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Abnormal muscles that may affect axillary lymphadenectomy: surgical anatomy

K. Natsis · K. Vlasis · T. Totlis · G. Paraskevas ·
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Abstract *Purpose* The present study aimed at summarizing and presenting the anomalous muscles that a surgeon might encounter during axillary lymphadenectomy (AL). *Methods* For this purpose, both the anatomical and surgical literature was reviewed and an anatomical study on 107 cadavers was carried out. Furthermore, based on the anatomical features of the anomalous muscles that came up during our study and taking into consideration the landmarks of the AL, we further analyzed the complications that may arise from each of these muscles, along with their preoperative and intraoperative recognition and management. *Results* The literature review revealed that there are three supernumerary muscles that may affect the AL, namely the Langer's axillary arch, the pectoralis quartus and the chondroepitrochlearis muscles, as well as the aplasia of the lower part of the pectoralis major muscle. Eight out of the 107 (7.48%) cadavers that we dissected had such an abnormal muscle in the axilla. Specifically, the axillary arch was found unilaterally in five cadavers (4.67%) and the pectoralis quartus muscle was present

unilaterally in three cadavers (2.8%). One cadaver had both an axillary arch and a pectoralis quartus muscle in the right side. The abdominal and almost the whole sternocostal portion of the pectoralis major as well the pectoralis minor muscle were absent in one cadaver (0.93%). The chondroepitrochlearis muscle was not found in any of the cadavers that we dissected. *Conclusions* The present study offers the necessary preoperative knowledge for recognizing these muscles during AL, avoiding thus the complications that may arise from them.

Keywords Surgical oncology · Breast cancer · Axilla · Anatomy · Variations · Complications

Introduction

Axillary lymphadenectomy (AL) constitutes a common surgical procedure for the breast surgeon. The normal anatomy of the axilla is well-known to all surgeons, but its anatomical variations are not that well understood, though they are neither seldom nor few.

During the surgical approach of the axilla, the boundaries of the surgical field form a triangle with the serratus anterior muscle at its base and the medial surface of the humerus, where the pectoralis major and the latissimus dorsi muscles meet, at its apex. Normally, the axilla contains the neurovascular bundle and its branches, the lateral branches of some intercostal nerves, loose adipose areolar tissue, many lymph nodes and vessels, and occasionally the 'axillary tail' of the breast [1]. These anatomical structures are expected to appear during AL.

There are several anatomical studies [2–11] and few surgical studies [12–16] describing anatomical variations of the latissimus dorsi, the anterior serratus and the

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pectoralis major muscles. Clinically, not all of these muscular anomalies are important for the AL. However, from a topographical point of view, *only the anomalous muscles that pass through the axilla or change the boundaries of the surgical field may affect AL*. In the literature, there has been no study distinguishing these anomalous muscles from numerous muscular abnormalities of this region. Moreover, the implications for the AL have been analyzed only in terms of the most common of these muscular anomalies, which is the axillary arch [13, 16].

The purpose of our study was to summarize and present the anomalous muscles that a surgeon might encounter during AL. Furthermore, for each of these muscles we attempted to determine its implications for the AL, provide precise information for its intraoperative recognition and propose its proper management.

Materials and methods

For this purpose, the literature was reviewed in order to distinguish the anomalous muscles that pass through the axilla or change the boundaries of the AL surgical field. Following this, the frequency and the main anatomical features of these anomalous muscles were recorded.

An anatomical study was carried out in order to obtain a more accurate perception of these anomalous muscles' topography and morphology, as well as their relations to the adjacent structures. Specifically, the axillary cavities of 107 embalmed cadavers, of which 48 male and 59 female Caucasian adults, were dissected both for researching and tutorial purposes. The cadavers showed no evidence of previous trauma, skeletal disorder and breast or axilla surgery and there was no mention of metastatic cancer or irradiation to the axilla in the medical record of any subject. In total 214 axillary cavities were dissected and examined for the presence of any anomalous muscles that either pass through the axilla or change the boundaries of the AL surgical field. In the cadavers where such an anomalous muscle was found, the anatomical features were recorded, emphasizing on the muscles relations to the landmarks of the AL, such as the axillary vein and the muscles that form the surgical field.

Results

Literature review

There are three supernumerary muscles, namely the axillary arch, the pectoralis quartus and the chondroepitrochlearis muscles, as well as the aplasia of the lower part of the pectoralis major muscle, which pass through the axilla or change the boundaries of the surgical field during AL (Fig. 1).

The axillary arch or Langer's axillary arch or axillo-pectoral muscle is a supernumerary muscle which can be found crossing the axilla in the relatively high frequency of 7–8% of the population [15, 17, 18]. The typical axillary arch extends from the anterior border of the latissimus dorsi muscle to the posterior layer of the pectoralis major tendon passing through the axillary cavity and over the neurovascular bundle of axilla. However, this anomalous muscle shows great variability and there have been described many unusual axillary arches inserted into anywhere along a line extending from the pectoralis major insertion to the coracoid process. Additionally, the axillary arch may rarely originate from the serratus anterior muscle. Multiple axillary arches, as well as, a single axillary arch with multiple insertions have also been reported. The axillary arch can either be muscular or fibromuscular, its shape has been described as triangular or most often as fusiform and its belly may range between a small muscular slip and a strong muscular mass [4, 9, 10, 19, 20].

The pectoralis quartus muscle, according to Bonastre et al. [4], although it has been reported to have a high frequency of 11–16%, it is thought to be rarer than the axillary arch. It is a supernumerary muscular slip which arises from the costochondral junction of the fifth and sixth ribs or from the anatomical structures around them, namely the lateral margin of the pectoralis major or the rectus sheath. The pectoralis quartus appears as a long and flat muscular band that extends along the lateral margin of the pectoralis major. It is located slightly deep to this margin and it may be distinctively separate or loosely connected to it. The pectoralis quartus passes over the neurovascular bundle to be inserted in or near the deep layer of the pectoralis major tendon. A double insertion of the pectoralis quartus has also been reported. It may even insert into the axillary arch, when this muscle is present [3, 4].

Regarding the chondroepitrochlearis muscle there are only few cases reported in the literature, while Flaherty et al. [21] encountered this abnormal muscle in one out of 200 cadavers (0.5%). The chondroepitrochlearis muscle is a quite long muscular band which may arise from the costal cartilages or the aponeurosis of the external oblique muscle just inferior to the pectoralis major muscle. An origin from the lateral margin of the pectoralis major muscle has also been reported. However, this anomalous muscle follows a course deviating from this margin and crosses the axilla to be inserted in the medial surface of the humerus, distal to the pectoralis major tendon and usually in the medial epicondyle of the humerus [3, 22, 23].

Pectoral muscles deformities have been reported to be present in about 1:5,000–1:11,000 [24]. There are reports of absence of the pectoralis major muscle abdominal portion on its own [1], or combined with absence of the lower part of its sternocostal portion [25]. In the case reported by Clark [25]

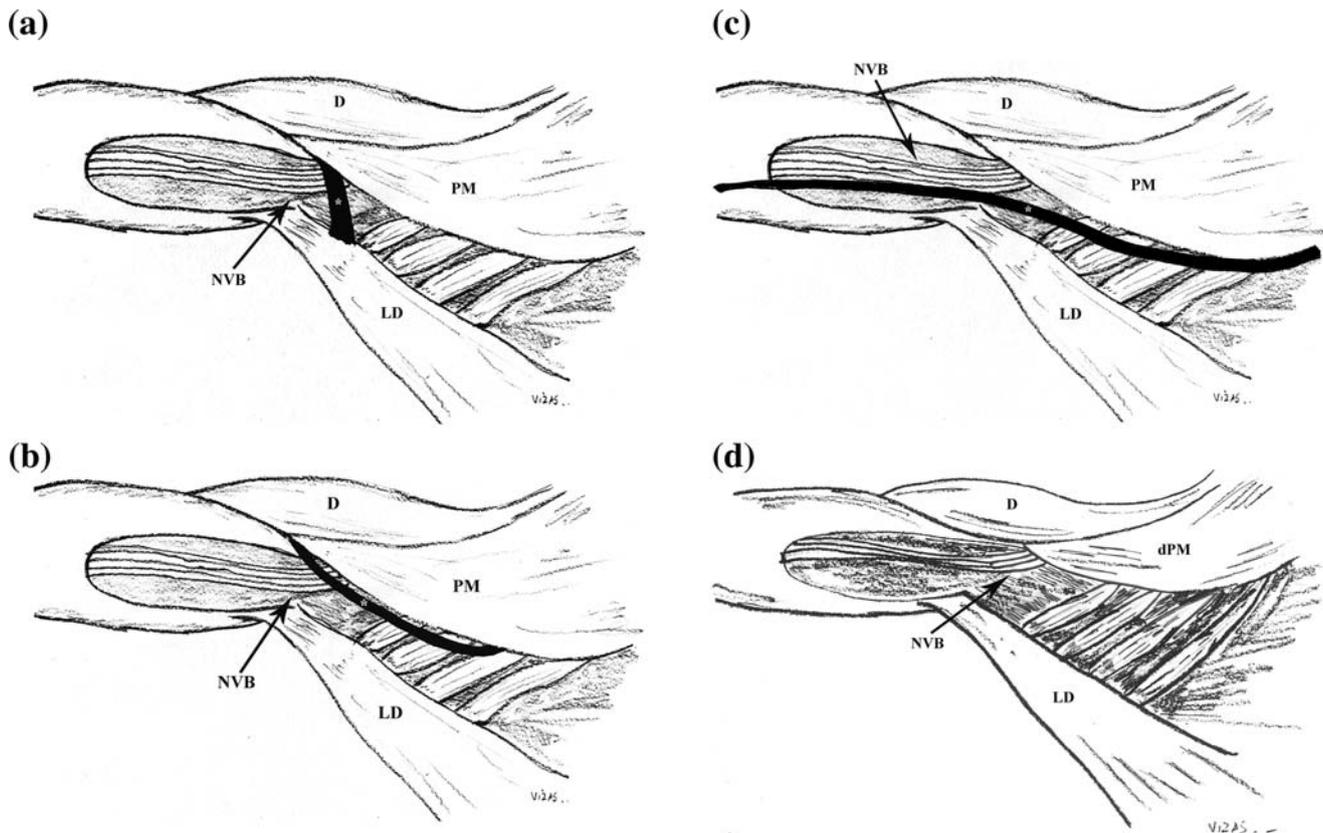


Fig. 1 Illustrations of the abnormal muscles that may affect the axillary lymphadenectomy: **a** the axillary arch (*highlighted area-asterisk*); **b** the pectoralis quartus muscle (*highlighted area-asterisk*); **c** the chondroepitrochlearis muscle (*highlighted area-asterisk*); **d** the

aplasia of the lower part of the pectoralis major muscle (*D* deltoid muscle, *PM* pectoralis major muscle, *LD* latissimus dorsi muscle, *NVB* neurovascular bundle, *dPM* deficient pectoralis major muscle)

the pectoralis minor muscle was also absent, whereas total aplasia of the pectoralis major has also been reported [24].

Anatomical study

Eight out of the 107 (7.48%) cadavers had abnormal muscles in the axilla. The male to female ratio was 5:3 and there were no subjects with bilateral anomalies. Specifically, the axillary arch was found unilaterally in five cadavers (4.67%) and the pectoralis quartus muscle was present unilaterally in three cadavers (2.8%). One cadaver had both an axillary arch and a pectoralis quartus muscle in the right side. The abdominal and almost the whole sternocostal portion of the pectoralis major as well the pectoralis minor muscle were absent in one cadaver (0.93%). The chondroepitrochlearis muscle was not found in any of the cadavers that we dissected.

A typical axillary arch (Fig. 2a) was present in three cadavers, one right-sided and two left-sided and their diameters at their midpoints (*d*) were 7, 10, and 19 mm, respectively. In the right axilla of one cadaver, there were two atypical axillary arches (Fig. 2b). The lateral axillary

arch (*d*: 10 mm) originated from the anterior border of the latissimus dorsi muscle, while the medial axillary arch (*d*: 7 mm) originated from the serratus anterior muscle, situated deep and medial to the lateral axillary arch. Both arches crossed the axilla and inserted into the coracoid process, after passing in front of the axillary vessels and nerves. In the left side of one cadaver, there was an atypical axillary arch and an atypical pectoralis quartus muscle (Fig. 2c). The axillary arch (*d*: 14 mm) originated from the anterior border of the latissimus dorsi muscle, it passed through the axilla and in front of the neurovascular bundle of axilla and was inserted into the coracoid process. The pectoralis quartus muscle (*d*: 7 mm) originated aponeurotic from the rectus sheath along with the abdominal portion of the pectoralis major muscle. The pectoralis quartus fused only at its origin with the lateral margin of the pectoralis major muscle. Then it deviated from the pectoralis major and crossed the axilla towards the anterior margin of the latissimus dorsi muscle whereat it attached fleshy, at the origin of the axillary arch. All axillary arches appeared almost fusiform; they were muscular and became aponeurotic only in their insertion.

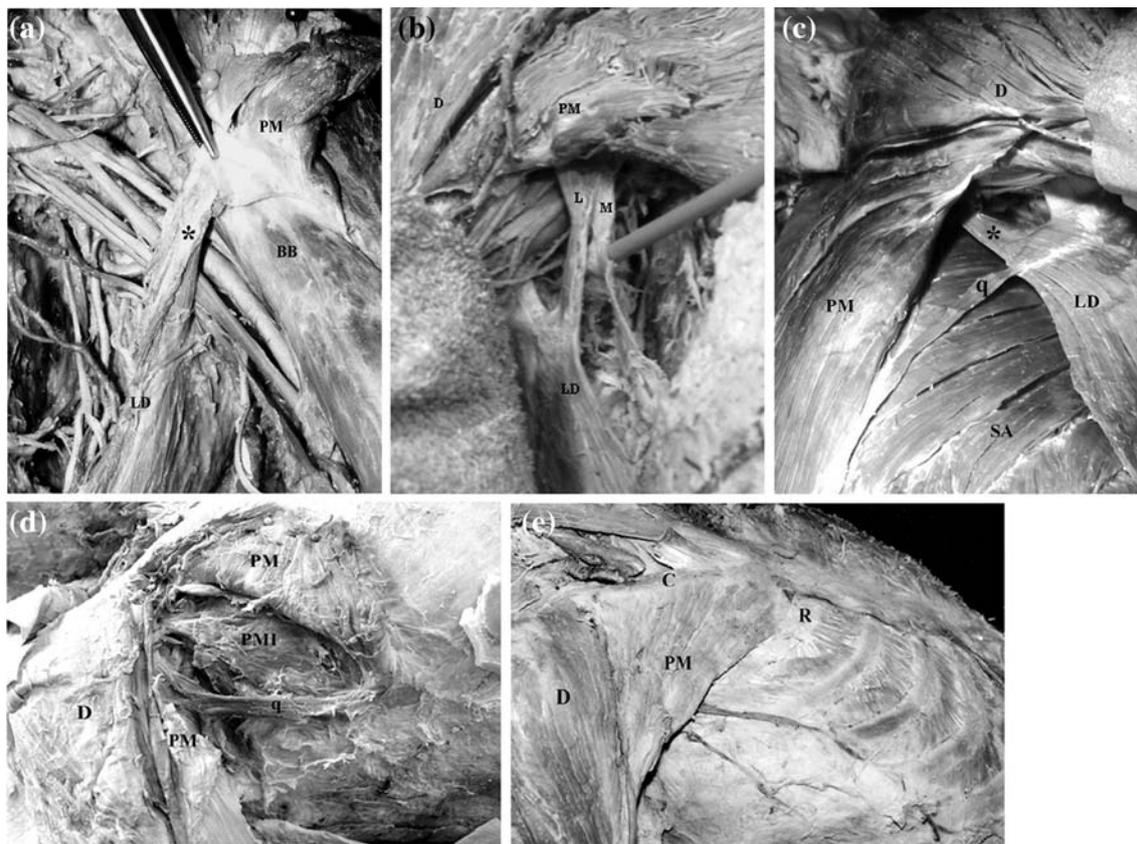


Fig. 2 The findings of our anatomical study: **a** the left axilla of a cadaver having a typical axillary arch (*); **b** the right axilla of a cadaver having two atypical axillary arches (*L* lateral axillary arch, *M* medial axillary arch); **c** the left axilla of a cadaver having an atypical axillary arch (*) and a pectoralis quartus muscle (*q*); **d** The right axilla

of a cadaver having a pectoralis quartus muscle (*q*). **e** The right axilla of a cadaver having an aplasia of the lower part of the pectoralis major muscle (*PM* pectoralis major muscle, *PMI* pectoralis minor muscle, *LD* latissimus dorsi muscle, *SA* serratus anterior muscle, *D* deltoid muscle, *BB* biceps brachii muscle, *C* clavicle, *R* second rib)

A pectoralis quartus muscle (Fig. 2d) was present in two more cadavers, one right-sided and one left-sided and their diameters at their midpoints were 12 and 15 mm, respectively. In both cadavers the pectoralis quartus originated aponeurotic from the chondrocostal junction of the fifth rib, just deep to the lateral margin of the pectoralis major muscle. Then, it ran parallel and slightly deep to this margin, being distinctly separate from it. Finally, it inserted in the fascia brachialis, just deep to the pectoralis major tendon.

In the right side of a cadaver the abdominal and almost the whole sternocostal portion of the pectoralis major muscle were absent (Fig. 2e). The remaining pectoralis major muscle consisted of the clavicular and a small part of the sternocostal portion between the first and second rib. The pectoralis minor muscle was also absent.

Discussion

In our anatomical study the axillary arch, the pectoralis quartus and the pectoralis major aplasia were found, in a

4.67, 2.8, and 0.93%, respectively, while no chondroepitrochlearis muscle was observed. In the literature, the frequency of these muscular abnormalities is higher in cadaveric dissections than the one reported during surgery. To be more precise, only the axillary arch has been found during surgical procedures, in a 0.25–6.52% percentage [12–16]. This lower frequency during surgery is probably due to the fact that even experienced surgeons are not familiar with the existence of the axillary arch [15]. This fact accounts for the other anomalous muscles as well, but it can also be attributed to the fact that during surgery the region is not dissected thoroughly, because the purpose of surgery is other than the recognition of anatomical variations, which is the case in anatomical dissections. However, failure to recognize the axillary arch during AL is not complications free. These complications have been reported in the literature. First of all, the axillary arch may impede the approach of the axilla and cover the lateral group of level I nodes, so that they may not be fully cleared. Moreover, the anterior margin of the latissimus dorsi muscle comprises the lateral border of the AL

surgical field and the axillary arch could be misregarded as this margin. In this case the axillary arch may lead the surgeon one level above the axillary vein and as a result the neurovascular bundle of the axilla may be injured. Persistence of the axillary arch after AL increases the risk of upper limb lymphedema due to compression of the axillary vein and the lateral lymphatic trunks [13, 14, 16]. Since these complications are significant, researchers conclude that *once the axillary arch exists, it should be recognised during AL* [13, 16].

Regarding the pectoralis quartus, the chondroepitrochlearis and the aplasia of the lower part of pectoralis major muscle, there are no studies reporting their intraoperative recognition. As a result, the significance of these anatomical variations for the AL is not known. The pectoralis quartus and the aplasia of the lower part of pectoralis major constitute two anatomical variations which, due to their location, change the medial border of the AL surgical field. The pectoralis quartus muscle transposes this margin laterally and downwards whereas the aplasia medially and upwards. Failure to recognise the pectoralis quartus may lead the operation to a lower level and as a result, the axillary vein is located deep under the pectoralis quartus and the pectoralis major muscles. The aplasia of the lower part of the pectoralis major may lead the operation to a higher level and increases the risk of injury to the axillary neurovascular bundle. On the other hand, the chondroepitrochlearis and the atypical pectoralis quartus muscles, such as the one found in our study which is similar to the unique atypical pectoralis quartus to our knowledge [4], are anatomical variations that pass through the axilla. Thus, these anatomical variations are located within the surgical field and they impede the approach and removal of the axilla content. The reasons mentioned above indicate why the anomalous muscles affecting the AL are the ones that pass through the axilla or change the boundaries of the AL surgical field. Additionally, apart from the axillary arch, *recognition of the other three anomalous muscles seems to be useful, if not necessary, for the surgeon who copes with AL.*

Preoperative diagnosis of these abnormal muscles, except for the very rare case of an excessive deficiency of the pectoralis major muscle, appears to be difficult. The axillary arch and the chondroepitrochlearis muscle may appear as a visible axillary mass [15, 19, 26]. With regard to imaging modalities, a recent study [9] mentions that venography, mammography, axillary echography, computed tomography and magnetic resonance imaging have been used to detect the presence of the axillary arch only in sporadic clinical reports. There are no reports of preoperative recognition of the pectoralis quartus and the chondroepitrochlearis muscles. *Therefore, presently recognition of these anomalies is feasible only intraoperatively.*

An important factor for the intraoperative recognition of each anatomical variation is awareness of the anatomical variations that may appear in a specific region, along with their main anatomical features. The surgeon should bear in mind the appearance of these muscles within the surgical field during AL. The typical axillary arch is located at the lateral part of the surgical field and appears as a ventral extension of the anterior margin of the latissimus dorsi. The axillary arch has indeed been mistaken for the anterior margin of the latissimus dorsi muscle during AL [13]. The basic point for the recognition of the axillary arch is the fact that it runs ventral to the neurovascular bundle of the axilla in contrast to the latissimus dorsi muscle (Fig. 2a). The surgeon must be aware of the great variability of the axillary arch, mainly with regard to its insertion field, as mentioned above. The most frequent atypical axillary arch inserts in the coracoid process and is located more medially in the axilla (Fig. 2b, c) [8, 10]. During AL, the pectoralis quartus muscle appears as a muscular bundle parallel to the lateral margin of the pectoralis major muscle, situated slightly deep and laterally to the muscle margin, throughout its course (Fig. 2d). Unlike the axillary arch, the morphology of the pectoralis quartus is fairly constant [4]. The only atypical pectoralis quartus muscle that has been reported in the literature [4] is similar to the one described in the present study, which extended between the pectoralis major lateral margin and the origin of the axillary arch, at the anterior margin of the latissimus dorsi muscle (Fig. 2c). The chondroepitrochlearis muscle during AL appears as a muscular bundle that begins either from or near the lateral margin of the pectoralis major muscle, but soon deviates from it and courses towards the medial surface of the humerus, distal to the pectoralis major muscle. The variations described in the literature regarding the distal attachment of the chondroepitrochlearis muscle [22] do not change the appearance of this anomalous muscle during AL. Concerning the aplasia of the lower part of the pectoralis major muscle (Fig. 2e), the surgeon, being aware of this anatomical variation, can recognize it from the anomalous orientation of the lateral margin of the pectoralis major muscle. Excessive deficits of the pectoralis major muscle are easily recognized.

As to the management of these muscular anomalies during AL, in cases of aplasia of the pectoralis major muscle the surgeon should just recognize it and be careful to avoid injury to the neurovascular bundle of the axilla. When the axillary arch is recognized, it should be divided mainly because its persistence may increase the risk of postoperative upper limb lymphedema, due to compression of the axillary vein and the lateral lymphatic trunks [13, 16]. There are no reports in the surgical literature with regard to the chondroepitrochlearis and the pectoralis quartus, as it has already been mentioned. However, due to

its location in the axilla, the chondroepitrochlearis impedes the surgeon during AL and therefore we propose its division. As to the pectoralis quartus, it can be retracted along with the lateral margin of the pectoralis major muscle. Once the atypical pectoralis quartus is present, we believe that it should be divided, because it has similar appearance as the chondroepitrochlearis muscle. Division of these muscles can be performed without any functional deficit for the patient since they are not only insignificant functionally, but also contracture of the axillary arch and chondroepitrochlearis, which resulted in limitation of shoulder abduction, has been reported [27].

Conclusions

In the current study, we attempted to present every anomalous muscle that a surgeon might encounter during AL, along with their variations. We believe that we offered the necessary preoperative knowledge for recognizing these muscles during the operation, avoiding thus the complications that may arise from them.

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