Coexistence of bilateral Langer's arm arch and Kaplan's anastomosis: a case report and literature review

Axel O. Colombo[1], Sofia Funes[1], Agustina Medin[1], Tomás Ferré[1], Juan M. De Zan[1], Mariana Bendersky[1,2]

[1] Living Anatomy Laboratory, 3rd Normal Anatomy Department, School of Medicine, University of Buenos Aires, Argentina
[2] ENyS (National Scientific and Technical Research Council - CONICET)

SUMMARY

The axillopectoral muscle [Langer's arm arch (LAA)], is described as a supernumerary musculo-tendino-fascial structure, which connects at least two muscles that make up the walls of the axillary fossa. This anatomical variant is found in around 7% and 15% of the population, usually unilaterally, on the right side and in females. Kaplan described a nervous communication between the dorsal and the terminal superficial branches of the ulnar nerve, both sensory, with an incidence of the 2% to 4%.

A case report is presented of an anatomical preparation, in which Langer's arm arch and Kaplan anastomosis coexisted on both sides. A review of literature of LAA and Kaplan's anastomosis is also presented. The knowledge of these anatomical variations is important as they are involved in a wide variety of vascular, nervous and functional disorders of the upper limb.

Key words: Langer's arm arch – Kaplan's anastomosis – Anatomical variations – Upper limb – Gross anatomy

INTRODUCTION

Alexander Ramsay discovered the LAA in 1795, and in 1812 he made the first publication about it. However, it was Carl Langer that described it more accurately in 1846, and that is the reason why the arch was named after him (Hoogbergen and Kauer, 1992). The Langer's arm arch (LAA) is described as a supernumerary musculo-tendino-fascial structure connecting two or more muscles that make up the boundaries of the axillary fossa, usually from the *latissimus dorsi* muscle to the to the lower fibers of the pectoralis major muscle (Macalister, 1889; Piñero et al., 1975; Ortiz et al., 2009; Hirtler, 2014). This anatomical variation is found in about 7% to 15% of the population, mostly females, and is more frequently unilateral, right sided (Hoogbergen and Kauer, 1992). The utmost importance of studying the LAA lies in the fact that it is involved in several disorders of the upper limb, such as loss of axillary concavity; axillary vein entrapment; numbness, paresthesias, and burning sensation in the upper limb; venous thrombosis of the upper limb; hyperabduction syndrome; shoulder instability; masking of axillary lymph nodes; and compression of axillary nerve elements (Stopford, 1918; Paraskevas et

Corresponding author:
Axel Omar Colombo. Living Anatomy Laboratory, 3rd Normal Anatomy Department, School of Medicine, University of Buenos Aires, Argentina.
E-mail: axelcolombo59@gmail.com

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al., 2008; Ballesteros-Acuña, Bravo-Pacheco and Forero-Porras, 2019; Bonilla-Sepúlveda, 2021).

In 1963 Kaplan described a nervous communication between the dorsal branch of the ulnar nerve and the terminal superficial branch of the same nerve. This nervous communication is formed on the hypothenar region, being its prevalence between 2% to 4%. Kaplan's anastomosis provides sensory innervation to this region, with variations on the nervous distribution pattern. It accounts for the pain and loss of sensitivity in patients undergoing hand surgery due to damage to the pisiform bone, the flexor carpi ulnaris tendon, or damage to the Guyon canal (Torre et al., 2015). To the best of our knowledge, there have been no reports of the co-occurrence of aforementioned anatomical variations within a singular subject's bilateral upper extremities.

We present a case report of an anatomical preparation in which LAA and Kaplan's anastomosis were found bilaterally during routine dissection. A literature review was made in classical anatomy textbooks, PubMed, Google scholar and Scielo about previous reports of these anatomical variations.

CASE PRESENTATION

A male cadaver of 50 to 55 years old at death, preserved in 10% formalin, was subjected to routine anatomical dissection for research and teaching at the 3rd Normal Anatomy Department of the School of Medicine of the University of Buenos Aires. Both upper limbs were dissected using standard techniques.

Langer's arm arch

Dissection began with removal of the skin and superficial fascia of the arms and torso, and then of the subcutaneous tissue and fascia. The anterior surface of the pectoralis major (PM) was dissected following the direction of its fibers, from proximal to distal. Around its distal portion, a supernumerary muscular fascicule was found, showing different dispositions in each upper limb (Fig. 1). On the right side (Figs. 2, 3), it extended from the ascending distal portion of the latissimus dorsi muscle to the coracoid process, on the joined insertion of the short head of biceps brachii muscle and coracobrachialis muscle (conjoined tendon).

On the left side (Figs. 4, 5), it extended as his right homonymous from the *latissimus dorsi* to the conjoined tendon, but it was also inserted on the distal portion of the PM. Then, the PM was sectioned distally and rebated medially for dissecting and later sectioning the pectoralis minor muscle, in order to display the vascular-nervous elements of the axilla. Both aberrant muscles laid across the neurovascular bundle as they adopted a musculo-tendino-fascial consistency. Their proximal origin was completely muscular, but their distal

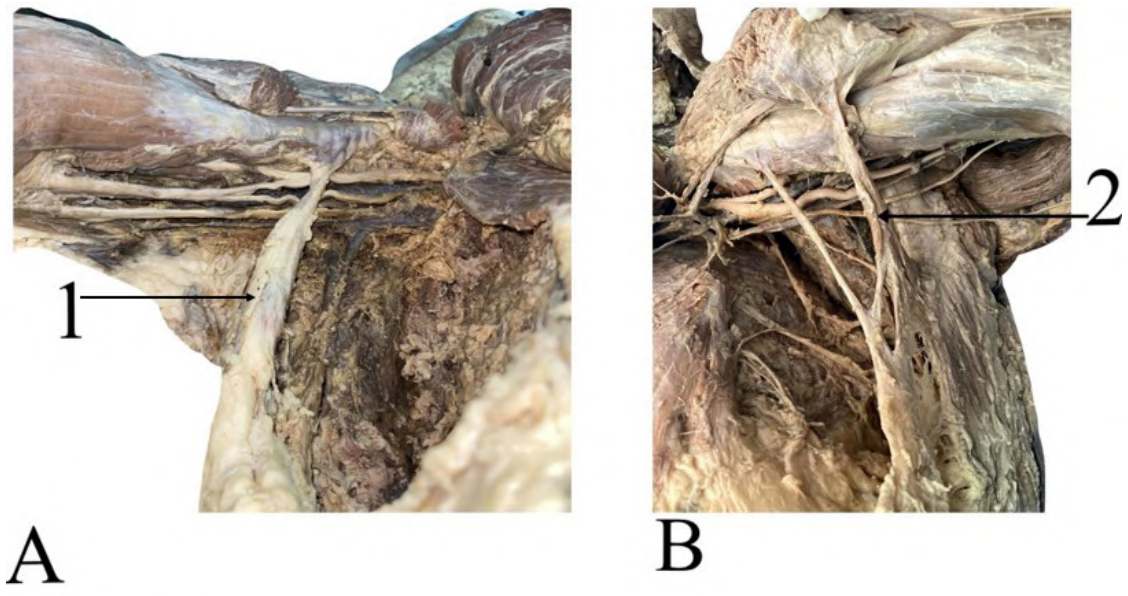

Fig. 1.- A: right axilla. **B:** left axilla. 1: right Langer's arm arch; 2: left Langer's arm arch.

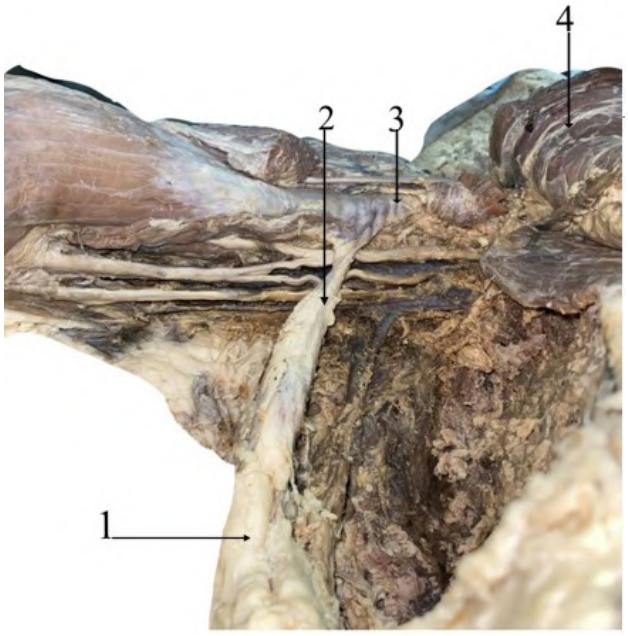

Fig. 2.- Right axilla. 1: latissimus dorsi; 2: Langer's arm arch; 3: conjoined tendon; 4: pectoralis major.

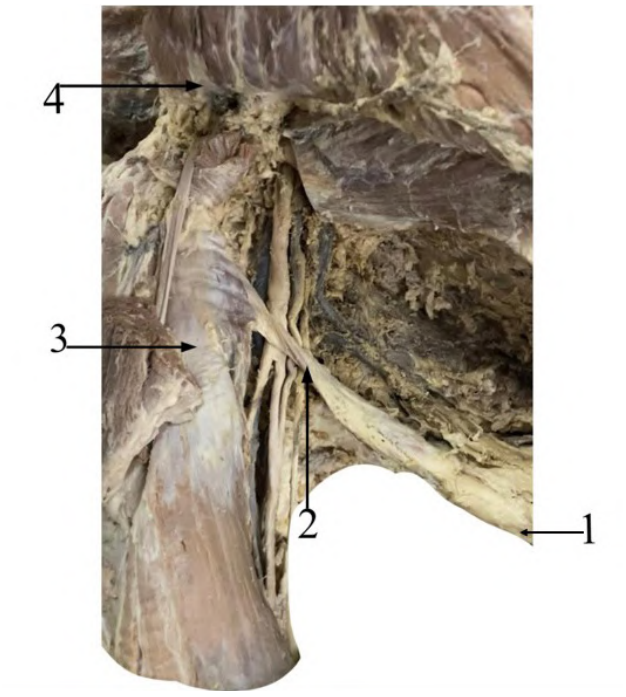

Fig. 3.- Right axilla. 1: latissimus dorsi; 2: Langer's arm arch; 3: conjoined tendon; 4: pectoralis major.

portion was tendino-fascial. A bilateral Langer's arm arch was then identified and classified based on its specific structural origin, relations, and subsequent termination (Piñero et al., 1975).

Kaplan´s anastomosis

Moving on to the dissection of the cadaveric preparation, both upper limbs were dissected. The ulnar nerve was followed to its end.

By doing so, we were able to notice how, on the left side, a nervous branch was born from the medial edge of the superficial terminal branch of the ulnar nerve. This anomalous branch crossed the hypothenar region and the distal portion of the flexor carpi ulnaris muscle, from lateral and proximal to medial and distal, in order to reach the dorsal branch of the ulnar nerve, just before the dorsal branch of the ulnar nerve passed to the posterior

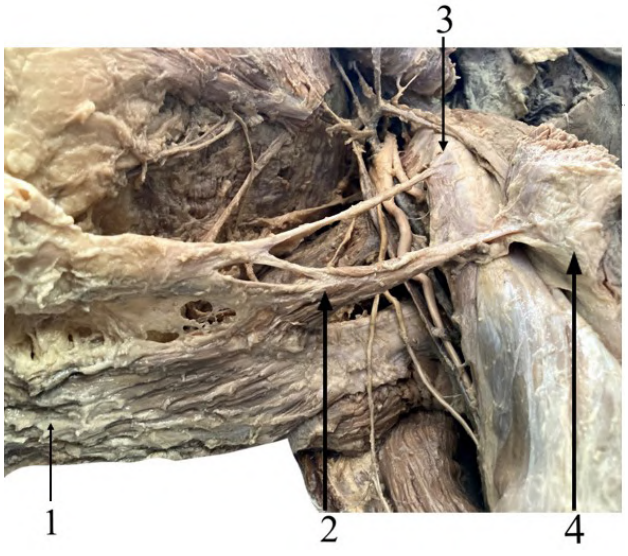

Fig. 4.- Left axilla. 1: latissimus dorsi; 2: Langer's arm arch; 3: conjoined tendon; 4: pectoralis major.

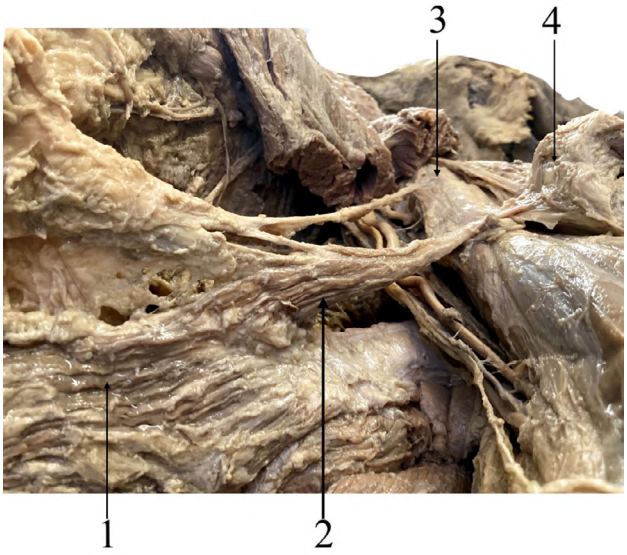

Fig. 5.- Left axilla. 1: latissimus dorsi; 2: Langer's arm arch; 3: conjoined tendon; 4: pectoralis major.

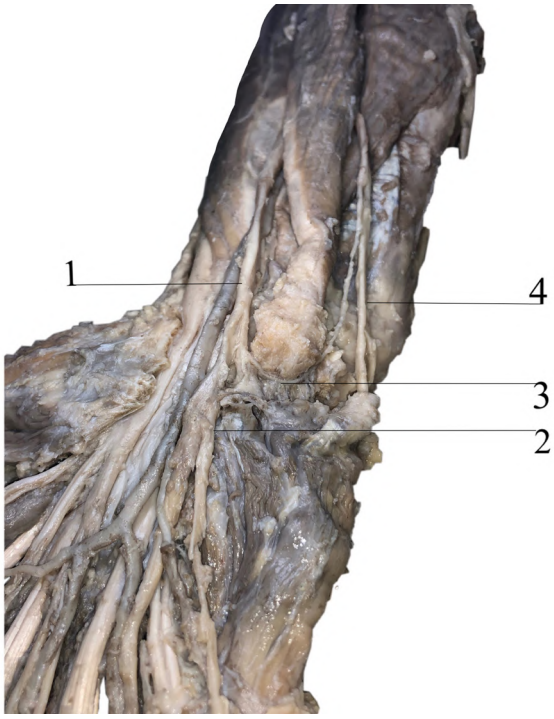

Fig. 6.- Right hand. 1: ulnar nerve; 2: superficial branch of the ulnar nerve; 3: Kaplan's anastomotic branch; 4: dorsal branch of the ulnar nerve.

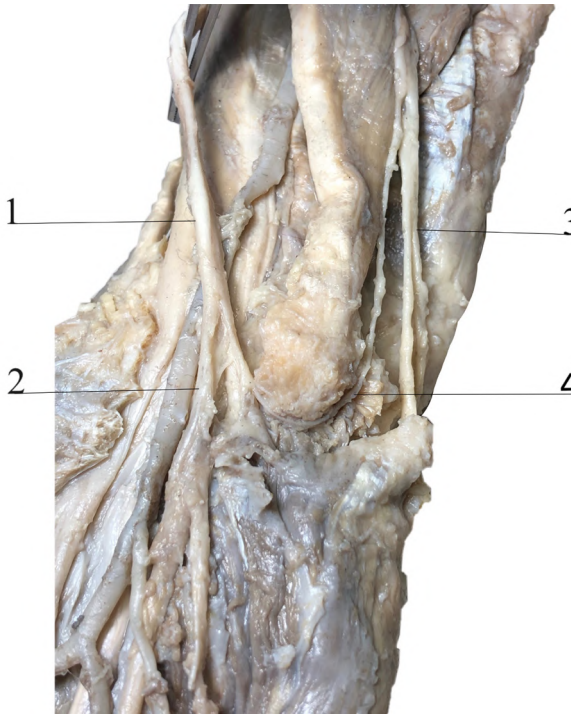

Fig. 7.- Right hand. 1: ulnar nerve; 2: superficial branch of the ulnar nerve; 3: dorsal branch of the ulnar nerve; 4: Kaplan's anastomotic branch.

portion of the wrist, over the ulnar canal [Guyon] (Figs. 8, 9). On the right side this anastomosis was found on a deeper level. On account of this we decided to follow this anastomotic branch from its origin until it reached the dorsal branch of the ulnar nerve, just to discover how in the lower third of the forearm it described a faithful pass around the distal insertion of flexor carpi ulnaris muscle.

Carrying on its way, (from lateral to medial) it outlined the pisiform bone, went deep into the hypothenar muscles and finally reached the ulnar nerve right before this one entered the cubital canal (Figs. 6, 7). On behalf of the anatomical disposition of these supernumerary branches, we were able to assume that they were Kaplan ´s anastomosis (Garibaldi and Nucci, 2000; Torre et al., 2015; Iwanaga et al., 2021).

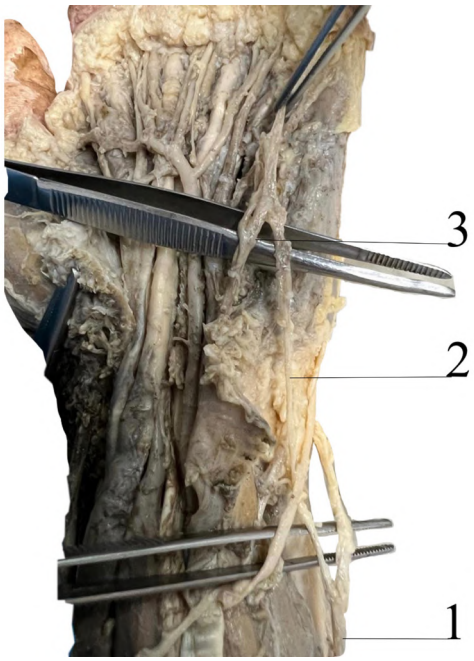

Fig. 8.- Left hand. 1: dorsal branch of the ulnar nerve; 2: Kaplan's anastomotic branch; 3: superficial branch of the ulnar nerve.

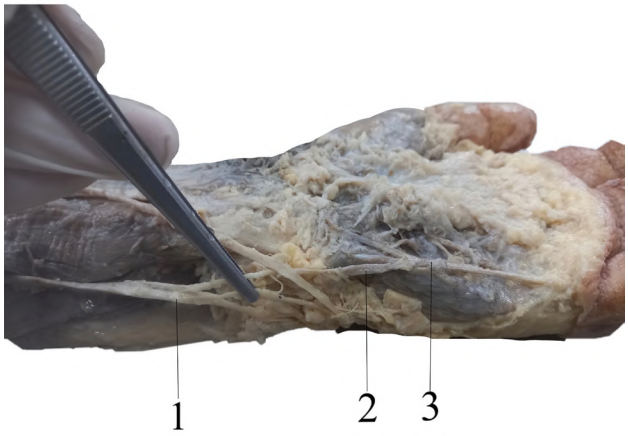

Fig. 9.- Left hand. 1: dorsal branch of the ulnar nerve; 2: Kaplan's anastomotic branch; 3: superficial branch of the ulnar nerve.

DISCUSSION

We present a case report of the coexistence of two different anatomical variations on both upper limbs in the same individual. As far as we know, this is the first description of this co-occurrence.

Langer's arm arch

Langer's arm arch (LAA), also known as axillo-pectoral muscle or pectorodorsal arch (Piñero et al., 1975), is described as a musculo-tendino-fascial structure that extends from the *latissimus dorsi* muscle to the *pectoralis major*, and sometimes it can also have attachments to the short head of the biceps brachii muscle or its fascia, teres major muscle, coracoid process, coracobrachialis muscle or its fascia, and pectoralis minor muscle (Tubbs et al., 2016). This supernumerary muscle is found by dissection, surgery, or by palpating the base of the axillary region while maintaining the upper limb in abduction at 90° (Clarys et al., 1996). The embryological origin of this structure is related to a large extension of muscle associated with the skin called "*panniculus carnosus*", highly developed in mammals in order to improve functional mobility of the arm. Its incidence varies on around 7% to 15% of the population and it has mostly been found unilaterally, on the right side and in females. It has also been found to exist with other slips of muscle arising from the fascia over the fifth digitation of the serratus anterior muscle and the interval between the pectoralis major and latissimus dorsi muscles (Tubbs et al., 2016). Diverse authors had been able to accomplish a common categorization according to these variabilities (Bonilla-Sepúlveda, 2021):

1. *"According to the structure:* Type I (muscular), Type II (tendinous), including four different subtypes depending on their insertion and innervation.
2. *According to the origin:* Category 1, the most usual, arises from the lateral edge of the *latissimus dorsi*, and ends on the distal portion of the *pectoralis major*. Category 2 consists of an incomplete arch which distal insertion, described by Testut in 1884, may vary from the *pectoralis minor* and the axillary fascia, to the *biceps brachii* , the *coracobrachialis*, the coracoid process, and the intertubercular groove (Testut and Latarjet, 1984).
3. *According to the shape:* Type 1, is described as a well-defined muscle born from the lateral edge of the latissimus dorsi. Type 2 consists of a group of fibers that leave the lateral edge of the *latissimus dorsi* in order to reach and cross the axilla. Type 3 is a fan-shaped arch."

According to this classification, we could establish that our case, on the right axilla, regarding its characteristics, can be classified as:

1. *According to the structure:* the proximal portion is type 1, and the distal is type 2.
2. *According to the origin:* category 2, being its distal insertion on the conjoined tendon.
3. *According to the shape:* type 1.

On the left axilla, regarding its characteristics, it can be classified as:

1. A*ccording to the structure:* the proximal portion is type 1, and the distal is type 2.
2. *According to the origin:* category 1 and 2, as its distal insertion is by two fascicles.
3. *According to the shape:* type 3.

In most of the cases, the innervation of the LAA is provided by the *ansa pectoralis*, the medial pectoral nerve or the thoracodorsal nerve, and it receives blood from the lateral pectoral artery (Tubbs et al., 2016). Other studies have concluded that these are deeply connected to the embryological origin of the arch.

The LAA is involved in several vascular, nervous and functional alterations of the upper limb, such as: loss of axillary concavity (Ortiz et al., 2009); axillary vein entrapment (Ballesteros-Acuña et al., 2019); numbness, paresthesias, and burning sensation in the upper limb; venous thrombosis of the upper limb (Tilney et al., 1970); hyperabduction syndrome (Piñero et al., 1975); shoulder instability; masking of axillary lymph nodes; and compression of axillary nerve elements with loss of sensibility and pain. Furthermore, the presence of this arch brings up complications during the resection of lymph nodes during breast cancer surgery (Ballesteros-Acuña et al., 2019).

Kaplan's anastomosis

Nervous anastomoses are frequently found on the upper limb, but most of them are motor fibers, for example Martin Gruber's and Riche-Cannieus anastomosis. Sensory anastomoses are quite rare to find and Kaplan's anastomosis is an example of them, being described as an unusual branch connecting the superficial terminal branch of the ulnar nerve with the dorsal branch of the same one along the hypothenar region. This supernumerary branch was first identified by Kaplan in dissection and has become known as a Kaplan's anomalous branch. In joining the superficial branch, a Kaplan's anomalous branch makes a loop around the pisiform; Kaplan surmised this loop to be a source for persistent pisiform pain (Tubbs et al., 2016). This anastomosis explains why patients that had suffered ulnar nerve injuries around the cubital canal may present with hypesthesia not only on the palm but also on the dorsal region of the hand (something that is usually related to more proximal ulnar injuries) leading to misdiagnosis and uncertain interpretation of neurophysiological studies.

According to this anastomosis characteristics, it can be classified in 6 types:

1. *Hankins & Flemming*, if the anastomosis takes place on the cubital canal [Guyon] between the dorsal branch of the ulnar nerve and the ulnar nerve (Hankins and Flemming, 2005).
2. *Kaplan*, if the anastomosis is done between the dorsal branch of the ulnar nerve and the superficial terminal branch of the ulnar nerve (Hankins and Flemming, 2005).
3. *Hoogbergen & Kauer*, if the anastomosis is done between the dorsal branch of the ulnar nerve and the terminal motor branch of the same nerve (Hankins and Flemming, 2005).
4. *Camper*, if the anastomosis is done between the dorsal branch of the ulnar nerve and the medial palmar digital nerve of the fifth finger (Hankins and Flemming, 2005).
5. *Wulle*, same as Camper, the difference lies in the fact that it forms at the level of the proximal phalanx of the fifth finger (Hankins and Flemming, 2005).
6. *McCarthey & Nalebuff*, there is no nervous communication, but there is an aberrant branch being born from the dorsal branch of the ulnar nerve and ending on the pisiform bone (Hankins and Flemming, 2005).

There are no studies that report the prevalence of these different types of anastomosis, but Kaplan's anastomosis is known to be rare.

According to the aforementioned classification, in our subject, the right hand had a type 1 (Hankins-Flemming) anastomosis, and the left one, a type 2 (Kaplan).

In short, on the same cadaveric preparation where we found LAA bilaterally, we also found two Kaplan's anastomoses, one on each hand.

CONCLUSION

This case report highlights the unusual coexistence of two anatomical variations: Langer's arm arch and Kaplan's anastomosis, and also the bilateral disposition of both of them in a male subject. Anatomical variations generally have no effect on the function of the body under normal circumstances, but their knowledge is important to improve diagnosis and treatment. An unresolved question pertains to whether the detection of multiple anatomical variations within a single individual could serve as an indication for the presence of other associated variations or abnormalities.

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