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Unique case of vascularization: superficial brachial artery and radial persistent median artery

Megan K. Kalinowski et al., Radial persistent median artery

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ABSTRACT

During a routine cadaveric dissection of a 93-year-old male donor, unique arterial variations were observed in the right upper extremity. This rare arterial branching pattern began at the third part of the axillary artery (AA), where it gave off a large superficial brachial artery (SBA) before bifurcating into the subscapular artery and a common stem. The common stem then gave off a division for the anterior and posterior circumflex humeral arteries, before continuing as a small brachial artery (BA). The BA terminated as a muscular branch to the brachialis muscle. The SBA bifurcated into a large radial artery (RA) and small ulnar artery (UA) in the cubital fossa. The UA branching pattern was atypical, giving off only muscular branches in the forearm and a deep UA before contributing to the superficial palmar arch (SPA). The RA provided the radial recurrent artery and a common trunk (CT) proximally before continuing its course to the hand. The CT from the RA gave off a branch that divided into anterior and posterior ulnar recurrent arteries, as well as muscular branches, before it bifurcated into the persistent median artery

(PMA) and the common interosseous artery. The PMA anastomosed with the UA before entering the carpal tunnel and contributed to the SPA. This case presents a unique combination of arterial variations in the upper extremity and is clinically and pathologically relevant.
Key words: persistent median artery, superficial brachial artery, brachial arterial variation

INTRODUCTION

Typically, post-gestational anatomy displays the radial and ulnar arteries stemming from the BA, a continuation of the AA at the lower border of the teres major muscle. The AA is the primary source of vascularization to the arm and forearm as described in anatomical texts. In some cases, the AA divides into two major branches (an SBA and a BA) to supply the upper limb. This variation of the SBA arising from the AA was found in 12.2% of cadaveric arms in a study of Korean cadavers. The SBA often continues distally and divides into the ulnar and brachial arteries (Yang et al., 2008).

In most cases, the median artery (MA) of the forearm, a branch of the UA, regresses during the 8th week of gestation. The MA serves as the primary source of blood to the hand during intrauterine growth. In rare cases, the MA remains as an embryological remnant called the PMA with a prevalence ranging from 4.2% to 6.6% (Singla et al., 2012; Eid et al., 2011; 2012; Patnaik & Paul, 2016).

The most common forms of the PMA are either the antebrachial type, in which the artery provides blood supply to the median nerve but does not reach the hand, or palmar type, in which the PMA passes through the carpal tunnel and is involved in the formation of the SPA (Ikeda et al., 1998; Nayak et al., 1988; Haładaj et al., 2019). The palmar type is the direct remnant of the embryonic form and contributes to the arterial supply of the hand, whereas the antebrachial type is due to a partial regression (Eid et al., 2011; Nayak et al., 1988; Haładaj et al., 2019). The prevalence of each type is variable and inconsistent in literature. Some reports show the palmar type has a prevalence of 0.9-50% and the antebrachial type is reported to have a prevalence of 70-76% in individuals with PMAs (Ikeda et al., 1998; George & Henneberg, 1996; Huelin et al. 1979; Rodríguez-Niedenführ et al., 1999). Most cases present with the PMA arising from the UA as an accessory branch while others report the PMA coming from the common interosseous artery (Singla et al., 2012; Eid et al., 2011; Natis & Gigis, 2009; Muratore & Ozer, 2011). Both variations travel through the forearm as a main source of blood supply to the median nerve before either stopping at the wrist or crossing it to contribute to the SPA (D'Costa et al., 2006).

The presence of a PMA can have a variety of clinical implications that primarily impact surgical cases in the wrist region, especially with carpal tunnel release procedures (Osiak et al. 2021). The PMA can be associated with compression of the median nerve resulting in carpal tunnel syndrome type signs and symptoms (Jones & Ming, 1998). Other clinical manifestations include calcification, thromboses, atherosclerosis and anterior interosseous nerve compression (D'Costa et al., 2006; Dickinson & Klienert, 1991; Beran et al., 1997; Khashaba, 2002; Kele et al., 2002; Tsagarakis et al., 2004).

Although the PMA itself is not a novel discovery, the origin and relationship with other vasculature in this case created a unique presentation that has not been described in the literature. This case presents an entirely unique branching pattern from the AA to arterial termination in the hand with the most notable variation being the PMA arising from a CT from the RA.

CASE PRESENTATION

The donor was received through the Saint Louis University Gift of Body Program of the Center for Anatomical Science and Education (CASE) with signed informed consent from the donor. The CASE gift body program abides by the rules set forth by the Uniform Anatomical Gift Act.

During a routine anatomy laboratory dissection, an unusual vasculature pattern was identified in the right upper limb of a 93-year-old male cadaver. The initial variation was observed as an SBA branching from the third part of the AA. After giving off a large SBA, the AA bifurcated into the subscapular artery and a common stem. The common stem traveled deep to the lateral cord's contribution to the median nerve, before it gave off the anterior and posterior circumflex humeral arteries and continued as a smaller BA (Figures 1,2).

The BA, which was 24.6 cm in length and had a diameter of approximately 3.8 mm, continued into the arm giving off numerous muscular branches as well as the deep brachial artery, which traveled with the radial nerve to the posterior compartment of the arm in the typical fashion (Figure 2). The BA continued distally, giving off the superior and inferior ulnar collateral arteries before terminating as a muscular branch to the brachialis muscle in the cubital fossa deep and lateral to both the median nerve and the SBA (Figures 3,4).

The SBA crossed over the medial cord's contributions to the median nerve and ran laterally to the nerve (Figure 2). It was 25.8 cm in length, had a diameter of approximately 5.4 mm, and bifurcated 1.08 cm proximal to the base of the cubital fossa as a small UA and a large RA (Figure 4).

The UA had an atypical branching pattern. It did not give off the anterior and posterior ulnar recurrent arteries or the common interosseous as normally seen. Rather, the UA provided only muscular branches along its course to contribute to the SPA after giving off the deep ulnar branch as it entered the hand. (Figures 4,5).

The RA also presented an atypical branching pattern. The RA traveled deep to the pronator teres muscle after first giving off the radial recurrent artery which anastomosed with the radial collateral artery as expected. While between the two heads of the pronator teres it then gave off a CT that gave a branch for a common trunk for the anterior and posterior ulnar recurrent arteries, anastomosing with typical ulnar collateral arteries (Figures 4,6). The CT then provided muscular branching before bifurcating into the PMA medially and the common interosseous artery laterally. The common interosseous artery gave rise to the anterior and posterior interosseous arteries as expected while the PMA initially traveled lateral to the median nerve before crossing it anteriorly and coursed medially to the nerve, giving off many muscular branches in the forearm. The diameter of the PMA was 2.8 mm. The PMA anastomosed with the UA just before entering the carpal tunnel (Figure 5). In the hand, together with RA, the PMA contributed to the SPA.

The subscapular artery and the humeral circumflex arteries traveled in a typical fashion after branching from the AA and common stem, respectively.

DISCUSSION

The median artery (MA) of the forearm is an embryological structure that delivers blood to the fetal hands during the first trimester of gestation. One hypothesis states that the MA arises from a plexus of capillaries that supply blood to the upper limb very early during gestation (Singer, 2005). These capillaries progressively differentiate and mature from the proximal to distal parts of the upper limb over time, forming the MA as well as other arteries. The MA typically undergoes regression and becomes an unnamed small artery that travels with the median nerve in the carpal tunnel, often supplying the nerve (Singer, 2005). Thus, the blood supply of the hand is typically replaced by the ulnar and radial arteries, as seen in children and adults. However, there is some debate about the exact timing of regression. Some sources claim the MA regresses at 8 weeks of gestation, while others argue that it regresses during the 28th to 52nd days (approximately 4 to 7 weeks) of gestation when the embryo is approximately 23 mm long. Yet, other sources claim that the MA regresses during the perinatal stage and early infancy (Rodríguez-Niedenführ et al., 1999; Kopuz et al., 1995). Regardless, if the MA fails to regress altogether, it remains as the PMA.

It has recently been noted that the prevalence of PMA is approximately 4%, though it is more commonly reported in individuals of South African descent, where the frequency was 27.1% (Henneberg et al., 1992). When discussing the presentation of PMAs in the general population, there is no difference in prevalence when comparing sexes or unilaterality/bilaterality (Eid et al., 2011; Acarturk et. al, 2008; Henneberg et al., 1992).

The PMA is often an important source of blood supply for the hand not only during gestation, but also during childhood and adulthood in populations with a PMA and a partial or complete absence of an SPA (Patnaik & Paul, 2016). Thus, it is important to note the presence and location of the PMA via ultrasound before performing wrist surgery on these patients to avoid injury to this important blood source.

The presence of a PMA is generally asymptomatic if the diameter is between 1 and 1.5 mm, but, more often, it can be a source of pain and paresthesia when a thrombus or aneurysm increases the diameter to greater than 2 mm (Khashaba, 2002; Chen et al., 2017; Barfred et al., 1985; Jeon et al., 2020). Altered median nerve function through thrombosis, aneurysm, rupturing, or physical impingement by the PMA can cause sudden onset of carpal tunnel symptoms. Sometimes, identifying the PMA as the cause of carpal tunnel can be difficult, especially if symptoms mimic tenosynovitis (Fricker et al., 1996). This highlights the importance of utilizing ultrasound imaging during diagnosis.

In a Polish study involving open carpal tunnel release surgery, a PMA was found in 2.8% of cases intraoperatively. Three of these PMAs contained thromboses, and all three required surgical resections (Osiak et al. 2021). Thus, there are a variety of suitable approaches to treating a PMA thrombus.

The presence of a PMA has been implicated in various entrapment neuropathies. For example, proximal median nerve neuropathies have been described in cases where the PMA pierces or splits the median nerve (Jones & Ming, 1988). Additionally, the presence of a PMA can contribute to pronator teres syndrome or anterior interosseous syndrome. Pronator teres syndrome may be caused by a PMA that perforates the median nerve and gives rise to anomalous vascular leash and fibrous bands to the flexor muscles, which compresses the nerve (Claassen et al., 2008; Proudman & Metnz, 1992). Although compression of the anterior interosseous nerve occurs most frequently by the head of the pronator teres muscle, anterior interosseous syndrome was noted in a patient whose PMA pierced the anterior interosseous nerve below the elbow (Proudman & Metnz, 1992).

The PMA could be considered as an alternate source of graft tissue for coronary artery bypass grafts (CABG) (Buch et al., 2019; Adnan & Yandrapalli, 2022). Use of the RA may result in symptoms such as paresthesia, pain, and occasionally hypoperfusion at harvest sites (Barner, 2013). The UA can be ligated when harvesting the RA for CABG, but this can result in severe ischemia, especially when both the UA and RA contribute to the SPA (Patnaik et al., 2002). The absence of the UA was responsible for hand ischemia after RA graft for CABG in a recently reported clinical case (Nunoo-Mensah, 1998). When there are multiple contributions to the SPA, the PMA may serve as a potential graft for a CABG without jeopardizing blood supply to the hand and may serve to minimize adverse postoperative symptoms.

The SBA is important in fetuses to support or replace the BA (Carroll et al., 2021). The current case presents a unique variation in the branching pattern of the SBA. This is a relatively rare variation of the SBA, found in 0.1-12.2% of patients (Carroll et al., 2021). In the early embryo, the superficial and deep brachial arteries anastomose at various levels of the arm, including a more proximal level and a more distal level (Singer, 2005; Yoshinaga et al., 2003). Normally, these anastomoses will regress along with the SBA, while the deep brachial artery will persist. However, if these anastomoses persist, the SBA will also persist, and its course of direction will depend on which anastomosis persists. For example, if the proximal anastomosis persists, the SBA will persist and course medial to the ulnar nerve. If the distal anastomosis persists, the SBA will persist and course lateral to the ulnar nerve; this is consistent with the variation found in the present case (Singer, 2005).

This SBA variation may or may not present with any pathology (Carroll et al., 2021). For unknown reasons, the SBA is more prone to injury and severe bleeding than the BA (Natsis et al., 2014; Chakravarthi et al., 2014). Awareness of this variant is especially important during orthopedic procedures such as repair of a fractured or dislocated humerus; as such, imaging before beginning a procedure would be prudent. The SBA in this case is found more superficially, making it more prone to injury.

CONCLUSIONS

The current case presents a novel set of vascular variations in the upper limb that includes an SBA and a PMA with a unique branching pattern that had not been previously reported in the literature. Awareness of such variations is important for healthcare providers due to the complications and pathology related to persistence of embryological arterial structures.

Disclosure

This case was presented, in part, in an abstract at the 2022 annual meeting of the American Association of Clinical Anatomists.

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Conflict of interest: None declared

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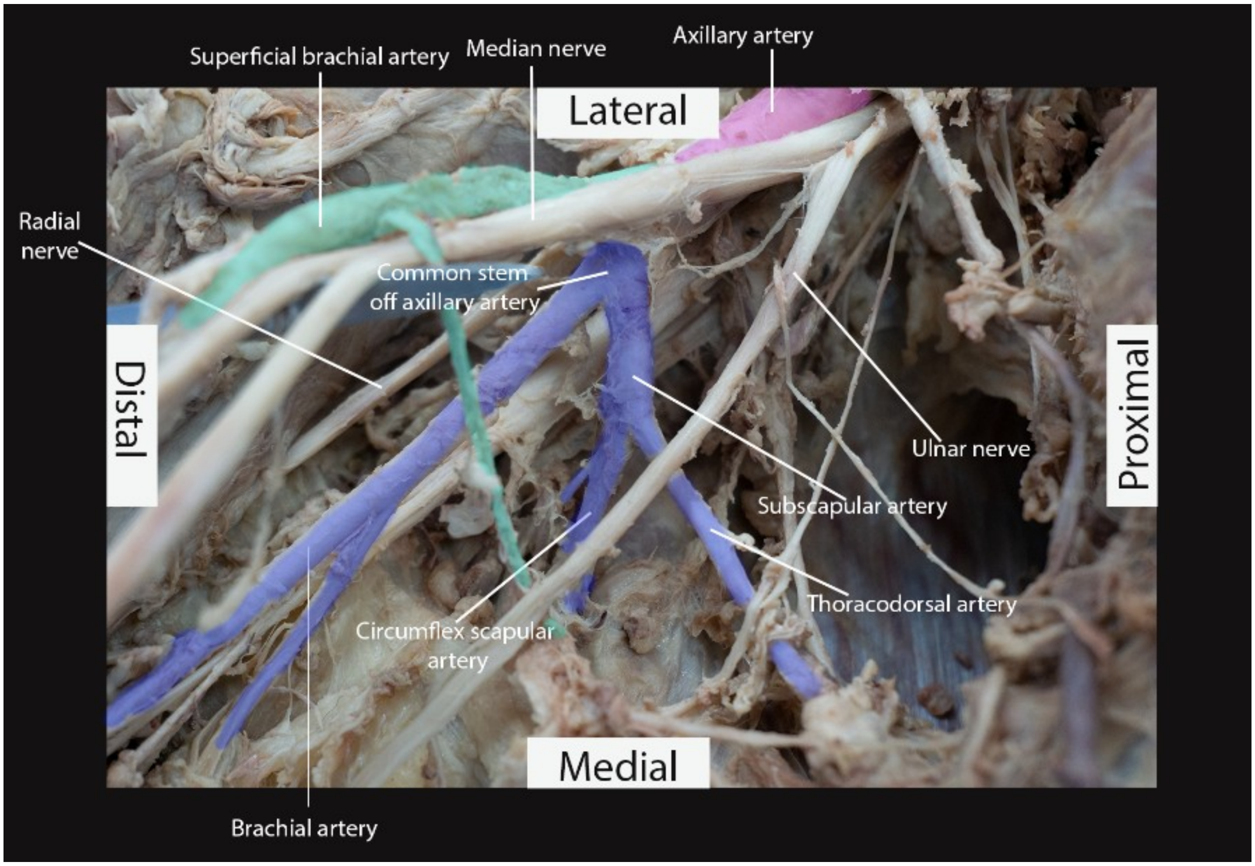

Figure 1. Medial view of the axillary region. The third part of the axillary artery (pink) gave off the superficial brachial artery (green), subscapular artery (purple) and a common stem for one of the branches, the brachial artery (purple). The superficial brachial artery with muscular branches visible, traveling superficially to the lateral contribution of the median nerve and running lateral to the median nerve.

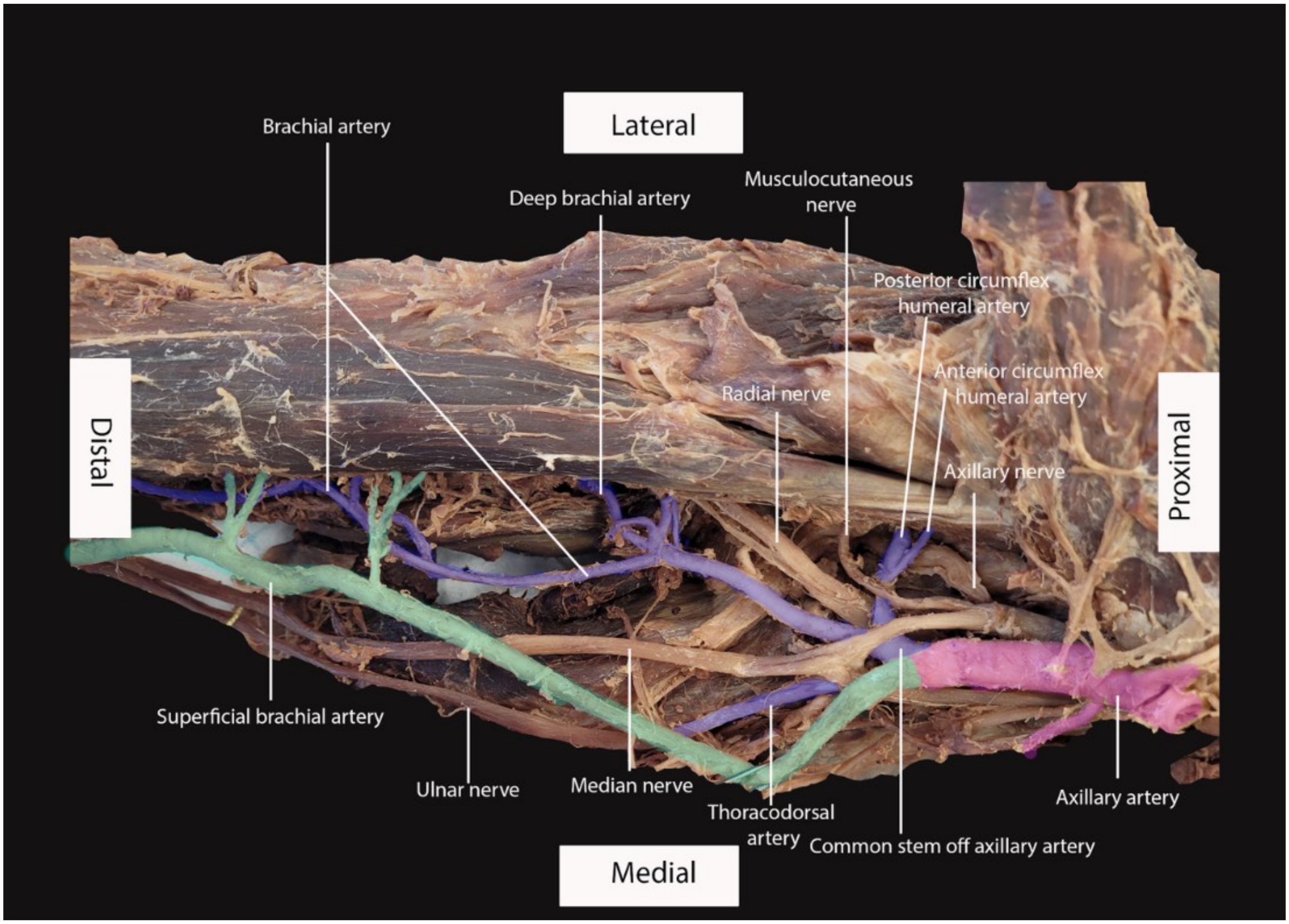

Figure 2. Axillary regions with additional views of the common stem off the axillary artery. The third of the axillary artery (pink) giving off the superficial brachial artery (green) with muscular branches in the biceps brachii. The common stem off the axillary (purple) gives off a division for the anterior and posterior humeral circumflex arteries, the subscapular artery traveling deep to the median nerve, and the brachial artery and deep brachial arteries.

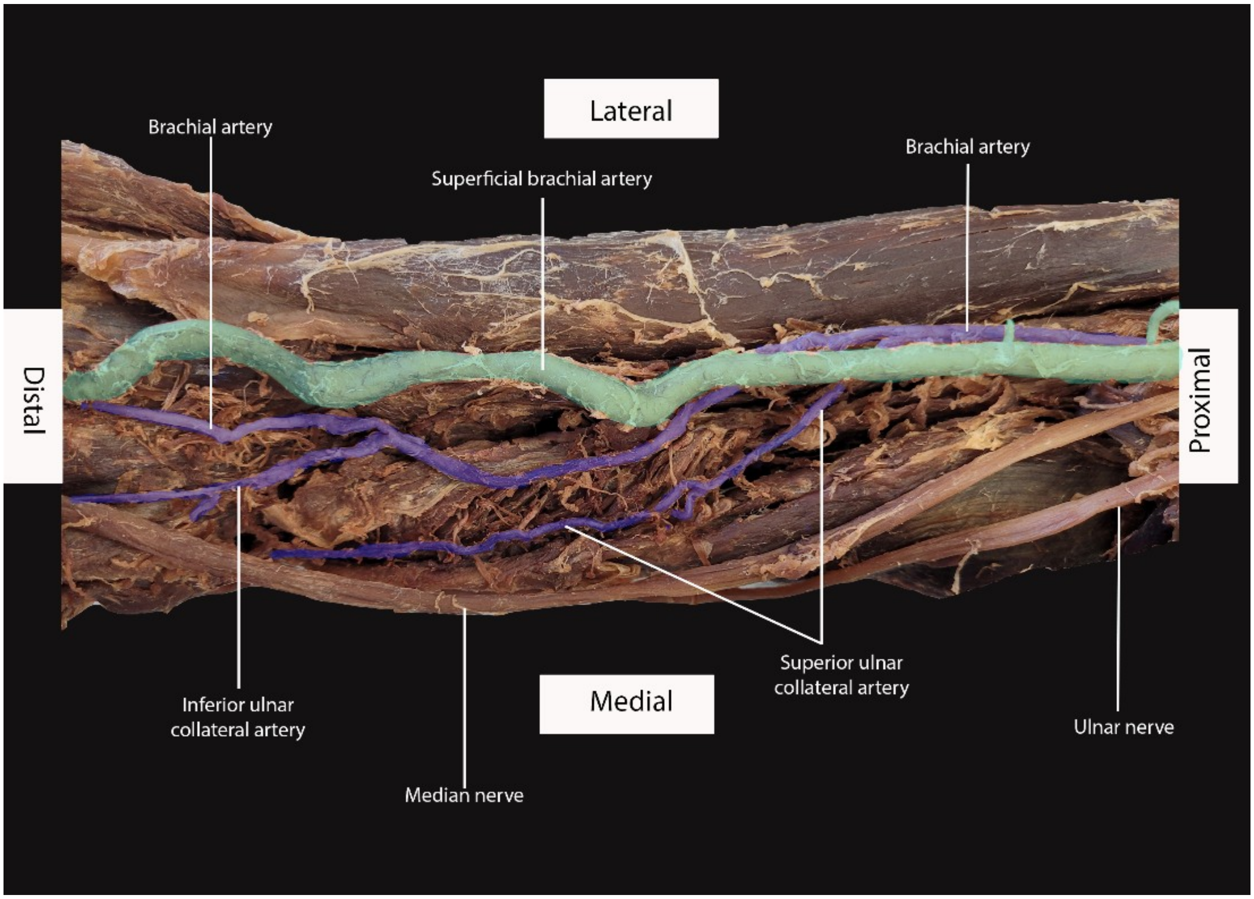

Figure 3. View of the arm proximally to the elbow joint. The superficial brachial artery (green) travels superficially to the neurovasculature of the arm, giving off muscular branches. The brachial artery (purple) travels distally with superior and inferior ulnar collateral arteries branches.

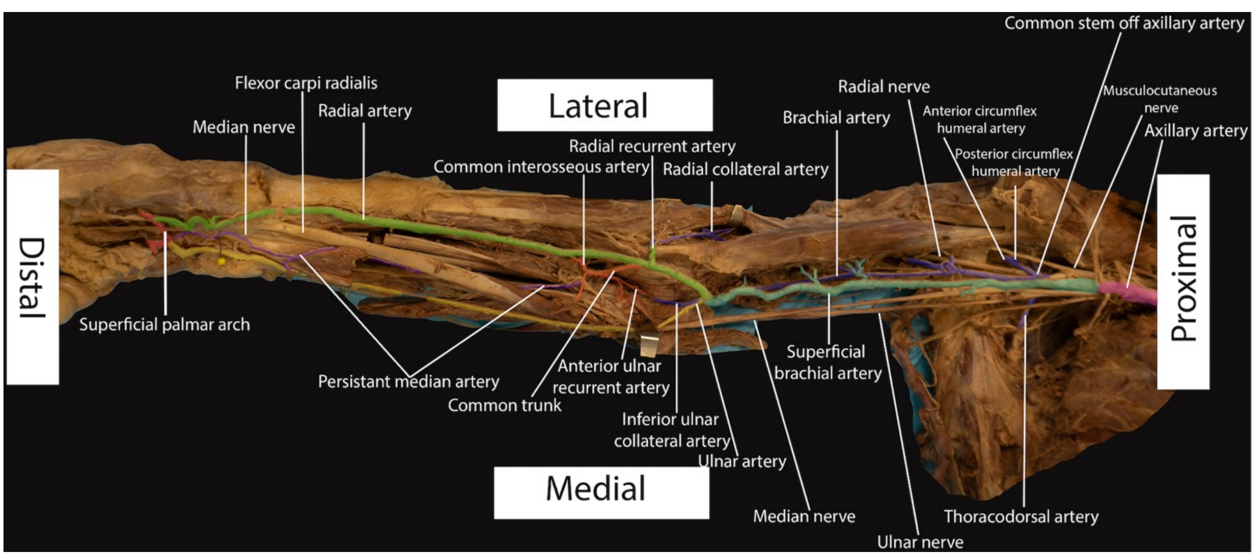

Figure 4. Overview of unique vascularization of the case. The axillary artery (pink) gives off the superficial brachial artery (aqua) traveling superficially to the brachial plexus before bifurcating into the radial artery (green) and ulnar artery (yellow). The common stem with branching (purple) becomes the brachial artery, giving off branches of the superior and inferior ulnar collateral arteries, radial collateral artery and muscular branches. It terminates in the brachialis muscle.

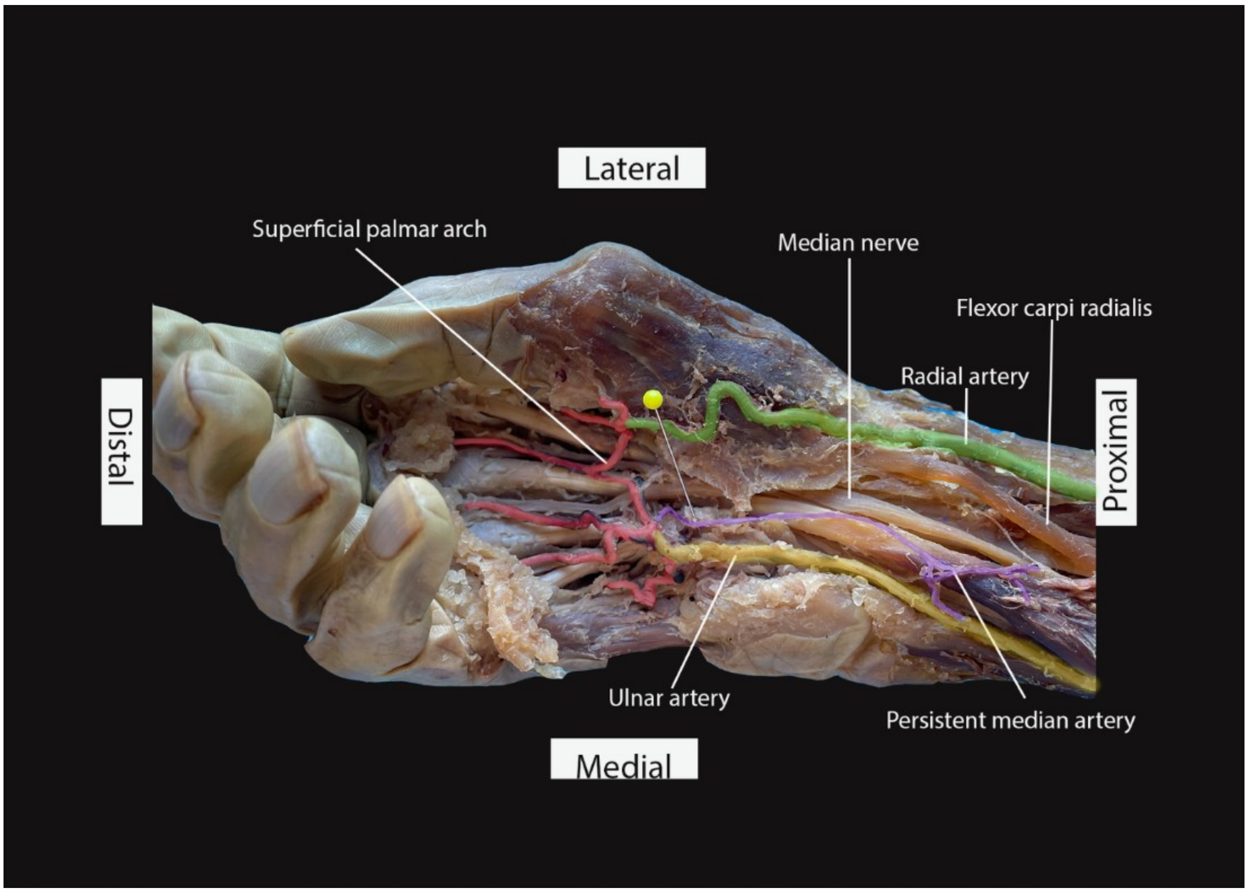

Figure 5. View of the superficial palmar arch containing the contributions of the ulnar artery (yellow) and radial artery (green). The persistent median artery (purple) is shown, anastomosing with the ulnar artery and entering the wrist.

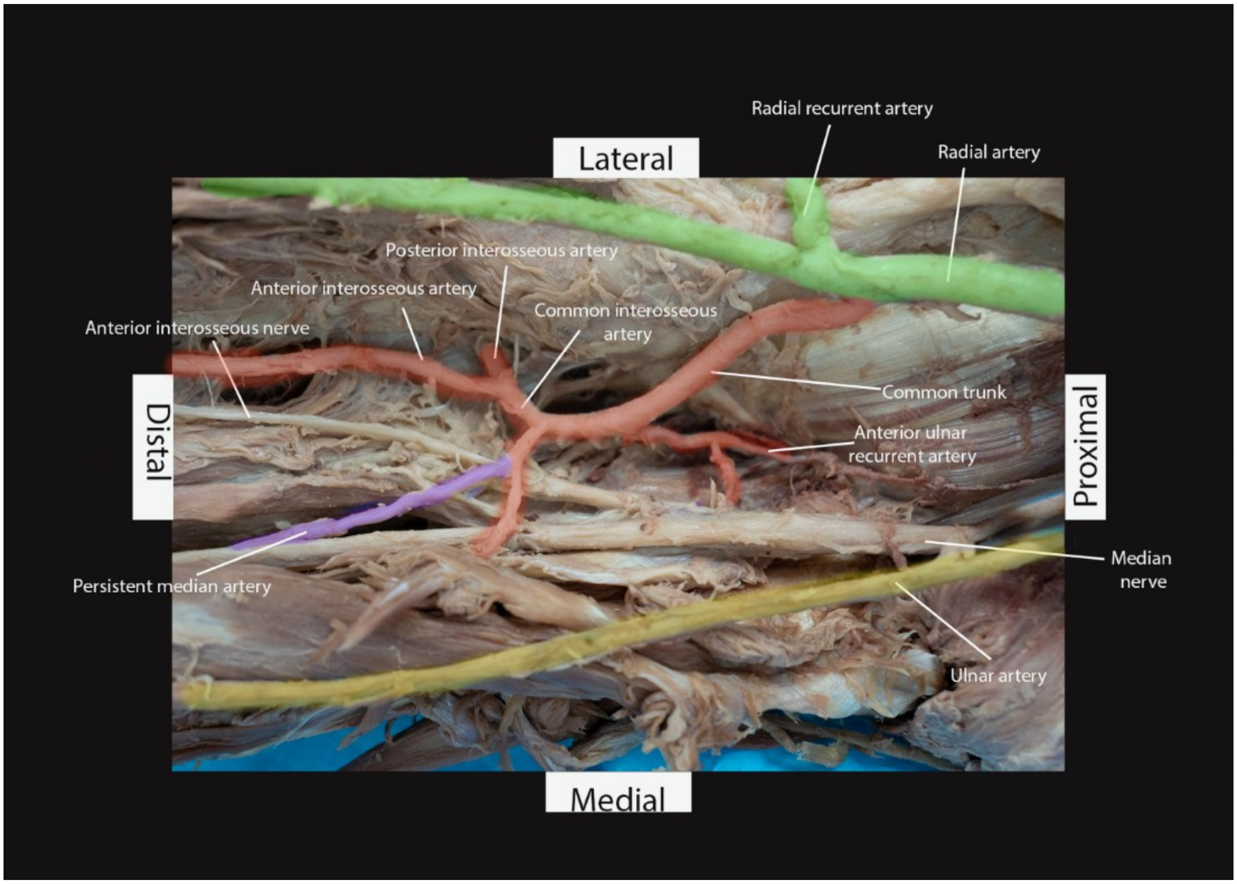

Figure 6. View of the unique branching of the radial artery (green). The CT arises from the radial artery, giving a branch for a common trunk for the anterior and posterior ulnar recurrent arteries. It continues to give the common interosseous artery and the persistent median artery (purple).