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The Existence of Axillary Arch in Human Fetus and Applied Importance and Clinical Implications in the Axillary Brachial Plexus Blocks

La Existencia de Arco Axilar en el Feto Humano y la Importancia Aplicada e Implicancias Clínicas en los Bloques de Plexo Braquial

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SUMMARY: Axillary arch is the most common muscle variation of axillary fossa that gains importance for regional interventional procedures, screening methods and physical examination. In order to avoid malpractice the variations must be borne in mind. This study has been planned to research the frequency and the features of the axillary arch in human fetus, to mention the potential clinical and functional significance of axillary arch while applying axillary brachial plexus block and reflect on possible complications. Axillary fossa was examined with a stereomicroscope in 20 upper extremities of ten human fetuses. The gestation ages ranged from 16 to 36 weeks. Axillary arch was determined in 2/20 specimen unilaterally. In both specimen, muscular slip detached from latissimus dorsi, passed anterior neurovascular bundle and ended posterior pectoralis major tendon and lateral border of intertubercular groove. In one specimen axillary arch was innervated with medial pectoral nerve whereas the other one did not have a particular innervating nerve branch. The possible effects of axillary arch in the axillary brachial plexus block applications are discussed. Arcus axillaris may have a potential clinical and functional significance with regard the axillary brachial plexus block applications and may have possible effects on failure rate and acute complications. Also, we think that this fetus study which the pure structure of the muscles without any usage effect can be observed will be beneficial regarding this topic.

KEY WORDS: Latissimus dorsi; Axillary fossa; Brachial plexus block; Langer's muscle.

INTRODUCTION

The axillary fossa is a complex shaped space which contains the neurovascular bundle of upper extremity, lateral branches of some intercostal nerves, a large number of lymph nodes, together with a quantity of fat and loose areolar tissue. It serves as a passage-way for the arteries, veins, nerves, and lymphatics passing between the trunk and the upper extremity (Standring, 2005). In order to avoid misdiagnosis with the screening methods and general physical examination, and to conduct correct treatment without causing complications in the interventional procedures on the axillary fossa, it is vitally important to have comprehensive knowledge concerning the anatomy of the axilla. Hence the variations must be borne in mind. The most common variation of axilla is the axillary arch (AA) (Daniels & della Rovere, 2000; Besana-Ciani & Greenall, 2005; Georgiev *et al*., 2007; Millet *et al*., 2007). Axillary arch may be an extension of the muscle bundle of latissimus dorsi (Miguel *et al*., 2001; Mérida-Velasco *et al*., 2003; Georgiev *et al*.), but may also commence by a tendon at the lateral side of the muscle (Mérida-Velasco *et al*.). Typical AA commences from the anterior (or lateral) edge of latissimus dorsi and by passing over the neurovascular bundle it inserts pectoralis major tendon (Natsis *et al*., 2010). Testut (1884) classified the AA as complete and incomplete, in terms of the distal insertion of this anomalous muscle. In the complete type, AA extends from the lateral side of latissimus dorsi to the insertion of the pectoralis major tendon on the humerus. In the incomplete type, AA may insert to the axillary fascia, lower part of the intertubercular groove, biceps brachii, coracobrachialis, and the inferior edge of the pectoralis minor or to the coracoid process. Uzmansel *et al.* (2010) classified the AAs in three groups in terms of their shapes. In type 1, a separate muscular mass, having a distinctive tendinous origin extends from the lateral border of latissimus dorsi horizontally,

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and then reaches its insertion by curving anteriorly and superiorly. In type 2, a group of fibers lie upward at the lateral side of latissimus dorsi as a part of it, and reach the axilla, then run anteriorly and superiorly to its insertion. In type 3, a group of fibers from the lateral border of latissimus dorsi spreads like a fan and joins the tendinous arch which reaches its insertion running anteriorly and superiorly.

The anatomical variations of the supernumerary muscle at the axillary fossa can make the access to the fossa and their content difficult (del Sol & Olave, 2005). Several reports describe its potential clinical relevance like axillary neurovascular compression, causing difficulty while sentinel lymph node biopsy and lymphadenectomy in the staging and treatment of melanoma and breast cancer (Serpell & Baum, 1991; Keshtgar *et al*., 1999; Mérida-Velasco *et al*.; Natsis *et al*.). Axillary brachial plexus block is a popular regional anesthesia technique for providing operative anesthesia of the upper extremity (Kriwanek *et al*., 2006). However, this block is an interventional procedure on the axillary fossa, there has been no data about AA and axillary brachial plexus block application in the anesthesiology literature.

The purpose of this study was to find the occurrence of AA in human fetuses that the pure structure without any usage effect can be observed. Furthermore, we paid special attention to its innervations. To our knowledge, the present study is rare among fetal studies about this variation. The differences or correlations between the AA in fetuses and adults might better help to understand anatomy of this variation. Differently from the previous studies, we also planned to mention the potential clinical and functional significance of AA with regard the axillary brachial plexus block applications and the possible effects on failure rate and acute complications.

MATERIAL AND METHOD

This study was conducted at Gaziantep University, Faculty of Medicine, and Department of Anatomy with 20 upper extremity examinations of the 10 spontaneously aborted fetuses (6 male, 4 female) fixed with 10 % formaline solution. The material was collected and examined in accordance with Turkish legislation. The procedures followed were in accordance with the ethical standards of the Committee on Human Experimentation of the faculty, which are based on the Helsinki Declaration in 2008. The gestation weeks of the fetuses, which had no external pathology, were determined according to the measurement of crown-rump length (CRL). Their ages ranged from 16 to 36 weeks of gestation. Dissection was carried out with stereomicroscope (Leica S4E). The existence of the AA, origin and insertion sides and the structural characteristics (muscular, tendinous or musculotendinous) were evaluated and classified according to Testut and Uzmansel *et al*. Further examination was performed to observe the innervations of AA.

RESULTS

Axillary arch was determined in two (10 %) specimens unilaterally from the 20 upper extremities of the fetuses. In both specimens, AA appeared as an extension of muscle fiber of latissimus dorsi, observed as round muscle bundle (Fig.1). This muscular fiber band originated from the lateral edge of latissimus dorsi as a part of it, occupies a total space of one third of this muscle and then extended to the posterior layer of pectoralis major tendon (Fig. 2). It merged with this tendon and terminated at the lateral edge of intertubercular sulcus. It was observed to pass over the neurovascular bundle. In accordance with Testut's classification (Testut), both of them were concordant with complete type. According to the classification of Uzmansel et al. both of them were in type 2.

In one of the specimens, AA was innervated with medial pectoral nerve (Fig. 2), whereas the other one did not have an individual innervating nerve branch. In both specimens, the part of the muscle fiber comprising the AA and being included in latissimus dorsi was innervated with thoracodorsal nerve (Fig. 2).

DISCUSSION

It was reported that the incomplete dorsoepitrochlearis muscle fuses with the insertion of the pectoralis major is known as the AA of Langer. The dorsoepitrochlearis anlage which is notified the embriological origin of AA appears in embryos between 15 and 18 mm (crown-rump length), and it then disappears, either fully or with strips remaining in the axilla (Haninec *et al.*, 2009). Phylogeneticly, it is thought to be the remnant of "*panniculus carnosus*" which is a skin-associated musculature like platysma and dartos, and lies between superfacial fascia and subcutaneous fat. It extends from the exterior part of middorsal region and ends at the medial side of the forearm skin. It is especially developed in low ranking rodents, so they can twitch their skin to protect themselves from the insects, and produce heat by shivering. In human beings, it lapses its functional significance due to

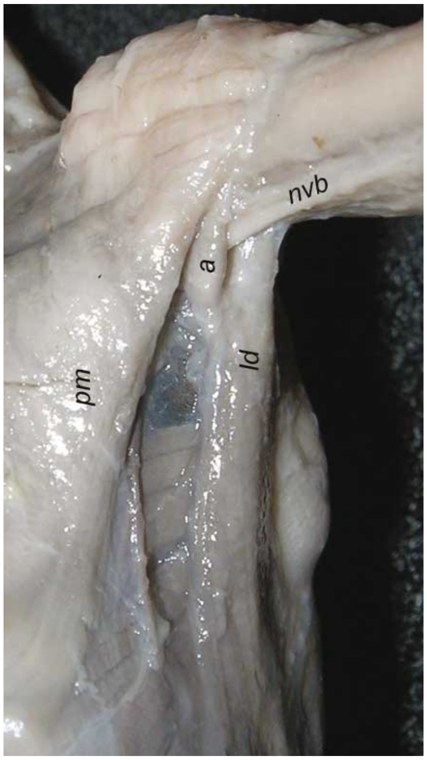

Fig. 1: axillary arch (a) divided from latissimus dorsi (ld) passing inferior neurovascular bundle (nvb) ending with pectoralis major (pm) .

the wide range of mobility of upper extremity (Rose *et al.*, 1977; Besana-Ciani & Greenall).

In structural features, AA may be only muscular, only tendinous or both musculotendinous. The structural features of the AAs which have been reported before are demonstrated on Table I. Uzmansel *et al.* observed that from the 14 AAs, half of them were muscular, the other half was musculotendinous and none of them were tendinous. They suggested that the AAs which are muscular or musculotendinous may become tendinous in later development. In our study, AA was an extension of latissimus dorsi in both specimen and, observed as round muscle bundle. They placed on the lateral side of the latissimus dorsi and occupy a total space of one third of this muscle. Therefore, it can be asserted that one third of the contraction force of the latissimus dorsi is conducted to the AA. We share the opinion belonging Mérida-Velasco *et al*. that such a strong pressure may lead to a compression on neurovascular bundle.

The innervation of the AA has been described in several studies as from the pectoral nerves or thoracodorsal nerve. The studies regarding the innervations of the AA are demonstrated on table 2. As displayed in one of the specimens of our study, an individual branch of nerve for innervation of AA was not detected

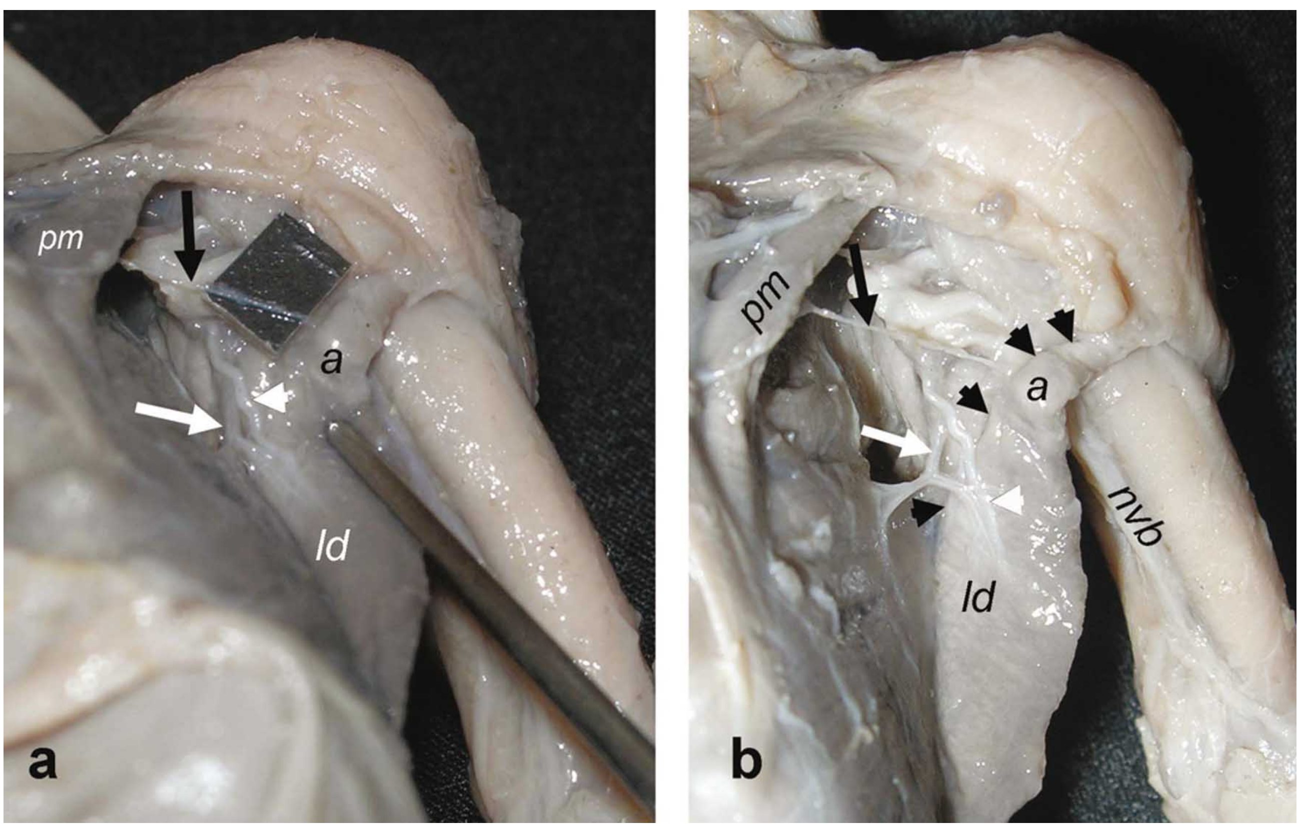

Fig 2: a) Innervation of the axillary arch (a) by medial pectoral nerve (black arrow) b) Muscle bundle comprising axillary arch extends into latissimus dorsi (ld). Black arrowhead points the medial edge of the muscle fiber in latissimus dorsi. White arrow, subscapular artery; white arrowhead, thoracodorsal nerve; nvb, neurovascular bundle; pm, pectoralis major.

Table I. Comparison of the axillary arch cases in the literature.

		Total axillae	**Number of AA**	**Incidence of AA (%)**	**Bilaterality**	**Muscular AA**	**Tendinous AA**	**Musculo-tendinous**
Adult cadaver	Kalaycioglu *et al.*, 1998	120	1	1%	-	1		
	Miguel *et al.*, 2001	100	3	3%	-	1		2
	Mérida-Velasco *et al.*, 2003	32	4	13%	1			
	Turgut *et al.*, 2005	52	1	2%	-			1
	Georgiev *et al.*, 2007	112	2	2%	-			2
	Bertone *et al.*, 2009	78	9	12%	1	8		1
	Rizk & Harbaugh, 2008	70	3	4%	-	3		
	Natsis *et al.*, 2010	214	6	3%	-			
Clinical study	Van Hoof *et al.*, 2008	604[1]	26	4%	7			
	Ando *et al.*, 2010	550	59	11%	-			
Fetus cadaver	Uzmansel *et al.*, 2010	100	14	14%	3	7		7
	Current study	20	2	10%	-			2

[1]Healthy volunteer

in some cases. In these cases, as fibers of latissimus dorsi exert persistence with the AA, we consider that the innervation of the AA is supplied to thoracodorsal nerve which innervates lattisimus dorsi.

Uzmansel *et al*. found 14 (14 %) AAs form the 100 upper extremities and AA exist in 11 (22%) of 50 fetuses. They reported that six (6%) of them were complete, six (6%) were incomplete and two (2%) were concordant with both types according to the classification of Testut. In the present study, both of them were concordant with complete type. Uzmansel *et al*. reported that seven of 14 AAs were in type 1, two were in type 2, and five were in type 3 according to their own classification. In the present study, according to the classification of Uzmansel *et al*. both of the AAs were in type 2.

The swelling in axilla caused by the axillary arch may be apparent with an inspection in most cases (van Hoof *et al*., 2008). In the physical examination of the axillary arch, it can easily be confused with lymphadenomegaly or soft tissue tumor (Besana-Ciani & Greenall). Especially in unilateral cases it may give the impact of mass (Ko *et al*., 2006). Ko *et al*. revealed the structure which was related with pectoralis major in the mediolateral oblique mammogram and considered normal, was in fact AA. Additionally, they determined a significant increase in positive upper limb neurodynamic test of the median nerve (ULNT1). Positive ULNT1 that could indicate a possible interaction of the AA with the axillary neurovascular bundle was followed by a transient disturbance of normal functioning of the latter. Minor symptoms of hyperabduction and external rotation of the shoulder may not only manifest themselves as the friction of the neural tissue

Table II. Nerve supply to the axillary arch in the literature.

	Total axillae	**Thoracodorsal nerve**	**Medial pectoral nerve**	**Intercostobrachial nerve**	**Pectoral loop**	**No innervation**
Kalaycioglu *et al.*, 1998	120	1				
Miguel *et al.*, 2001	100	3[a]				
Uzmansel *et al.*, 2010	100	14				
Bertone *et al.*, 2009	78			8		1
Georgiev *et al.*, 2007	112			1		1
Rizk & Harbaugh, 2008	70					3[b]
Mérida-Velasco *et al.*, 2003	64	3	1			
Turgut *et al.*, 2005	52	1				
Present study	20		1			1

[a] one of them was also innervated with the sixth intercostal nerve.
[b] may not be identified due to retrospective study of the specimen.

resulting from the compression of the neurovascular bundle but may also be due to the decrease of the flow in the axillary artery. AA may lead to a lymphoedema in the upper extremity due to the pressure in the axillary vein and lymph vessels (Daniels & della Rovere; Hafner *et al*., 2010). Van Hoof *et al.* stated a significant increase in the minor symptoms of individuals with AA which did not prevent daily activities, did not require treatment and were not diagnosed as seriously ill.

Axillary block is a type of regional anesthesia of the brachial plexus, administered at the distal part of the axilla. Although axillary variations is important while performing an interventional procedure on the axilla, to our knowledge there is no data about AA in anesthesiology literature. Axillary block is performed that patients lying in the supine position and the arm which is to be operated is placed on the 90o abduction and the forearm on 90º flexion parallel to the long axis of the trunk (Brown, 1999). This position is same with the provoking maneuver of AA. To determine the needle insertion site, the artery is palpated over the humerus at the point of conjunction of the pectoralis major and corachobrachialis. The needle insertion point was marked immediately over the artery-pulse. From the needle insertion point, the needle was inserted parallel to the artery, at an angle of approximately 30o to the skin (Brown). The swelling in axilla caused by the AA in most cases may be apparent with an inspection (Van Hoof *et al*.). Thus, in this position an anesthesiologist may identify an AA in the patients with a normal body mass index and changed the insertion site of the needle to the distal, the midhumeral point. However, in obese patients, especially in morbid obese patients it would be difficult to determine an AA by inspection and palpation. It was reported that obesity may have a small effect on superficial block performance requiring artery palpation like axillary block (Hanouz *et al.*, 2010). In these patients, the unclear pulsation of axillary artery can be related with obesity and, the coexistence of obesity and AA may lead failure of the axillary block or cause acute complications as a result of intravascular (arterial or venous) injection.

Hafner *et al*. performed hyperabduction of the arm of a 17 year-old female and were able to provoke a complete compression of the axillary vein which was determined via color duplex scan and phlebography. In the patient with AA, the position for performing axillary block of brachial plexus can cause congestion in the distal part of axilla due to axillary vein compression and this may lead vascular puncture and can be recognized by blood aspiration. However, while performing a continuous catheter technique for axillary block, if the catheter passes under the AA, and the AA has compressed completely on the axillary vein, blood may not be aspirated although vascular puncture has been done. According to this, local anesthetic agent may be injected intravasculary and cause systemic toxic effect, cardiac arrest and may lead to death. Differently from the adults, the muscular type of AA is more frequent in children (Uzmansel *et al*.) and may compress the neurovascular bundle more than the other types.

Among the other pathologies that AA brought about, hyperabduction syndrome (Mérida-Velasco *et al*.; Georgiev *et al*.; Rizk & Harbaugh, 2008) thoracic outlet syndrome (Georgiev *et al*.; Rizk & Harbaugh) shoulder instability syndrome (Petrasek *et al.*, 1997) and thrombosis of upper extremity (Turgut *et al.*, 2005) have been reported. So, during preoperative evaluation for axillary block, the chronic pain of the arm should be investigated. When the arm with AA is positioned for performing axillary block before an operation of an injury, the emerging pain of the arm can be attributed to the pain of the injury although it is caused by an AA. On the other hand, in pediatric patients, axillary block is performed under general anesthesia or sedation, so they could not express their pain caused by AA.

Among different populations, various frequencies of the AA have been reported from cadaver and clinical studies (Table I); however most of the authors have reported a similar frequency of 7–8% (Georgiev *et al*.). Cramer *et al*. (1995) reported a success rate of 95% of axillary block in 111 children who underwent forearm fracture reduction in the emergency department. Kriwanek *et al*. was used axillary block successfully in 18 (90%) of the 20 children. Wedel *et al.* (1991) reported a 92.4% success rate in 134 axillary blocks in children in the operating room. The similarity between the reported incidence of failure rate in the axillary block and the occasional incidence of AA bring to mind that AA may affect the success of the block. Hence, during the preoperative anesthesia visit hyperabduction test can be applied the patients whom axillary block will be performed, as the mallampati test which is applied for evaluation of airway before general anesthesia. If the anesthetist found the absence of pulse of axillary artery or a weak pulsation, an axillary fossa ultrasonography may help to diagnose.

Uzmansel *et al*. showed the relation between the occurrence of AA and the variations in the formation of the proximal part of brachial plexus. Also they reported that the union from T2 was observed in 57.1% of specimens with AA and in 11.6% of specimens without AA and commented that there may be a developmental relationship between the formation of the brachial plexus and occurrence of the AA. Hence, we think that before performing brachial plexus blocks (interscalen, supraclavicular), having information about AA's of the patient may give an opinion to the administrator about the formation of brachial plexus and may decrease the insufficient anesthesia.

In conclusion, AA has a potential clinical and functional significance with regard the axillary brachial plexus block applications and may have possible effects on failure rate and acute complications. We think that during the preoperative anesthesia visit hyperabduction test can be applied the patients whom axillary block will be performed. The clinicians, radiologists, surgeons and anesthetists must bear the AA which is a frequent variation of axillary region in mind. Variations are important for in order to perform correct diagnosis and technique and, reduce the rate of the complications. Differently from the adults, the muscular type of AA is more frequent in fetuses. So we think that the pure structure of the muscles without any usage effect can be observed by fetus studies. Therefore, this study within the limited number of fetus studies in the literature will be beneficial regarding this topic.

ORHAN, M.; KERVANCIOGLU, P. & COCELLI, L. P. la existencia del arco axilar en el feto humano y la importancia aplicada e implicancias clínicas en los bloqueos del plexo braquial. ***Int. J. Morphol., 30(1)***:272-278, 2012.

RESUMEN: El arco axilar es la variación muscular más común de la fosa axilar, siendo de importancia para la región en los procedimientos de intervención, los métodos de selección y el examen físico. Con el fin de evitar las negligencias se debe tener en cuenta las variaciones. El objetivo de este estudio fue determinar la frecuencia y las características del arco axilar en el feto humano. Es necesario mencionar la importancia del potencial clínico y funcional del arco axilar en la aplicación de bloqueo axilar del plexo braquial y sus posibles complicaciones. La fosa axilar fue examinada bajo microscopio estereoscópico en 20 miembros superiores de diez fetos humanos. La edad de gestación varió de 16 a 36 semanas. El arco axilar se observó unilateralmente en 2/20 especímenes. En ambos especímenes el músculo cruzó anteriormente el paquete neurovascular y terminó en el tendón del músculo pectoral mayor y en el margen lateral del surco intertubercular. En un especimen el arco axilar se encontraba inervado por el nervio pectoral medial, mientras que en el otro no existía una determinado ramo del nervio. Se discuten los posibles efectos del arco axilar en las aplicaciones de bloqueo axilar del plexo braquial. Puede tener un significado potencial clínico y funcional, en lo que se refiere a la aplicación de bloqueo axilar del plexo braquial y aademás producir efectos de complicaciones agudas.

PALABRAS CLAVE: Músculo latísimo del dorso: Fosa axilar; Bloqueo axilar del plexo braquial; Musculo de Langer.

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