dissected specimens are shown in Figure 1. Four specimens were from the right side and four were from the left side. Gender, ethnicity and age were unknown. All brachial plexus identified were of a classic type. No anatomic variants were found in this sample.

## DISCUSSION

Although brachial plexus diseases are common and anesthetic blockade of the brachial plexus even more frequent, articles studying this anatomic region are scarce. A search in Medline, PubMed and LILACS from 1950 to 2008 using key words “brachial plexus” and “anatomic variants” or “anatomic variations” yielded only 78 articles. Much of the recent literature concentrates on new imaging technology, but consistently disregards describing either normal anatomy or anatomic variants, rather concentrating on diseases or comparing different imaging technologies.

## Normal anatomy

The brachial plexus originates from the dorsal and ventral rami of the fifth cervical through first thoracic spinal cord segments<sup>1</sup>. At the level of the posterior cervical triangle, each ramus unites to form three trunks, as follows: C5 and C6 form the superior trunk; C7 forms the middle trunk; and C8 and T1 form the inferior trunk. Each trunk bifurcates into ventral and dorsal divisions. At the level of the axillary region, three fascicles are formed, as follows: the lateral fascicle is formed by the ventral divisions of the superior and middle trunks; the medial fascicle is formed by the ventral division of the inferior trunk; and the dorsal fascicle is formed by the dorsal divisions of all three trunks.

## Anatomic variants

The prevalence of anatomic variants varies among different samples in the literature. One of the first common variants described was the pre-fixation or post-fixation of the brachial plexus<sup>1,8</sup>. The prefixed type of brachial plexus occurs when C4 contributes to its formation and usually T1 does not. The post-fixed type occurs when C6 through T2 form the brachial plexus. Prevalence of the prefixed type varies from 12 to 30%<sup>5,7</sup>; and the post-fixed type occurs from zero to 11% of cases<sup>5</sup>. In two series from Brazil, the prefixed type was described in 20 to 24% of cases; and the post-fixed type in 0-6% of cases<sup>4,6</sup>. A rare variant was described by Fazan and others<sup>6</sup>, where the C5 and C6 roots split into anterior and posterior divisions, originating two superior trunks. Connections between the lateral and medial fasciculus are relatively common (mostly between the lateral fasciculus and the ulnar nerve, between both pectoralis nerves or between the median and musculocutaneous nerve). In Harris's series, 26/30 superior limbs had such a variant<sup>1</sup>. In Fazan's series, the lateral fasciculus to ulnar nerve connection was found in 30% of cases.<sup>6</sup>

## Imaging the brachial plexus

Two imaging modalities are mostly used to view the brachial plexus. Computed tomography myelography is used in traumatic brachial plexus

**Figure 1.** Examples of anatomic samples of the normal human brachial plexus.



Note: A=axillary nerve; Me = median nerve; Mu = musculocutaneous nerve; FP = posterior fasciculus; FM = medial fasciculus; FL = lateral fasciculus; R = radial nerve; U = ulnar nerve.

*injuries to differentiate avulsions from neuropraxis of brachial plexus components, but does not individualize each anatomic structure well enough to allow describing anatomic variants<sup>9</sup>. Thus, it is an imaging modality useful only in disease processes. Magnetic resonance imaging has gained momentum in exploring various regions of the human body, allowing nearly anatomical detail without radiation exposure<sup>9,10,11</sup>. Usual sequences include multiplanar T1, T2 and short-term inversion recovery (STIR)<sup>12</sup>. These sequences allow 2D visualization of the brachial plexus and to differentiate between inflammatory, neoplastic and traumatic diseases. More recently, isotropic 3D T2 turbo-spin-echo (TSE) sequence with STIR and variable flip angle radiofrequency excitations (SPACE: Sampling*

*Perfection with Application optimized Contrasts using different flip angle Evolutions) allow high-resolution 3D images to be obtained and should be fertile ground for research exploration.<sup>13</sup>*

## CONCLUSION

*Anatomic variants of the brachial plexus were not found in the present sample of anatomic specimens from a single academic center. However, the small sample studied may not allow generalization of our results to the Brazilian population. Review of the current literature allowed describing the main anatomic variants and imaging modalities to stimulate further research in this area.*

## Variantes do plexo braquial: um estudo anatômico

### Resumo

O plexo braquial é um sítio frequente de lesões traumáticas, inflamatórias e neoplásicas. Variantes anatômicas ocorrem em até 48% dos casos, dependendo da população estudada e da técnica de

imagem. O objetivo do estudo foi descrever as principais variantes anatômicas nas nossas peças e compará-las às variantes descritas em outras populações. Dez peças anatômicas (cinco de cada lado) de cadáveres de idade e gênero desconhecido estavam preservadas em formol. Essas peças foram dissecadas desde as raízes da coluna cervical até a região axilar, identificando-se cada raiz, tronco e fascículo. Em todas as peças estudadas, o plexo braquial foi do tipo clássico, originado da quinta raiz cervical até a primeira raiz torácica. Variantes anatômicas descritas na literatura foram revisadas. Nenhuma variante anatômica foi encontrada nessas peças. Concluiu-se que variantes anatômicas do plexo braquial são aparentemente raras na nossa população. No entanto, amostras maiores devem ser estudadas antes de se generalizarem esses resultados na nossa população.

**Palavras-chave:** Plexo braquial- Dissecação -Variantes anatômicas.

## REFERENCES

- 1 HARRIS, W. *The true form of the brachial plexus, and its motor distribution.* *J. Anat. Physiol.*, London, v.38, p.399-422, 1904.
- 2 HUMPHRIES, S.V. *Brachial plexus block: report on 350 cases.* *Br. Med. J.*, London, v.1, p.163-164, 1950.
- 3 KULENKAMPEFF, D. *Brachial plexus anaesthesia: its indications, technique, and dangers.* *Ann. Surg.*, Philadelphia, v.87, p.883-891, 1928.
- 4 ALBERTONI, W.M. et al. *Estudo anatômico do plexo braquial na criança até os seis meses de idade.* *R. Bras. Ortop.*, Rio de Janeiro, v.29, p.163-169, 1994.
- 5 BOWDEN, R.E.M. *The applied anatomy of the cervical spine and brachial plexus.* *Proc. R. Soc. Med.*, London, v.59, p.1141-1146, 1966.
- 6 FAZAN, V.P.S. et al. *Brachial plexus variations in its formation and main branches.* *Acta Cir. Bras.*, São Paulo, v.18, p.14-18, 2003.
- 7 ONGOÏBA, N.; DESTRIEUX, C.; KOUMARE, A.K. *Anatomical variations of the brachial plexus.* *Morphologie, Paris*, v.86, n.273, p.31-34, 2002.
- 8 DUKES, L.; OWEN, S.A. *Anomalies in the cervical and upper thoracic region, involving the cervical vertebrae, first rib and brachial plexus.* *J. Anat. Physiol.*, London, v.36, p.290-291, 1902.
- 9 CASTILLO, M. *Imaging the anatomy of the brachial plexus: review and self-assessment module.* *AJR Am. J. Roentgenol.*, Leesburg, v.185, p.S196-204, 2005.
- 10 GEREVINI, S. et al. *Diagnostic value and surgical implications of the magnetic resonance imaging in the management of adult patients with brachial plexus pathologies.* *Surg. Radiol. Anat.*, Berlin, v.30, n.2, p.91-101, 2008.
- 11 YOSHIKAWA, T. et al. *Brachial plexus injury: clinical manifestations, conventional imaging findings, and the latest imaging techniques.* *Radiographics*, Oak Brook, v.26, p.S133-143, 2006. *Suppl.1*
- 12 FREUND, W. et al. *MR neurography with multiplanar reconstruction of 3D MRI datasets: an anatomical study and clinical applications.* *Neuroradiology*, Berlin, v.49, p.335-341, 2007.
- 13 VIALON, M. et al. *High-resolution and functional magnetic resonance imaging of the brachial plexus using an isotropic 3D T2 STIR (Short Term Inversion Recovery) SPACE sequence and diffusion tensor imaging.* *Eur. Radiol.*, Berlin, v.18, n.5, p.1018-1023, 2008.

Recebido em / Received: 11/11/2008  
Aceito em / Accepted: 26/03/2009