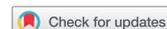


Superficial location of the brachial plexus and axillary artery in relation to pectoralis minor: a case report

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Knowledge of the anatomy of the infraclavicular fossa is important as this region is a target site for anaesthesia of the upper limb during infraclavicular approaches to brachial plexus blocks and in central venous cannulation of the axillary or subclavian veins. The cords of the brachial plexus and the axillary artery and vein are classically described as being located deep to the pectoralis minor and major muscles in the infraclavicular fossa. A rare variation was observed on one side of an individual, out of a total of 170 dissections, in which the brachial plexus and axillary artery were located between the pectoralis minor and major muscles. This variation was observed on the right-hand side of a male cadaver, and resulted in a more superficial position of the cords of the brachial plexus and axillary artery in relation to the skin. This superficial position of these vital structures may lead to an increased risk of complications during clinical procedures, such as infraclavicular brachial plexus blocks, central venous cannulation or surgery. Ultrasound should be used whenever possible to visualise variant positions of arteries, veins, nerves or muscles during these and other procedures.

Keywords: anatomical variation, axillary artery, brachial plexus, infraclavicular region, pectoralis minor

Introduction

The infraclavicular fossa is an important anatomical area, in which infraclavicular approaches to brachial plexus blocks and central venous cannulation of the subclavian vein via the axillary vein are routinely performed in clinical practice.^{1,2} The anterior border of the infraclavicular fossa is formed by the pectoralis minor and major muscles, the medial border by the ribs and intercostal muscles, the superior border by the clavicle and the coracoid process of the scapula, and the lateral border by the humerus. The cords of the brachial plexus as well as the axillary artery and vein are situated in the infraclavicular fossa.¹

The brachial plexus innervates all the structures of the upper limb, and originates from spinal roots C5, C6, C7, C8 and T1, which are located between the anterior and middle scalene muscles.³ The trunks arise in the posterior triangle of the neck from the union of the roots; C5 and C6 roots join to form the superior trunk, C8 and T1 unite to form the inferior trunk, while C7 continues as the middle trunk. The trunks surround the first part of the axillary artery and pass over rib one, deep to the clavicle, where they each divide into anterior and posterior divisions. All three of the posterior divisions unite posterior to the axillary artery to form the posterior cord, the anterior divisions of the superior and middle trunk form the lateral cord on the lateral side of the axillary artery, while only the anterior division of the inferior trunk gives rise to the medial cord on the medial side of the artery. The cords are therefore named according to their position relative to the second part of the axillary artery and are situated deep to the pectoralis major and minor muscles. The terminal branches of the brachial plexus arise from the cords in the region of the third part of the axillary artery, inferior to the distal border of pectoralis minor, and supply skin and muscles of the upper limb.⁴ The lateral cord gives rise to the musculocutaneous nerve and the lateral root of the median nerve, the medial cord gives rise to the

medial root of the median nerve and the ulnar nerve, and the posterior cord divides into the radial and axillary nerves.³

The axillary artery is a continuation of the subclavian artery once it has passed over the first rib. The pectoralis minor muscle is located superficial to the axillary artery and it is this relationship that is used to divide the artery into three parts. The first part of the axillary artery is situated between the first rib and the superior border of pectoralis minor, the second part is deep to pectoralis minor, and the third part is located between the inferior borders of pectoralis minor and teres major muscles, after which it is known as the brachial artery.⁵ The axillary artery is accompanied by the axillary vein, a continuation of the brachial vein at the inferior border of teres major. The axillary vein is superficial to the axillary artery and becomes the subclavian vein as it crosses over the outer border of rib one.⁶

The pectoralis major and minor muscles overlie the axillary artery, vein and cords of the brachial plexus. Pectoralis major has an extensive origin from the clavicle, sternum, first to seventh costal cartilages and the external oblique aponeurosis, and inserts into the lateral lip of the intertubercular sulcus of the humerus. Pectoralis minor is situated deep to pectoralis major and originates from the anterior surface of the third, fourth and fifth ribs and inserts into the coracoid process of the scapula. As described above, the cords of the brachial plexus and the second part of the axillary artery are deep to pectoralis minor⁶ (Figure 1).

Knowledge of the anatomy of the infraclavicular fossa is relevant to surgeons operating in this area, as well as anaesthesiologists performing infraclavicular brachial plexus blocks, or cannulating the subclavian and axillary veins for central venous access.⁷ Variation in the position and relationship of anatomical structures in the infraclavicular region could result in inadvertent injury to the axillary artery or brachial plexus, failure to adequately block the

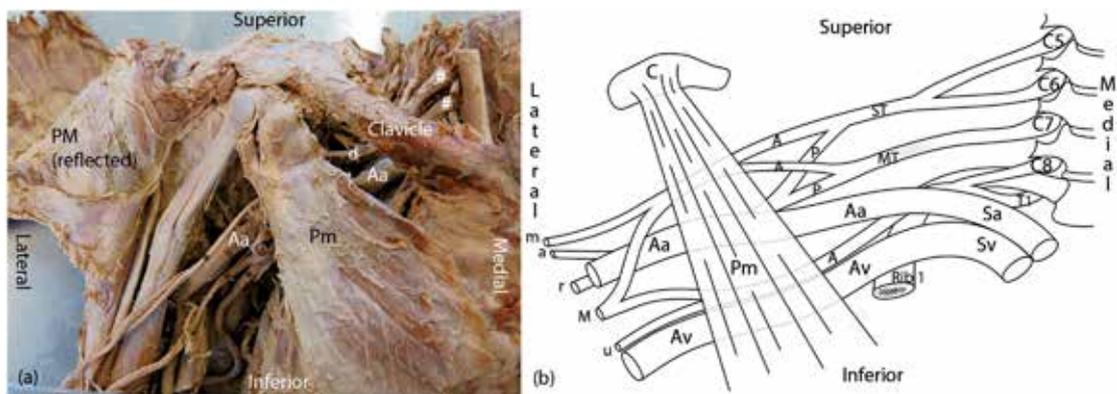


Figure 1: Anatomy of the brachial plexus and axillary artery (Aa) in relation to pectoralis minor (Pm) as seen on dissection (A) and in a schematic (B). The cords and the second part of the axillary artery are situated deep to pectoralis minor. The anterior position of the axillary vein (Av) in relation to the artery is indicated in B.

Note: # = roots; d = divisions; * = terminal branches; Sa = subclavian artery; Sv = subclavian vein; ST = superior trunk; MT = middle trunk; A = anterior divisions; P = posterior divisions; C = coracoid process; m = musculocutaneous nerve; a = axillary nerve; r = radial nerve; M = median nerve; u = ulnar nerve. Photograph by Kerri Keet. Schematic by Gregory Keet.

nerves of the brachial plexus, or local anaesthetic toxicity. The consequences could be serious as haemorrhage and sensory or motor nerve damage could result from an incorrectly placed needle in this area.

Variations in the branches of the axillary artery and the nerves forming the brachial plexus have been reported in the literature.⁸⁻¹⁰ In addition, variations in the relationship of the brachial plexus and axillary artery to surrounding structures, such as the scalene muscles, have also been observed.¹¹ The position of pectoralis minor relative to the brachial plexus and axillary artery appears to be constant as there is little variation documented in the literature. Previously, only one study has reported

variation in the position of the muscle in relation to these structures.⁷ We report the superficial position of the brachial plexus and axillary artery in relation to pectoralis minor that was observed unilaterally during the dissection of the infraclavicular region in one cadaver in a study of 85.

Case report

During a cross-sectional study of 85 embalmed human cadavers during the years 2011 and 2012, which investigated the anatomical relationships between the brachial plexus, axillary artery and adjacent muscles, a rare variation was observed. On the right side of a male cadaver, the axillary artery and cords of the brachial plexus were located superficial to the pectoralis minor

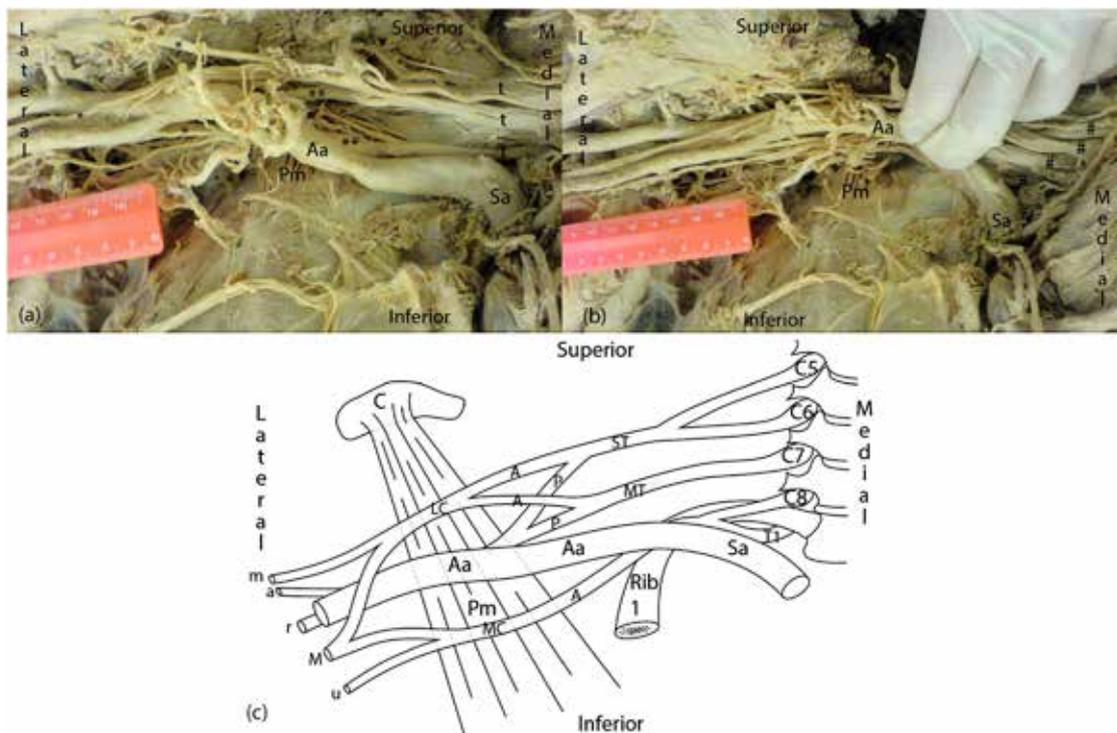


Figure 2: Superficial position of the brachial plexus and axillary artery (Aa) in relation to the pectoralis minor muscle (Pm) as observed on the right side of a male cadaver. A shows the relationship as discovered during dissection, in B the nerves and artery are retracted to expose the underlying muscle. C is a schematic of the variation.

Note: Sa = subclavian artery; # = roots; t = trunks; ** = cords; * = terminal branches; ST = superior trunk; MT = middle trunk; A = anterior divisions; P = posterior divisions; C = coracoid process; m = musculocutaneous nerve; a = axillary nerve; r = radial nerve; M = median nerve; u = ulnar nerve. Photographs by Kerri Keet. Schematic by Gregory Keet.

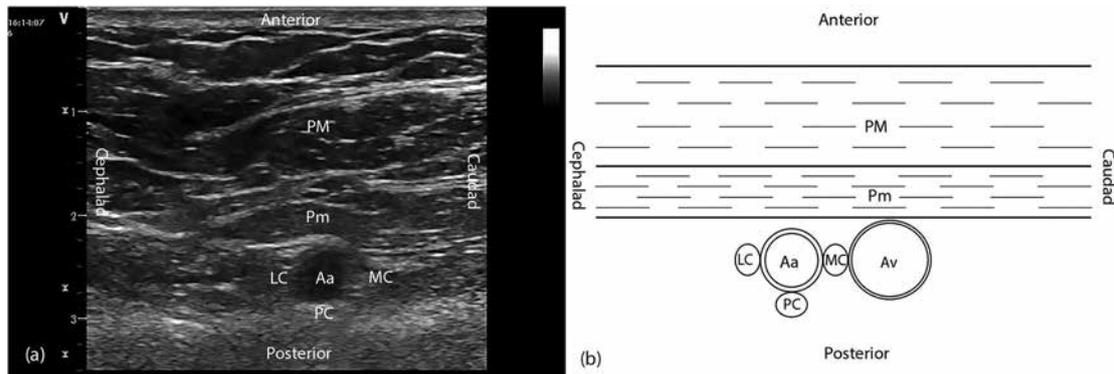


Figure 3: Ultrasound view (11 MHz linear probe) of the infraclavicular region (A), indicating the position of the axillary artery (Aa) and the medial (MC), lateral (LC) and posterior (PC) cords of the brachial plexus deep to pectoralis minor (Pm) and pectoralis major (PM) muscles. The cords are not easily visualised; the locations in which they are expected to be observed relative to the axillary artery are indicated in A, and are shown more clearly in the schematic in B, along with the position of the axillary vein (Av).

Note: Ultrasound image supplied by Etienne Coetzee. Schematic by Gregory Keet.

muscle, instead of in their usual deep position (Figure 2). The pectoralis major muscle was located immediately superior to the brachial plexus and axillary artery.

In this individual, the brachial plexus and axillary artery did not display any variations in their usual positions relative to one another and the scalene muscles. There were no variations in the origin and insertion of pectoralis minor; the only variation present was the location of this muscle deep to the brachial plexus and axillary artery. The left side of the same individual did not display any variation in the brachial plexus, axillary artery or pectoral muscles. The relationship between the axillary vein and pectoralis minor could not be determined on either side as the vein had been damaged during prior dissection by medical students.

Discussion

The superficial location of the brachial plexus and axillary artery in relation to pectoralis minor instead of in their usual, deeper position is a rare variation that has only been reported once in the literature. In 1994, Tan and Tan⁷ observed this position on both sides of one individual in a study of 50 cadavers. No information, such as sex or age, is available about this individual. In our study, this variation was observed in a male cadaver on the right side only, while the left side showed the usual position.

Changes in cell signalling by pectoralis minor during embryological development could explain the altered position of the brachial plexus and axillary artery in relation to this muscle. During the fifth week of gestation, muscle tissue develops from the mesenchyme of the para-axial mesoderm. Chemo-attractants and chemo-repulsants are chemical substances which guide the growth cones of axons along the correct path. Signalling occurs between the mesenchymal cells and the growth cones, which establishes anatomical relationships between muscles and nerves. Alterations in signalling between these structures may result in variation in the pathway of the nerve and its relationship to adjacent muscles. Alternatively, changes in blood flow to the developing muscles and axons could also result in variation in their position.¹² Congenital absence of the pectoralis minor muscle, which is known as Poland's syndrome, is suggested to be caused by interruption of blood flow to the upper limb buds. However, a more recent study found the presence of the pectoral branch of the thoraco-acromial artery, which supplies pectoralis minor, in a patient with Poland's syndrome.¹³ Whatever the cause of

altered embryological development may be, the results are lifelong.¹²

There are clinical implications to the superficial position of the brachial plexus and axillary artery relative to pectoralis minor. The presence of the muscle deep to the nerves and arteries suggests that these structures are closer to the skin than might be expected by clinicians. Infraclavicular brachial plexus blocks and central venous cannulation of the axillary or subclavian veins are two common procedures performed in the infraclavicular fossa that require knowledge of the average depth of the nerves and vessels, as they involve accessing these structures through the skin.^{1,2,14} The position of the axillary vein was unable to be determined in this case due to damage from a previous dissection, thus its relationship to pectoralis minor is unknown.

Brachial plexus blocks are a commonly performed alternative to general anaesthesia for surgical procedures involving the upper limb.¹⁴ They are also commonly used in combination with general anaesthesia to provide intraoperative and postoperative analgesia. The various infraclavicular approaches to brachial plexus blocks are utilised for surgery on the elbow, forearm and hand and may be used as an alternative to supraclavicular blocks, which have a higher risk of complication, in particular accidental pneumothorax.¹ In one of the approaches, the axillary artery is visualised by means of a high-frequency linear ultrasound probe placed in the parasagittal plane inferior to the clavicle and medial to the coracoid process. Once the artery has been identified, the needle is inserted and anaesthetic solution injected around the axillary artery in order to anaesthetise the cords of the brachial plexus, which can be difficult to visualise individually.¹ In this approach, the axillary artery and cords of the brachial plexus are located deep to the pectoralis major and minor muscles (Figure 3).

The varying position of the axillary artery and cords between the pectoralis major and minor muscles may affect the infraclavicular approach to brachial plexus block if the axillary artery cannot be identified. As long as ultrasound is used and the axillary artery can be successfully identified, the superficial position of the brachial plexus and axillary artery should pose no higher risk of damage than may be usually expected when performing this block. The risk of complication is increased for clinicians in healthcare facilities who may not have access to ultrasound and therefore use surface landmarks for guiding their blocks.¹⁴ These clinicians may not be aware of the possibility of these structures being located closer to the skin and therefore have

a higher risk of puncturing a vessel or damaging a nerve of the plexus. Central venous cannulation of the axillary or subclavian vein in the infraclavicular fossa should also be guided by ultrasound. Failure to do so could result in a higher complication rate due to possible variation in structures located in the infraclavicular region.

Conclusion

The superficial position of the cords of the brachial plexus and axillary artery relative to pectoralis minor is a rare variation that could result in increased complications during procedures such as infraclavicular brachial plexus blocks and central venous cannulation of the axillary and subclavian veins. Ideally, ultrasound should always be used for any procedure in the infraclavicular region, in order to reduce the risk of accidental nerve or vessel damage as a result of variation in the position of structures in this region.

Acknowledgements – The authors would like to thank the body donors and their families. Thanks are also offered to Gregory Keet for drawing the schematics, and to Ettienne Coetzee, Specialist Anaesthetist, Department of Anaesthesia and Perioperative Medicine, University of Cape Town for providing the ultrasound image.

Disclosure statement – No potential conflict of interest was reported by the authors.

Funding – Funding for the study was provided by the National Research Foundation and the University of Cape Town.

Ethics approval – Ethical approval for the use of human cadavers in research at our institution is approved under a blanket statement, thus no formal consent was required.

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Received: 13-11-2017 Accepted: 10-06-2018