A variation in the origin of the median nerve associated with an unusual origin of the deep brachial artery

Pais, D.*, Casal, D., Santos, A. and O'Neill, JG.

Department of Anatomy, Faculty of Medical Sciences, New University of Lisbon,
Campo Mártires da Pátria, 130, 1169-056 Lisbon, Portugal

*E-mail: diogo.pais@fcm.unl.pt

Abstract

A thorough anatomical knowledge of the normal conformation and variations of the brachial plexus, its branches and the vessels with which they are related is of paramount importance for anatomists, surgeons, anesthesiologists and radiologists. During routine anatomical dissection of the left axilla and supraclavicular region of a 69 year-old male preserved corpse, the medial root of the median nerve was found to receive a supplementary branch from the medial aspect of the terminal portion of the lateral cord. This anastomotic branch crossed in a narrow space between the axillary artery and the deep brachial artery that originated unusually proximally from the third portion of the axillary artery. To our knowledge, the association of this type of origin of the median nerve with a deep brachial artery deriving from the axillary artery has not been cited in recent medical literature. This particular disposition of the origin of the median nerve could help explain why, in some cases, injury of the lateral cord or upstream to the lateral cord may lead to the unexpected presentation of weakness of forearm flexors and thenar muscles.

Keywords: brachial plexus, variation, median nerve, peripheral nervous system, deep brachial artery.

1 Introduction

Walsh was the first to describe brachial plexus variations, reporting two brachial plexus anomalies in 350 brachial plexus dissections (WALSH, 1877). Since then, numerous descriptions of the variations of the brachial plexus and its cords have been reported (KERR, 1918; JACHIMOWICZ, 1925; HIRASAWA, 1928; MILLER, 1939; TSIKARAS, HYTIROGLOU, 1983; LEE, SIR, KANG et al., 1992; UZUN, 1999; ONGOIBA, KOUMARE 2002; MATEJCIK, 2005) The amount of variation identified has been such that, as early as 1918, Kerr had already described 29 types of brachial plexus and in 1931 Hirasawa raised that number to 31 (NAKATANI, TANAKA and MIZUKAMI, 1998). However, most of the studies conducted on brachial plexus anatomy and variations have focused mainly on variation of the entire brachial plexus (PANDEY, SHUKLA, 2007). The literature is much scarcer regarding variation specifically of the cords and individual terminal branches (BONNEL, 1984; PANDEY, SHUKLA, 2007).

The median nerve is functionally one of the most important terminal branches of the brachial plexus (MOORE, 2006). Classically, the median nerve is thought to be formed in front of the axillary artery by the union of one lateral and one medial root, originating from the lateral and medial cords of the brachial plexus, respectively (JOHNSON, VEKRIS, ZOUBOS et al., 2006; MOORE, 2006). However, various studies have been conducted on the variations of this nerve and of the relations of this nerve with the axillary artery (LENGELE, DHEM, 1989; LE MINOR, 1990; UZUN, SEELIG, 2001; PANDEY, SHUKLA, 2007), showing that the traditional view of the anatomy of the median nerve is not always true.

Although, mainly for didactical purposes, the axillary artery and its six major branches, which are intimately related with the brachial plexus, are described as if they were constant (CAVDAR, ZEYBEK and BAYRAMICLI, 2000; MOORE, 2006), several studies have shown that they have no fixed pattern (DEGARIS, SWARTLEY, 1928; TROTTER, GASS and BRUA et al., 1930; HUELKE, 1959; CAVDAR, ZEYBEK, BAYRAMICLI, 2000).

The anatomical, clinical, surgical and anaesthesiological importance of these variations can not be overemphasized (KOGAN, LEWINSON, 1998; UZUN, 1999; CAVDAR, ZEYBEK, BAYRAMICLI and 2000; SHIN, SPINNER, STEINMANN et al., 2005; CHUANG, 2006; PHAM DANG, PATRA, CHAILLOU et al., 2006; OLUYEMI, OFUSORI, OKWUONU et al., 2007).

In this paper, the authors describe a variation in the origin of the median nerve associated with an unusual high origin of the deep brachial artery that was found on a routine dissection. This constellation of variations is not found in recent medical literature.

2 Case report

During routine dissection of the left supraclavicular region and axilla of a 69 year-old male preserved corpse, following the recommendations of a Human Anatomy dissection manual (ESPERANÇA-PINA, CORREIA, GOYRI O'NEILL et al., 2001), an usual origin of the median nerve and of the deep brachial artery were noted (Figure 1).

The median nerve was formed in the anterior and medial aspect of the axillary artery by the confluence of two roots. The lateral root originated, as usual, from the lateral

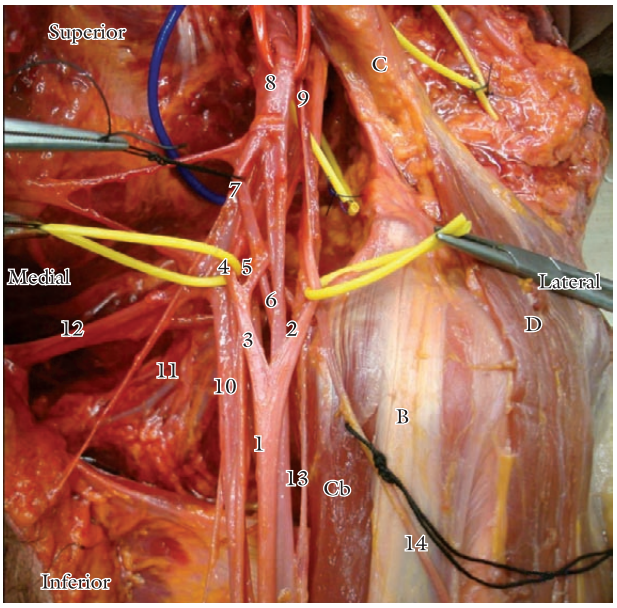

Figure 1. Anteromedial view of a dissection of the left axilla, showing the brachial plexus and its terminal branches. A variation in the origin of the medial root of the median nerve and of the deep brachial artery is seen. C) clavicle; D) deltoid muscle; Cb) coracobrachial muscle; and B) long head tendon of the upper arm biceps muscle. 1) median nerve; 2) lateral root of the median nerve; 3) medial root of the median nerve; 4) contribution of the medial cord of the brachial plexus to the medial root of the median nerve; 5) contribution of the lateral cord of the brachial plexus to the medial root of the median nerve; 6) axillary artery; 7) deep brachial artery; 8) subclavian artery; 9) lateral cord of the brachial plexus; 10) axillary vein; 11) subscapular vessels; 12) lateral thoracic vessels; 13) musculocutaneous nerve; and 14) cefalic vein.

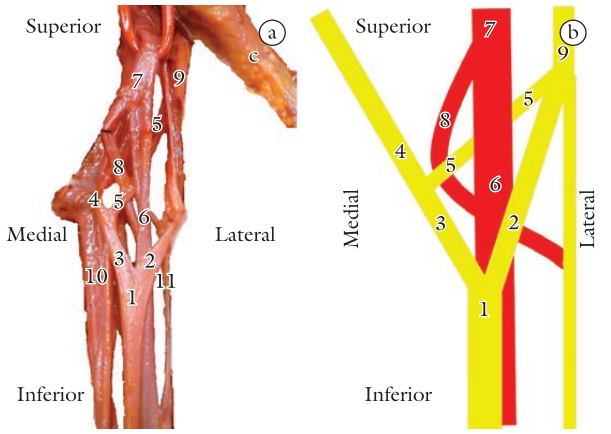

Figure 2. Scheme of the variation in the origin of the medial root of the median nerve and of the deep brachial artery after digital subtraction of all unrelated anatomical strcutures from Figure 1 (Figure 2a) and in a simplified drawing (Figure 2b). C- clavicle. 1) median nerve; 2) lateral root of the median nerve; 3) medial root of the median nerve; 4) contribution of the medial cord of the brachial plexus to the medial root of the median nerve; 5) contribution of the lateral cord of the brachial plexus to the medial root of the median nerve; 6) axillary artery; 7) subclavian artery; 8) deep brachial artery 9) lateral cord of the brachial plexus; 10) axillary vein; and 11) musculocutaneous nerve.

cord, whereas the medial root received not only a major contribution form the medial cord, but also a smaller branch from the medial aspect of the terminal portion of the lateral cord (Figures 1 and 2). In addition, the deep brachial artery originated from the posterior and medial aspect of the third part of the axillary artery, crossing obliquely laterally and downwards behind the axillary artery and reaching the groove for the radial nerve in the posterior aspect of the humerus. The anastomotic branch between the lateral cord and the medial root crossed obliquely downwards and medially in the narrow space between the axillary artery anteriorly and the deep brachial artery posteriorly (Figure 2).

The protocol for this research did not include any specific issue that needed to be approved by the Ethics\Committees of our institutions. The work conformed to the provisions of the Declaration of Helsinki in 1995 (as revised in Edinburgh 2000).

3 Discussion

In the literature review that the authors conducted, there was no description of the medial root of the median nerve receiving a subsidiary branch from the lateral cord, and this branch being placed between the axillary artery anteriorly, and an unsual high deep brachial artery, originating from the axillary artery, posteriorly.

The most similar situation was reported in a large series of 344 brachial plexus dissections (PANDEY, SHUKLA, 2007) in which one or two communicating branches from the lateral cord joined the medial root of the median nerve in 8 cases (2,32%). However, in all these cases the communicating branches had a very close relationship with the axillary artery below the origin of the thoracoacromial trunk, but no association with vascular variations was reported.

A partially similar variation was also described recently in a cadaver with three anomalous connections in the origin and pathway of the median nerve (OLUYEMI, OFUSORI, OKWUONU et al., 2007). In this case, one of the anomalous connections consisted of one anastomosis between the lateral cord and the medial cord, as the latter gave off the medial root of median nerve, that is to say the abnormal communication originated slightly more proximal than in our case. In addition, this paper doesn't mention any particular vascular variation or the relation of this aberrant nerve communication with vascular structures.

The origin of the deep brachial artery from the axillary artery, as was observed in the case presented in this paper, is not unheard of (ADACHII, 1928; DEGARIS, SWARTLEY, 1928; MILLER, 1939; MCCORMACK, CAULDWELL and ANSON, 1953), but is rarely seen (0,1 to 3,2% of cases). However, to the best of the authors' knowledge, never has this variation been associated with a variation in the origin of the median nerve identical or even similar to the one portrayed in the present work.

Like most of the human anatomic variations, the variations encountered by the authors may be plausibly attributed to random factors influencing the mechanism of formation of the limb muscles, the peripheral

nerves and the vascular system during embryonic life (VENIERATOS, ANAGNOSTOPOULOU, 1998; RODRIGUEZ-NIEDENFUHR, BURTON, DEU et al., 2001). As it is known, the limb muscles develop from the mesenchyme of seemingly local origin, while the axons of the spinal nerves grow distally to reach the muscles and/or the skin. Thus, a lack of coordination between these two processes may have lead to the variation encountered in this study (VENIERATOS, ANAGNOSTOPOULOU, 1998). Upper limb vascular variations are presently thought to result from a stochastic process of persistence, enlargement and differentiation of parts of the initial capillary network which would normally remain as capillaries or even regress (RODRIGUEZ-NIEDENFUHR, BURTON, DEU et al., 2001).

There is mounting evidence that connections between the musculocutaneous nerve and the median nerve are as frequent as 20,2% (VENIERATOS, ANAGNOSTOPOULOU, 1998), and also that the fibers that cross these anastomoses play a significant role in the innervation of the anatomical structures traditionally described as being innervated by the median nerve, namely the pronator teres, flexor carpi radialis and thenar muscles, distal muscle belly of the index of the flexor digitorum superficialis, and even to contribute to the formation of the lateral digital nerves (MAEDA, KAWAI, KOIZUMI et al., 2009). Consequently, it is plausible that the anastomosis herein described represents a rarer form of communication between the lateral cord, or the musculocutaneous nerve that it originates, and the median nerve. This disposition of fibers could help explain why, in some cases, injury of the lateral cord proximal to the place of origin of the anastomotic branch between the lateral cord and the medial root of the median nerve, or lesions upstream the lateral cord, may lead to the unexpected presentation of weakness of forearm flexors and thenar muscles (SUNDERLAND, 1978; OLUYEMI, OFUSORI, OKWUONU et al., 2007).

In addition, it could be thought that by being positioned between the narrow space between the axillary artery and the unusual high deep brachial artery, the supernumerary connection between the lateral cord and the medial root of the median nerve is prone to vascular compression. According to the double-crush theory of nerve compression (YAO, 2006), this may make individuals with this variation more liable to develop median nerve compressive syndromes downstream (e.g. carpal tunnel syndrome) and, inversely, make the surgical treatment of more distal compressions less likely to be effective (WERTSCH, MELVIN, 1982; YAO, 2006). However, more studies are needed to confirm this hypothesis.

Finally, the knowledge of this particular disposition of the deep brachial artery and of its intimate relation with a supplementary branch to the medial root of the median nerve given off by the lateral cord may be of critical importance for surgeons, radiologists and anesthesiologists working in the axilla, shoulder or upper arm regions, in order to prevent potential iatrogeny and to facilitate interpretation of clinical findings.

Acknowledgments: We appreciate the efforts of all Technical Staff members of the Department of Anatomy, in particular of Mr. Carlos Lopes and of Mr. Marco Costa.

References

ADACHII, B. *Das arteriensystem der japaner*. Kyoto: Maruzen, 1928. p. 234-237.

BONNEL, F. Microscopic anatomy of the adult human brachial plexus: an anatomical and histological basis for microsurgery. *Microsurgery*, 1984, vol. 5, p. 107-118.

CAVDAR, S., ZEYBEK, A. and BAYRAMICLI, M. Rare variation of the axillary artery. *Clinical Anatomy*, 2000, vol. 13, p. 66-68.

CHUANG, D. Adult brachial plexus injuries. In MATHES, SJ. and HENTZ, VR. *Plastic surgery*. 2 ed. Philadelphia: Saunders, 2006. p. 515-560.

DEGARIS, C. and SWARTLEY, WB. The axillary artery in white and negro stocks. *American Journal of Anatomy*, 1928, vol. 41, p. 353.

ESPERANÇA-PINA, JR., CORREIA, M., GOYRI O'NEILL, J. and PAIS, D. Upper Limb. In ESPERANÇA-PINA, JR. (Ed.). *General anatomy and human dissection.* Lisbon: Lidel, 2001. p. 133-156.

HIRASAWA, MK. *Uber den plexus brachialis mitterlung die wurzeln des plexus brachial*. Universitatis Imperialis Kiotoensis, 1928. Impressio separata exactis scholar Medicinalis.

HUELKE, D. Variation in the origins of the branches of the axillary artery. *Anatomical Record*, 1959, vol. 35, p. 33-41.

JACHIMOWICZ, J. Les variation du plexus brachial (resumé). *Mémoire Anatomique de la Université Varsoviensis*. 1925, vol. 3, no. 1, p. 246-282.

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, p. 218-229.

KERR, A. The brachial plexus of nerves in man the variations its formation and branches. *American Journal of Anatomy*, 1918, vol. 23, no. 285-395.

KOGAN, I. and LEWINSON, D. Variation in the branching of the axillary artery: a description of a rare case. *Acta Anatomica*, 1998, vol. 162, p. 238-240.

LE MINOR, JM. A rare variation of the median and musculocutaneous nerves in man. *Archives d' Anatomie, d' Histologie et d' Embryologie*, 1990, vol. 73, p. 33-45.

LEE, HY., CHUNG, IH., SIR, WS., KANG, HS., LEE, HS., KO, JS., LEE, MS. and PARK, SS. Variations of the ventral rami of the brachial plexus. *Journal of Korean Medical Science*, 1992, vol. 7, p. 19-24.

LENGELE, B. and DHEM, A. Unusual variations of the vasculonervous elements of the human axilla: report of three cases. *Archives d' Anatomie, d' Histologie et d' Embryologie*, 1989, vol. 72, p. 57-67.

MAEDA, S., KAWAI, K., KOIZUMI, M., IDE, J., TOKIYOSHI, A., MIZUTA, H. and KADAMO, K. Morphological study, by teasing examination, of the communication from the musculocutaneous to median nerves. *Anatomical Science International*, 2009, vol. 84, p. 41-46.

MATEJCIK, V. Variations of nerve roots of the brachial plexus. *Bratisl Lek Listy*, 2005, vol. 106, p. 34-36.

MCCORMACK, L., CAULDWELL, EW. and ANSON, BJ. Brachial and antebrachial arterial patterns. *Surgery, Gynecology & Obstetrics*, 1953, vol. 96, p. 43-54.

MILLER, R. Observations upon the arrangement of the axillary artery and brachial plexus. *American Journal of Anatomy*, 1939, vol. 64, p. 143-163.

MOORE, KD. Upper Limb. In MOORE, KL., DALLEY, AF. and AGUR, AMR. *Clinically oriented anatomy*. 5 ed. Philadelphia: Lippincott Williams and Wilkins, 2006. p. 773-791.

NAKATANI, T., TANAKA, S. and MIZUKAMI, S. Two rare anomalies of the brachial plexus. *Journal of anatomy*, 1998, vol. 192, no. 2, p. 303-304.

OLUYEMI, KA., ADESANYA, OA., OFUSORI, DA., OKWUONU, CU., UKWENYA, VO., OM'INIABOHS, FA. and ODION, BI. Abnormal pattern of brachial plexus formation: an original case report: the internet. *Journal of Neurosurgery*, 2007, vol. 4, no. 2.

ONGOIBA, DC. and KOUMARE, AK. Anatomical variations of the brachial plexus. *Morphologie*, 2002, vol. 86, p. 31-34.

PANDEY, SK. and SHUKLA, VK. Anatomical variations of the cords of brachial plexus and the median nerve. *Clinical Anatomy*, 2007, vol. 20, p. 150-156.

PHAM DANG, C., PATRA, P., CHAILOU, P. and COSTARGENT, A. A different approach to the brachial plexus in the cervical region. *Annales francaises d' anesthesie et de reanimation*, 2006, vol. 25, p. 321-325.

RODRIGUEZ-NIEDENFUHR, M., BURTON, GJ., DEU, J. and SAÑUDO, JR. Development of the arterial pattern in the upper limb of staged human embryos: normal development and anatomic variations. *Journal Anatomy*, 2001, vol. 199, p. 407-417.

SHIN, AY., SPINNER, RJ., STEINMANN, SP. and BISHOP, T. Adult traumatic brachial plexus injuries. *Journal of the American Academy of Orthopaedic Surgeons*, 2005, vol. 13, p. 382-396.

SUNDERLAND, S. The median nerve: anatomical and physiological features. In SUNDERLAND, S. Nerves and nerve injury. 2 ed. Edinburg: Churchil Livingstone, 1978. p. 672-727.

TROTTER, M., HENDERSON, JL., GASS, H., BRUA, RS., WEISMAN, S., AGRESS, H., CURTIS, GH. and WESTBROOK, ER. The origins of branches of the axillary artery in whites and in American negroes. *The Anatomical Record*, 1930, vol. 46, p. 133-137.

TSIKARAS, PA. and HYTIROGLOU, PM. A variation in the formation of the brachial plexus characterized by the absence of C8 and T1 fibers in the trunk of the median nerve. *Bulletin de l' Association des Anatomistes*, 1983, vol. 67, p. 501-505.

UZUN, A. and SEELIG, LL. A variation in the formation of the median nerve: communicating branch between the musculocutaneous and median nerves in man. *Folia Morphologica*, 2001, vol. 60, p. 99-101.

UZUN, BS. Some variations in the formation of the brachial plexus in infants. Turkish Journal *of Medical Sciences*, 1999, vol. 29, p. 573-577.

VENIERATOS, D. and ANAGNOSTOPOULOU, S. Classification of communications between the musculocutaneous and median nerves. *Clinical Anatomy*, 1998, vol. 11, p. 327-331.

WALSH, J. The anatomy of the brachial plexus. *American Journal of Science*,1877, vol. 74, p. 387-428.

WERTSCH, JJ. and MELVIN, J. Median nerve anatomy and entrapment syndromes: a review. *Archives of Physical Medicine and Rehabilitation*, 1982, vol. 63, p. 623-627.

YAO, J. Double crush syndrome. In SLUTSKY, DH. (Ed.). *Peripheral nerve surgery*: practical applications in the upper extremity. Philadelphia: Churchill Livingstone, 2006. p. 277-284.

Received November 16, 2009
Accepted June 29, 2010