Title

Variations of accessory thoracic muscles identified in the ethnically diverse whole-body donation population in Northern California

Authors

Anderson, Hana
Weil, Jennifer A
Tucker, Richard P

Publication Date

2022-12-27

DOI

10.5603/fm.a2022.0109

Peer reviewed

ONLINE FIRST

ISSN: 0015-5659

e-ISSN: 1644-3284

Variations of accessory thoracic muscles identified in the ethnically diverse whole-body donation population in Northern California

Authors: Hana Anderson, Jennifer A. Weil, Richard P. Tucker

DOI: 10.5603/FM.a2022.0109

Article type: Case report

Submitted: 2022-07-21

Accepted: 2022-10-07

Published online: 2022-12-23

Variations of accessory thoracic muscles identified in the ethnically diverse whole-body donation population in Northern California

Hana Anderson, Jennifer A. Weil, Richard P. Tucker

Department of Cell Biology and Human Anatomy, University of California, Davis, School of Medicine, Davis, California, United States

Address for correspondence: Hana Anderson, University of California, Davis, Department of Cell Biology and Human Anatomy, 1 Shields Avenue, Davis, CA 95616 United States, tel: 530 752 0389, e-mail: hnanderson@ucdavis.edu

ABSTRACT

Accessory thoracic muscles in humans are relatively common and it is important to draw awareness to their variable presentations and potential clinical implications owing to their close association with the axilla. Here we report four cases of accessory thoracic muscle variations identified in the ethnically diverse whole-body donation population in Northern California (4 out of 48 donors, 8.3%). Of these, combined presentations of thoracic accessory muscles were observed in two of the donors, one involving bilateral axillary arches and a pectoralis quartus on the left and the other a unilateral axillary arch on the left and bilateral pairs of pectoral fascicles. In the former, the proximal ends of the left axillary arch and pectoralis quartus joined to form a common aponeurosis which inserted onto the deep tendon of the pectoralis major; in the latter, the pectoral fascicles originated from the surface of the ribs and inserted into the deep surface of the pectoralis major muscle. In the other two donors, unilateral axillary arches were observed. Our observations illustrate that accessory thoracic muscles, in isolated as well as combined forms, are commonplace in the general population. We also describe the proposed embryonic origins of these accessory

muscles, which may reflect their frequent occurrence, and potential clinical implications of these muscles, as discussed in literature.

Key words: accessory thoracic muscle, axillary arch, pectoralis quartus, latissimus dorsi, pectoralis major, cadaver, gross anatomy laboratory

INTRODUCTION

Muscles demarcating the axilla are used as critical landmarks of the region. An understanding of accessory muscles located in this region allows more accurate decision making during surgical procedures involving lymph nodes in the breast [10, 17, 21]. One of the well-known accessory thoracic muscles of this class is the axillary arch. The axillary arch, also referred to as Langer's axillary arch [24] or Achselbogen muscle [3], is a musculotendinous slip that crosses the axilla anteriorly [9]. Typically, the axillary arch originates from the anterior boarder of the latissimus dorsi near the base of the axilla and inserts onto the deep tendon of the pectoralis major. In some cases it inserts onto the coracoid process of the scapula, or onto musculotendinous structures near the proximal humerus [9]. The axillary arch is one of the more common variations of accessory thoracic muscles. In a recent meta-analysis report, the prevalence of the axillary arch has been reported as 5.3% [23], though it varies among populations [4, 14]. Another frequently reported accessory thoracic muscle associated with the axilla is the pectoralis quartus. The pectoralis quartus is defined as a muscular slip typically originating in the thorax lateral to, or at the lateral border of, the pectoralis major, and inserting onto the deep pectoralis major tendon, or onto the aforementioned insertion sites of the axillary arch [3, 4, 8].

Because of their common occurrence and implied clinical relevance, accessory thoracic muscles associated with the axilla warrant close attention. Although the axillary arch itself is common, occurrence of bilateral axillary arches as well as additional thoracic accessory muscle variations accompanying the axillary arch are less common [4, 23]. In the current study we report 4 cases of axillary arch variations identified among 48 donors (4/48 = 8.3%) of an ethnically diverse whole-body donation population. In one case, bilateral axillary arches were accompanied with a left pectoralis quartus, and in another a left

axillary arch was accompanied with bilateral pairs of pectoral fascicles, originating from the surface of the ribs and inserting onto the deep surface of the pectoralis major. We summarize these cases and briefly discuss their proposed origins based on the theories described in literature.

CASE REPORT

All 4 cases of axillary arch variations described below were identified in the gross anatomy laboratory for first-year medical students at the University of California, Davis, School of Medicine over a 2-year period (2020 and 2021).

Case 1

Bilateral axillary arches and a left pectoralis quartus were identified in an 80-year-old male donor diagnosed with cerebral atherosclerosis and vascular dementia. The left pectoralis quartus was first noted during the dissection of the thoracic region as a slender muscle slip embedded within the sub-cutaneous fat. This muscle slip attached distally to the superior border of the 6th rib superficial to the external oblique, and then ran along the inferolateral boarder of the pectoralis major, which covered the proximal half of the pectoralis quartus slip (Fig. 1A). In its entirety, the pectoralis quartus travelled laterally to the pectoralis minor and inserted onto the deep fascia of the pectoralis major and measured 12 cm long and 1.2 cm wide near its distal attachment. Based on the relative location to the pectoralis major and its distal and proximal attachments, we classified this accessory thoracic muscle as a pectoralis quartus [22]. Its insertion site at the pectoralis major was encased in a thick fascia to which the proximal end of another muscle slip, a left axillary arch, joined (Fig. 1B). Further dissection of this fascia revealed that the pectoralis quartus and axillary arch were linked via an aponeurosis (Fig. 1C). The source of innervation to the pectoralis quartus was found to be the medial pectoral nerve, which branched where it penetrated the pectoralis minor and extended to the pectoralis quartus (Fig. 1C). We did not find clear innervation to the axillary arch as seen for the pectoralis quartus.

The origin of the left axillary arch was found at the anteroinferior margin of the tendinous part of the latissimus dorsi. The striation of the axillary arch was perpendicular to

that of the latissimus dorsi, with a defining tendinous ridge located between the two (Fig. 1D). The left axillary arch measured 8 cm long and 0.6 cm wide at its midpoint. In addition, this donor had a right axillary arch. Like the left axillary arch, the right axillary arch originated from the anteroinferior margin of the tendinous part of the latissimus dorsi and inserted onto the fascia deep to the pectoralis major (Fig. 1E). Its dimension was 7 cm long and 0.6 cm wide at its midpoint. Both axillary arches traversed across the axilla anterior to the brachial plexus (Figs 1B & E).

Case 2

A left axillary arch and bilateral pairs of thoracic fascicles deep to the pectoralis major were identified in an 83-year-old male donor diagnosed with vascular dementia. The axillary arch was 8 cm long and 0.5 cm wide at its midpoint. Like the axillary arches described in Case 1, this axillary arch originated from the anterior margin of the tendinous part of the latissimus dorsi, and it inserted onto the deep fascia of the pectoralis major (Fig. 2A). In addition to the axillary arch pairs of pectoral fascicles were observed, on both the left and right sides, anterior to the pectoralis minor (Fig. 2B). These fascicles originated from the anterior surface of the ribs and eventually merged into the deep fascia of the pectoralis major. The fascicle pair on the right originated at the level of the 4th rib and ran closely parallel to each other, between which the medial pectoral nerve traversed from the pectoralis minor to the pectoralis major (Fig. 2C). Both fascicles measured 11.5 cm in length. The superior fascicle was 0.8 cm wide and the inferior fascicle was 0.6 cm wide. The fascicles on the left were more distant from each other, with the superior fascicle originating at the level of the 1st rib and the inferior fascicle at the level of the 3rd rib (Fig. 2D). The superior fascicle measured 6.5 cm in length and 1.0 cm in width, and the inferior fascicle was 11 cm in length and 0.7 cm in width.

Case 3

A right axillary arch was identified in an 82-year-old female donor diagnosed with Alzheimer’s disease (Fig. 3A). The arch originated from the anteroinferior margin of the tendinous part of the latissimus dorsi. Unlike the left axillary arch in Case 1, the muscle

fibers of this axillary arch ran in parallel and were continuous with those of the latissimus dorsi. The arch traversed across the axilla anterior to the brachial plexus and inserted onto the deep fascia of the pectoralis major.

Case 4

A right axillary arch crossing anterior to the intercostobrachial nerve in addition to the proximal terminal branches of the brachial plexus was identified in a 71-year-old male donor diagnosed with gastroesophageal adenocarcinoma (Fig. 3B). The axillary arch arose from the anteroinferior border of the latissimus dorsi tendon, perpendicular to its striation, and inserted onto the deep fascia of the pectoralis major near its lateral border.

DISCUSSION

Accessory thoracic muscles in humans have been reported in the literature for over 200 years [20]. The embryonic origins of the axillary arch and pectoralis quartus have been discussed by multiple authors based on their source of innervation as well as their phylogenetic relationships with thoracic muscles found in non-human mammalian species [3, 8, 11,14, 26, 28]. One of the frequently cited views is that these accessory thoracic muscles are remnants of the panniculus carnosus [2, 8, 11, 16], the cutaneous skeletal muscle sheets found in mammals such as cats, dogs, rodents, horses and to a certain extent in some primate species [11, 12]. Rostrally, the panniculus carnosus attaches to the humerus via the fascia deep to the pectoralis muscles, and caudally inserts beneath the dermis of the back and flank regions [11, 12, 25]. The observations that accessory thoracic muscles such as the sternalis, pectoralis quartus, and axillary arch, are often found physically connected to each other [1, 4, 7, 8] may reflect the close phylogenetic relationship proposed between the panniculus carnosus and pectoral muscles [8, 11, 16].

An alternative origin of the pectoralis quartus has been also proposed in literature. Based on comparative anatomical studies that show concurrent presence of the pectoralis quartus and the panniculus carnosus in several mammalian species, the view that the pectoralis quartus is a segmented portion of the lower part of the pectoralis major, not a vestigial rudiment of the panniculus carnosus, has been described [3]. In this view, the

pectoralis quartus is considered as a variation of the pectoralis major, to a certain extent similar to the pectoral fascicles found deep to the pectoralis major, which were identified in Case 2 of the current report. Deep accessory pectoral fascicles have been reported in primates such as chimpanzees and bonobos as a common occurrence [18]. In the same report, the authors also identified similar accessory pectoral fascicles in two human cadavers [18]. Independently, an accessory head of the pectoralis major muscle has been reported [13]. The bilateral paired accessory pectoral fascicles reported in Case 2 of the current report appears to be a rarer presentation of these muscles since the reports cited above described only unilateral accessory pectoral fascicles.

The source of the relatively common occurrence of accessory muscles of the pectoralis major and the latissimus dorsi may lie in the complex migration pattern taken by their myogenic precursor cells. Recent investigation on embryonic origins of the pectoral and latissimus dorsi muscles revealed that these superficial shoulder girdle muscles arise through the two-step process, referred to as the “in-out” mechanism, in which the myogenic precursors first migrate into the forelimb bud from the thoracic somites and then return to the trunk region to complete the muscle development [19, 27]. This complex developmental process may possibly lead to varied migration paths among the precursors, giving rise to accessory pectoral muscles associated with the pectoral and latissimus dorsi muscles.

Because the accessory thoracic muscles discussed above are common in the general population and closely associated with clinically important structures such as the neurovascular bundles and lymph nodes in the axillary region, awareness of their implications to medical procedures such as surgery and potential chronic conditions is warranted [6, 23]. For instance, potential interference of the axillary arch and the pectoralis quartus with sentinel lymph node biopsy and axillary lymphadenectomy have been discussed [10, 17, 21]. Also, compression on the neurovasculature in the axilla by the axillary arch may be involved in conditions such as a thoracic outlet syndrome [5] and can cause deep vein thrombosis [15]. The accessory pectoral muscles closely associated with axilla, therefore, have significant implications for regularly performed surgical procedures in the axillary region and chronic conditions affecting the axillary neurovasculature.

CONCLUSIONS

In this report, we examined 48 donors and found 4 cases of axillary arch (8.3%) in an ethnically diverse donor population. Additional thoracic accessory muscles were identified, a pectoralis quartus associated with bilateral axillary arches and bilateral paired pectoral fascicles associated with a unilateral axillary arch. Since these thoracic accessory muscles are in close proximity to the axillary lymph nodes and neurovasculature, the relatively common occurrence of these variations merits awareness.

Acknowledgements

The authors are grateful to the staff of the UC Davis Body Donation Program for their support and wish to express gratitude to the individuals who donated the bodies for the advancement of medical education and research.

Conflict of interest

The authors declare that they have no conflict of interest to report.

REFERENCES

1. Bergman RA. Doubled pectoralis quartus, axillary arch, chondroepitrochlearis, and the twist of the tendon of pectoralis major. Anat Anz. 1991;173(1):23–26.
2. Besana-Ciani I, Greenall MJ. Langer's axillary arch: Anatomy, embryological features and surgical implications. The Surgeon. 2005;3(5):325–327, doi: 10.1016/s1479-666x(05)80111-8.
3. Birmingham A. Homology and Innervation of the Achselbogen and Pectoralis Quartus, and the Nature of the Lateral Cutaneous Nerve of the Thorax. J Anat Physiol. 1889;23(Pt 2):206–223. Indexed in Pubmed PMID: 17231782
4. Bonastre V, Rodríguez-Niedenführ M, Choi D, et al. Coexistence of a pectoralis quartus muscle and an unusual axillary arch: Case report and review. Clin Anat. 2002;15(5):366–370, doi: 10.1002/ca.10053.
5. Clarys JP, Barbaix E, Van Rompaey H, et al. The muscular arch of the axilla revisited: its possible role in the thoracic outlet and shoulder instability syndromes. Man Ther. 1996;1(3):133–139, doi: 10.1054/math.1996.0261.

6. Douvetzemis S, Natsis K, Piagkou M, et al. Accessory muscles of the anterior thoracic wall and axilla. Cadaveric, surgical and radiological incidence and clinical significance during breast and axillary surgery. Folia Morphol. 2019;78(3):606–616, doi: 10.5603/FM.a2019.0005.
7. Humphry GM. Lectures on Human Myology. BMJ. 1872;2(601):4–5, doi: 10.1136/bmj.2.601.4.
8. Huntington GS. The Derivation and Significance of certain Supernumerary Muscles of the Pectoral Region. J Anat Physiol. 1904;39(Pt 1):1-54.27. Indexed in PubMed PMID: 17232622
9. Jelev L, Georgiev GP, Surchev L. Axillary arch in human: Common morphology and variety. Definition of "clinical" axillary arch and its classification. Ann Anat - Anat Anz. 2007;189(5):473–481, doi: 10.1016/j.aanat.2006.11.011.
10. Karanlik H, Fathalizadeh A, Ilhan B, et al. Axillary Arch May Affect Axillary Lymphadenectomy. Breast Care. 2013;8(6):424–427, doi: 10.1159/000357307.
11. Lanngworthy OR. The Panniculus carnosus in Cat and Dog and Its genetical Relation to the Pectoral Musculature. J Mammal. 1924;5(1):49-63. Available at https://www.jstor.org/stable/pdf/1373485.pdf
12. Langworthy OR. A morphological study of the panniculus carnosus and its genetical relationship to the pectoral musculature in rodents. Am J Anat. 1925;35(2):283–302, doi.org/10.1002/aja.1000350207
13. Loukas M, South G, Louis RG Jr, et al. A case of an anomalous pectoralis major muscle. Folia Morphol. 2006;65(1):100–103. https://journals.viamedica.pl/folia_morphologica/article/viewFile/16125/12763
14. Lhuaire M, Wehbe K, Garrido I, et al. Anatomy of the axillary arch: from its incidence in human to an embryologic and a phylogenetic explanation of its origins. Surg Radiol Anat. 2020;43(5):619-630, doi: 10.1007/s00276-020-02605-5.
15. Magee C, Jones C, McIntosh S, et al. Upper limb deep vein thrombosis due to Langer's axillary arch. J Vasc Surg. 2012;55(1):234–236, doi: 10.1016/j.jvs.2011.07.002.
16. Naldaiz-Gastesi N, Bahri OA, de Munain AL, et al. The panniculus carnosus muscle: an evolutionary enigma at the intersection of distinct research fields. J Anat. 2018;233(3):275–288, doi: 10.1111/joa.12840.
17. Natsis K, Vlasis K, Totlis T, et al. Abnormal muscles that may affect axillary lymphadenectomy: surgical anatomy. Breast Cancer Res Treat. 2010;120(1):77–82, doi: 10.1007/s10549-009-0374-5.
18. Potau JM, Arias-Martorell J, Bello-Hellegouarch G, et al. Inter- and Intraspecific Variations in the Pectoral Muscles of Common Chimpanzees *(Pan troglodytes)*, Bonobos *(Pan paniscus)*, and Humans *(Homo sapiens)*. BioMed Res Int. 2018;2018:1–12, doi: 10.1155/2018/9404508.
19. Pu Q, Huang R, Brand-Saberi B. Development of the shoulder girdle musculature. Dev Dyn. 2016;245(3):342–350, doi: 10.1002/dvdy.24378.
20. Ramsay A. Account of Unusual Conformations of Some Muscles and Vessels. Edinb Med Surg J. 1812;8(31):281–283. Indexed in PubMed PMID: 30329503

21. Scrimgeour GE, John ERS, Leff DR. Langer's arch: A rare but important consideration for axillary surgery with implications for training. Breast J. 2020;26(11):2226-2228,doi: 10.1111/tbj.14082.
22. Snosek M, Loukas M. Thoracic Wall Muscles. In: Bergman's Comprehensive Encyclopedia of Human Anatomic Variation. John Wiley & Sons, Ltd; 2016: 335–368,DOI:10.1002/9781118430309
23. Taterra D, Henry BM, Zarzecki MP, et al. Prevalence and anatomy of the axillary arch and its implications in surgical practice: A meta-analysis. The Surgeon. 2019;17(1):43–51, doi: 10.1016/j.surge.2018.04.003.
24. Testut, Léo. Les anomalies musculaires chez l'homme expliquées par l'anatomie comparée, leur importance en anthropologie par L. Testut: Précédé d'une préface par M. le professeur Mathias Duval. G. Masson, 1884: 107-116. https://www.biodiversitylibrary.org/item/68468#page/21/mode/1up
25. Theriault E, Diamond J. Nociceptive cutaneous stimuli evoke localized contractions in a skeletal muscle. J Neurophysiol. 1988;60(2):446–462, doi: 10.1152/jn.1988.60.2.446.
26. Turner Wm. On the Musculus Sternalis. J Anat Physiol. 1867;1(2):246-378.25. Indexed in PubMed PMID: 17230716
27. Valasek P, Theis S, DeLaurier A, et al. Cellular and molecular investigations into the development of the pectoral girdle. Dev Biol. 2011;357(1):108–116,doi: 10.1016/j.ydbio.2011.06.031.
28. Wilson JT. The Innervation of the Achselbogen Muscle. J Anat Physiol. 1912;47(Pt 1):8–17. Indexed in PubMed PMID: 17232944

Figure 1. Case 1: 80-year-old male donor presenting bilateral axillary arches and a left pectoral quartus muscle. (**A**) The left pectoralis quartus at the inferolateral boarder of the left pectoralis major. (**B**) A thick fascia encasing the insertion sites of the pectoralis quartus and the axillary arch that insert onto the deep fascia of the pectoralis major. (**C**) A closer look of box C demarcated in (B). An aponeurosis (*) linking the pectoralis quartus and the left axillary arch. A branch of the medial pectoral nerve innervates the pectoralis quartus. (**D**) A closer look of box D demarcated in (B). A tendinous ridge (*) is formed where the striation of the axillary arch perpendicularly meets that of the latissimus dorsi. (E) The right axillary arch; BB: biceps brachii; BP: brachial plexus; LAA: left axillary arch; LD: latissimus dorsi; MPN: medial pectoral nerve; Pma: Pectoralis major; Pmi: Pectoralis minor; PQ: pectoralis quartus; RAA: right axillary arch; TDN: thoracodorsal nerve

Figure 2. Case 2: 83-year-old male donor presenting a left axillary arch and bilateral pairs of thoracic fascicles deep to the pectoralis major. (**A**) The left axillary arch. (**B**) Bilateral thoracic fascicles. (**C**) A closer look of the right pectoral fascicles. The medial pectoral nerve travels between the fascicles to traverse from the pectoralis minor to the pectoralis major. (**D**) A closer look of the left pectoral fascicles; White arrowheads indicate pectoral fascicles. BP: brachial plexus; LD: latissimus dorsi; LAA: left axillary arch; MPN: medial pectoral nerve; PMa: pectoralis major; PMi: pectoralis minor

Figure 3. Case 3 and Case 4: 82-year-old female and 71-year-old male donor presenting a right axillary arch. (**A**) The right axillary arch traversing the axilla. (**B**) The right axillary arch traversing anterior to the intercostobrachial nerve; AArt: axillary artery; BB: Biceps brachii; BP: brachial plexus; CB: coracobrachialis; ICBN: intercostobrachial nerve; LD: latissimus dorsi; MN: median nerve; Pma: pectoralis major; RAA: right axillary arch

Fig. 1 A Anderson, Weil, Tucker

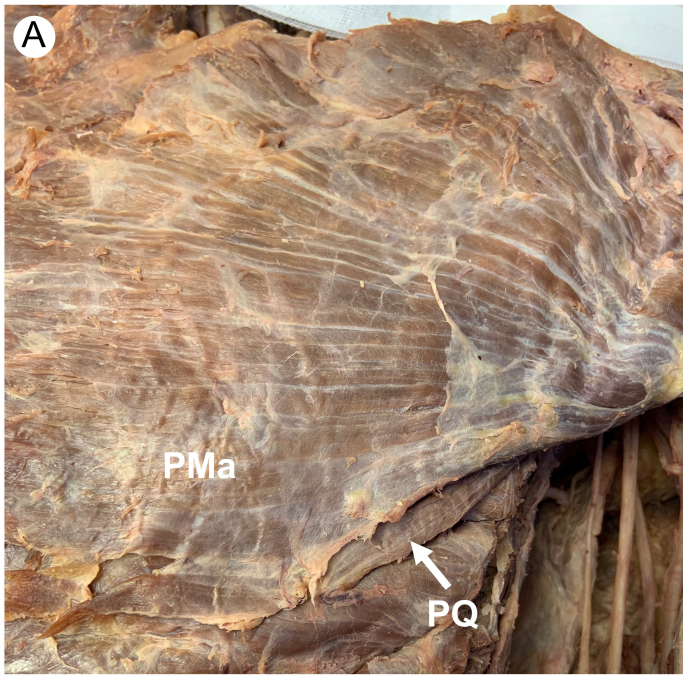

Fig. 1 B Anderson, Weil, Tucker

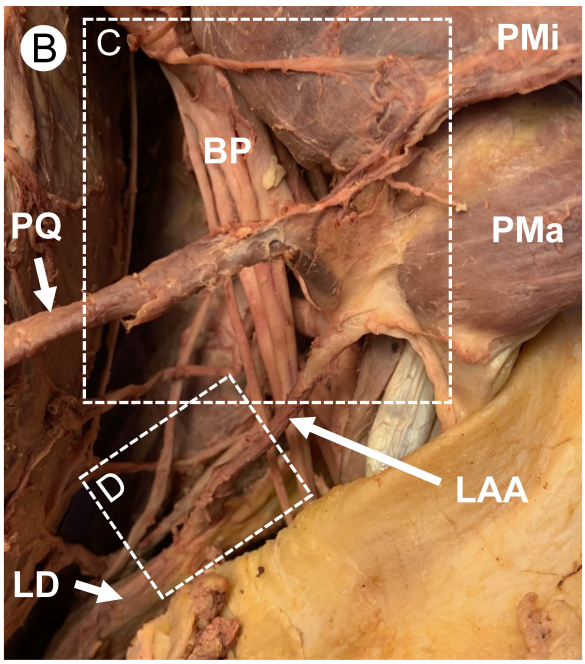

Fig. 1 C Anderson, Weil, Tucker

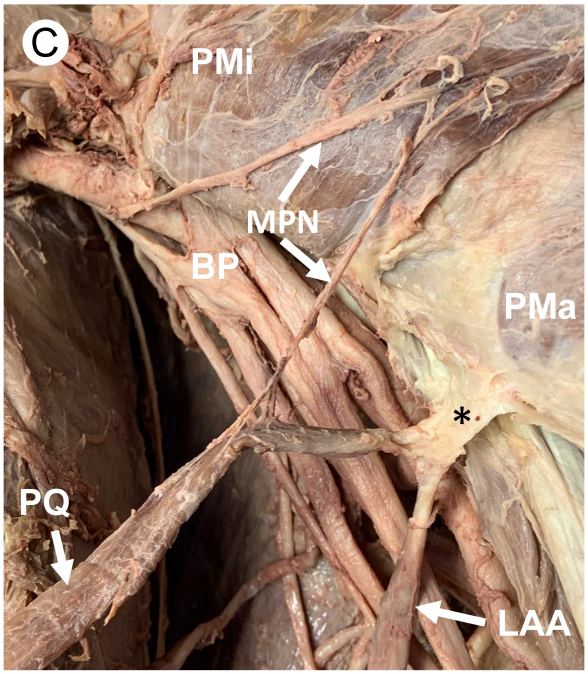

Fig. 1 D & E Anderson, Weil, Tucker

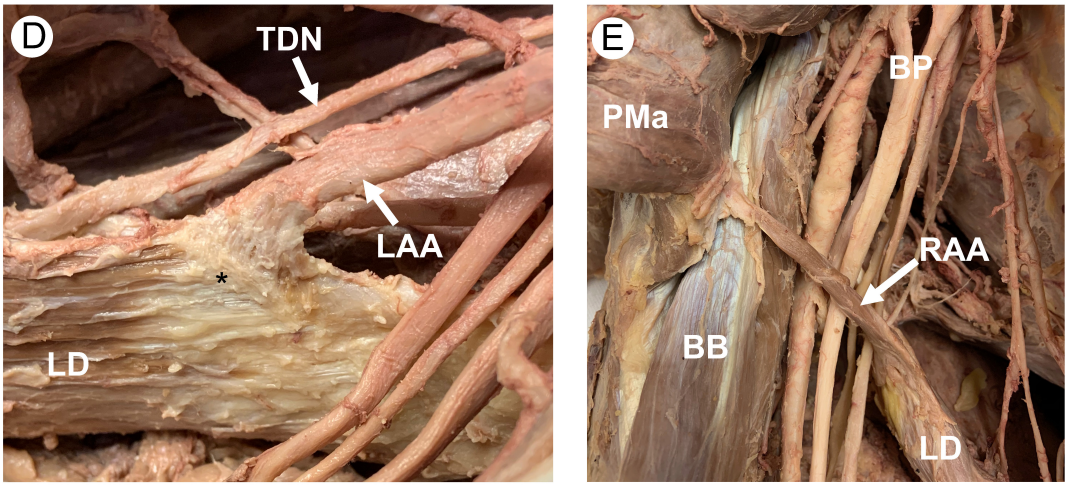

Fig. 2 A & B Anderson, Weil, Tucker

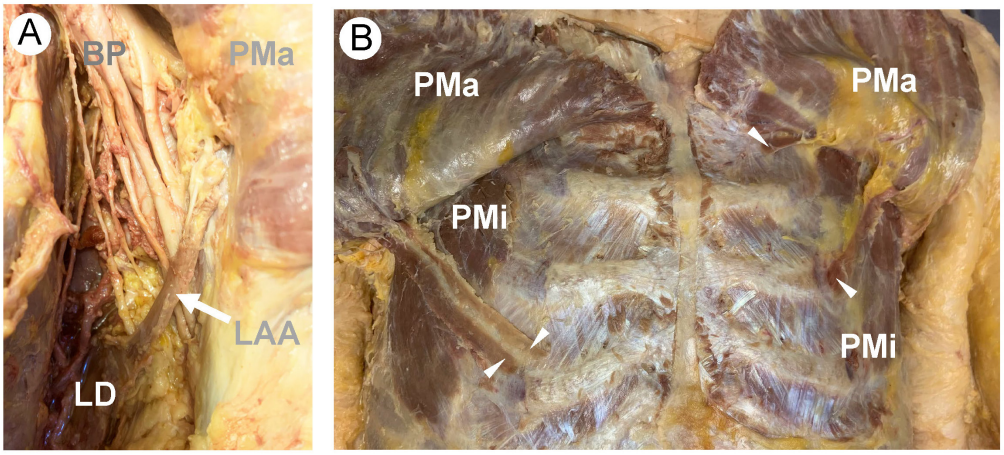

Fig. 2 C & D Anderson, Weil, Tucker

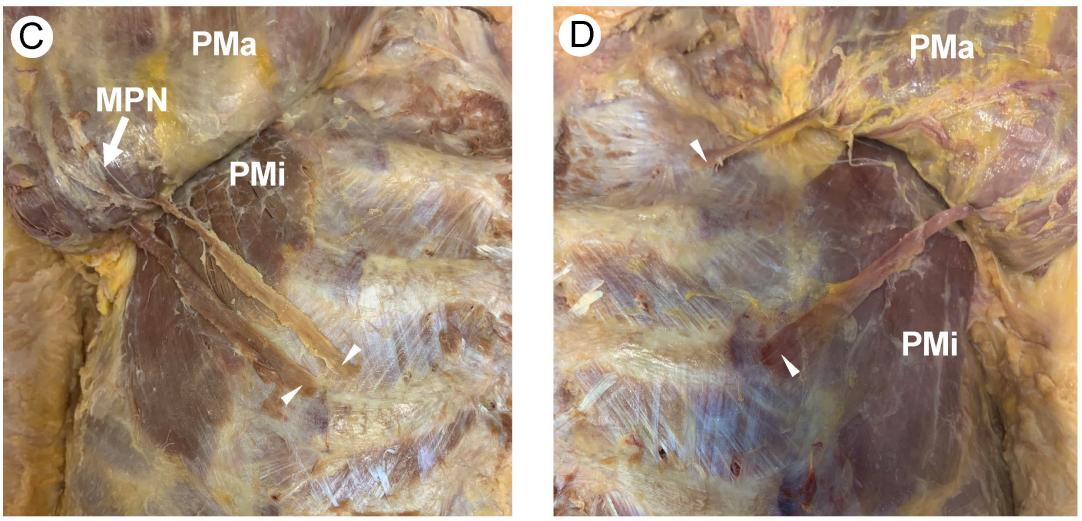

Fig. 3 A & B Anderson, Weil, Tucker