SHORT REPORT

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Study of two cases of high-origin radial artery in humans

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Summary

Variations in the normal arterial anatomical pattern are very common and among them the high origin of the radial artery is the most frequent variation. We report two cases of a unilateral high-origin radial artery with different variations in each case in the course of the artery, along with a review of the literature. From an embryological point of view, the presence of a radial artery of high origin is established by developmental stage 18 and may be due to a differentiated hemodynamic predominance of the deep arterial segments over the superficial arterial network, chemical factors, foetal position in the uterus, developmental arrest in early stages, and genetic predisposition. Additionally, a high-origin radial artery may complicate medical procedures, leading to misdiagnosis and easier injury. Finally, we discuss the terminology problem we came across reviewing the literature because a number of studies refer to this variant using different terms.

Key words: Anatomy – Arterial variations – Radial artery – High-origin

Introduction

The vascular variations of the upper limb have been well studied (Drizenko et al., 2000; Fuss, 1988; Pelin et al., 2006; Rodríguez-Niedenführ et al., 2003; Yalcin et al., 2006). Remarkably, there is evidence that these variations have captured the interest of anatomists from as early as 1600 (McCormack et al., 1953). The incidence of an abnormality in the arterial anatomy of the upper limb varies from 18.53% to 20% (McCormack et al., 1953; Rodríguez-Niedenführ et al., 2001a; Wankoff, 1962). Diversions of the radial artery from its normal anatomical pattern as regards its origin or its course constitute the largest group of vascular variations of the upper extremity (Drizenko et al., 2000; Gonzalez-Compta, 1991; McCormack et al., 1953; Rodríguez-Niedenführ et al., 2001b). Normally, when the axillary artery passes the inferior border of the tendon of the latissimus dorsi muscle it continues as the brachial artery. The brachial artery at the level of the radial neck divides into the radial artery and the ulnar artery. A radial artery of high origin may arise either from the brachial or more rarely from the axillary artery (Bergman et al., 1988; Drizenko et al., 2000; McCormack et al., 1953; Pelin et al., 2006). Due to its variant course the

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radial artery may be of clinical importance (Funk et al., 1995; Hazlett, 1949; Jurjus et al., 1986; Unglietta and Kadir, 1989).

The present article describes two cases of a unilateral high-origin radial artery with different variations in each case in the course of the artery, along with a review of the literature, an embryological explanation and its clinical impact.

Case Report

During anatomy dissection at our department, we observed two cases of radial arteries that were anomalous in their origin and course.

The first case was a unilateral case of a high-origin radial artery in a 77-year-old Caucasian female cadaver. The radial artery originated from the anteromedial surface of the left brachial artery, approximately 2.5 cm below the lower border of the latissimus dorsi tendon, at the origin of the deep brachial artery. The deep brachial artery had a normal course. Initially, the radial artery in the arm passed medial to the median nerve along with the brachial artery. In the distal part of the arm, the radial artery crossed over the median nerve running lateral to it. In the arm, it coursed along the medial border of the biceps brachii muscle, and supplied the anterior muscles with many vascular branches (Fig.1A). Then, it crossed the cubital fossa deep to the superficial veins and the bicipital aponeurosis. In the forearm, the radial artery was located over the pronator teres muscle, and it coursed along the medial border of the brachioradialis and beneath the antebrachial fascia. In the distal two thirds of the forearm, wrist and hand, the radial artery followed the usual course. At the point of its normal bifurcation, in the cubital fossa, the brachial artery did not divide and continued as an ulnar artery. We did not observe any anastomosis between the major arteries of the upper limb and the radial artery after the origin of the latter. Additionally, the palmaris longus muscle was absent in the forearm (Fig.1B). However, no other arterial, muscular or neural anatomical variations were observed in the left upper limb.

The second case was a unilateral high-origin radial artery in an 82-year-old Caucasian male cadaver. The radial artery originated from the anteromedial surface of the right brachial artery, approximately 2.7 cm distal to the lower border of the latissimus dorsi tendon and below the origin of the deep brachial artery. The deep brachial artery had a normal course. Initially, the radial artery passed lateral to the median nerve along with the brachial artery. Then, it crossed the median nerve twice, first under the nerve and then over it passing again lateral to it (Fig.2A). In the cubital fossa, the nerve passed under the superficial veins and the bicipital aponeurosis. In the forearm, wrist and hand, the radial artery had a normal anatomical pattern. Additionally, the palmaris longus muscle was absent in the forearm (Fig.2B). However, no other arterial, muscular or neural anatomical variations were present in the right upper limb.

Discussion

Anatomy

Variations in the normal arterial anatomical pattern are very common, with an incidence of up to 20 % (McCormack et al., 1953; Rodríguez-Niedenführ et al., 2001a; Wankoff, 1962). Radial artery variations are the largest group. According to the literature, the high origin of the radial artery is the most common arterial variation in the upper limb (Drizenko et al., 2000; Gonzalez-Compta, 1991). Many authors have studied this variation, and its incidence varies from 4.17% to 15.60% in cadavers and embryos (Adachi, 1928; Keen, 1961; McCormack et al., 1953; Muller, 1903; Quain, 1844; Rodríguez-Baeza et al., 1995; Rodríguez-Niedenführ et al., 2001a, b; Skopakoff, 1959; Wankoff, 1962; Weathersby, 1956). In angiographic images the incidence varies from 8.00% to 24.40% (Gonzalez-Compta, 1991; Janevski, 1962; Karlsson and Niechajev, 1982; Unglietta and Kadir, 1989; Valsecchi et al., 2006). Table 1 shows our results and a review of the literature.

This variant artery often arises from the proximal third of the brachial artery and less frequently from the axillary artery (Bergman et al., 1988; Drizenko et al., 2000; Keller et al., 1980; Rodríguez-Baeza et al., 1995). Usually, the radial artery of high origin runs along the medial border of the biceps brachii muscle, superficially to the median nerve (McCormack et al., 1953). At the level of the cubital fossa, the artery usually passes posterior to the bicipital aponeurosis and less frequently ante-

Table 1. Review of the literature concerning the incidence of a high-origin radial artery.

a/a	author	(year)	specimen	sample	cases	%	Origin (axillary/brachial)
1	Quain	1844	cadavers	429	53	12,35%	30% axillary-70% brachial
2	Muller	1903	embryos	300	31	10,33%	25,8% axillary-74,2% brachial
3	Adachi	1928	cadavers	410	29	7,07%	31% axillary-69% brachial
5	McCormack	1953	cadavers	750	107	14,27%	15% axillary-85% brachial
6	Weatherby	1956a	cadavers (249) and embryos (159)	408	/	15,60%	25% axillary-75% brachial
7	Skopakoff	1959	cadavers	610	55	9,02%	no reference
8	Keen	1961	cadavers	284	17	5,99%	no reference
9	Wankoff	1962	cadavers (3/4) and embryos (1/4)	800	79	9,88%	no reference
10	Janevski	1982	angiographic images	250	61	24,40%	21,3% axillary-78,7% brachial
11	Karlsson	1982	angiographic images	82	8	9,76%	12,5% axillary-87,5% brachial
12	Fuss	1985	cadavers	200	14	7,00%	no reference
13	Uglietta	1989	angiographic images (arteriograms)	100	8	8,00%	12,5% axillary-87,5% brachial
14	Rodriguez-Baeza	1995	cadavers	150	7	4,67%	25% axillary-75% brachial
15	Rodriguez-Niedenfuhr	2001	embryos	150	21	14,00%	24% axillary-76% brachial
16	Rodriguez-Niedenfuhr	2001	cadavers	384	53	13,80%	23%axillary-77% brachial
17	Valsecchi	2006	angiographic images	2211	185	8,30%	35,6% axillary-64,4% brachial
18	our results	2009	cadavers	48	2	4,17%	100% brachial

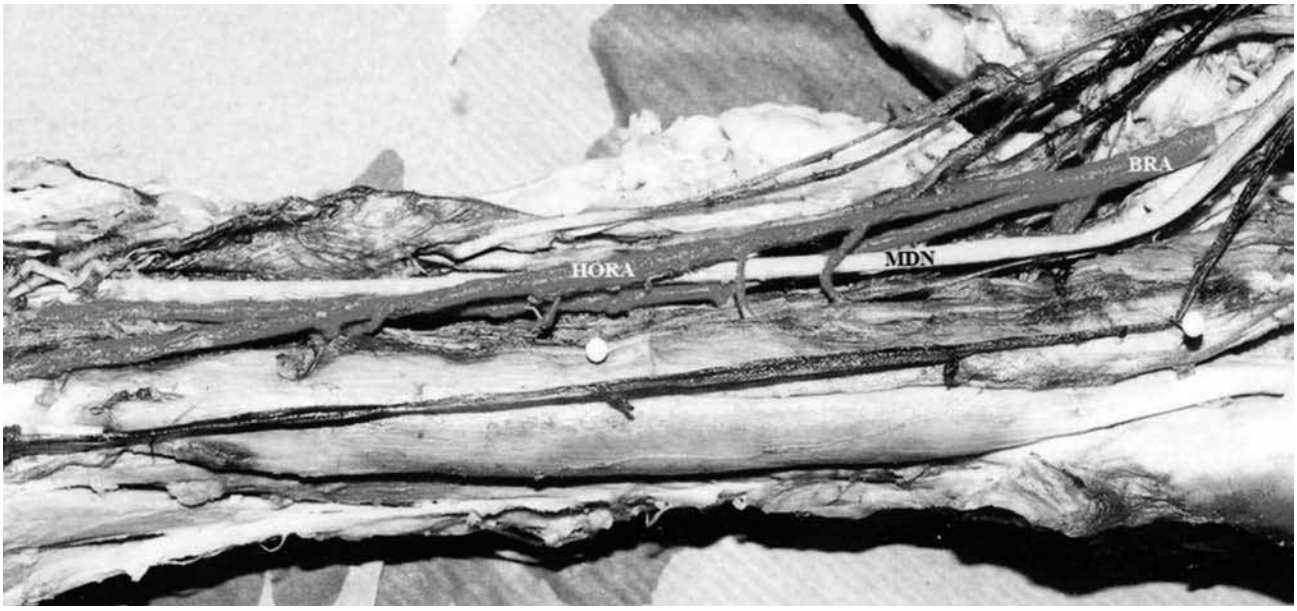

Figure 1A. Case 1. The radial artery originates from the proximal third of the left brachial artery and lies superficial to the median nerve. HORA: High origin of radial artery stained; BRA: Brachial artery stained; MDN: Median nerve.

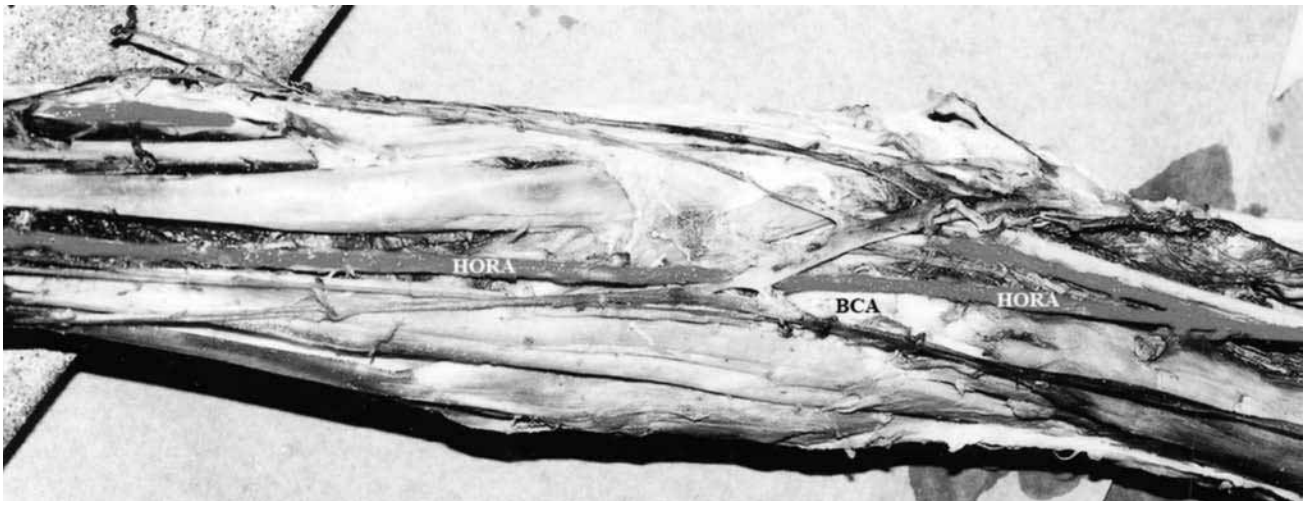

Figure 1B.- Case 1. In the cubital fossa the radial artery lies under the bicipital aponeurosis. In the forearm, the radial artery follows a course similar to that of a normal radial artery. HORA: High origin of radial artery stained; BCA: Bicipital aponeurosis.

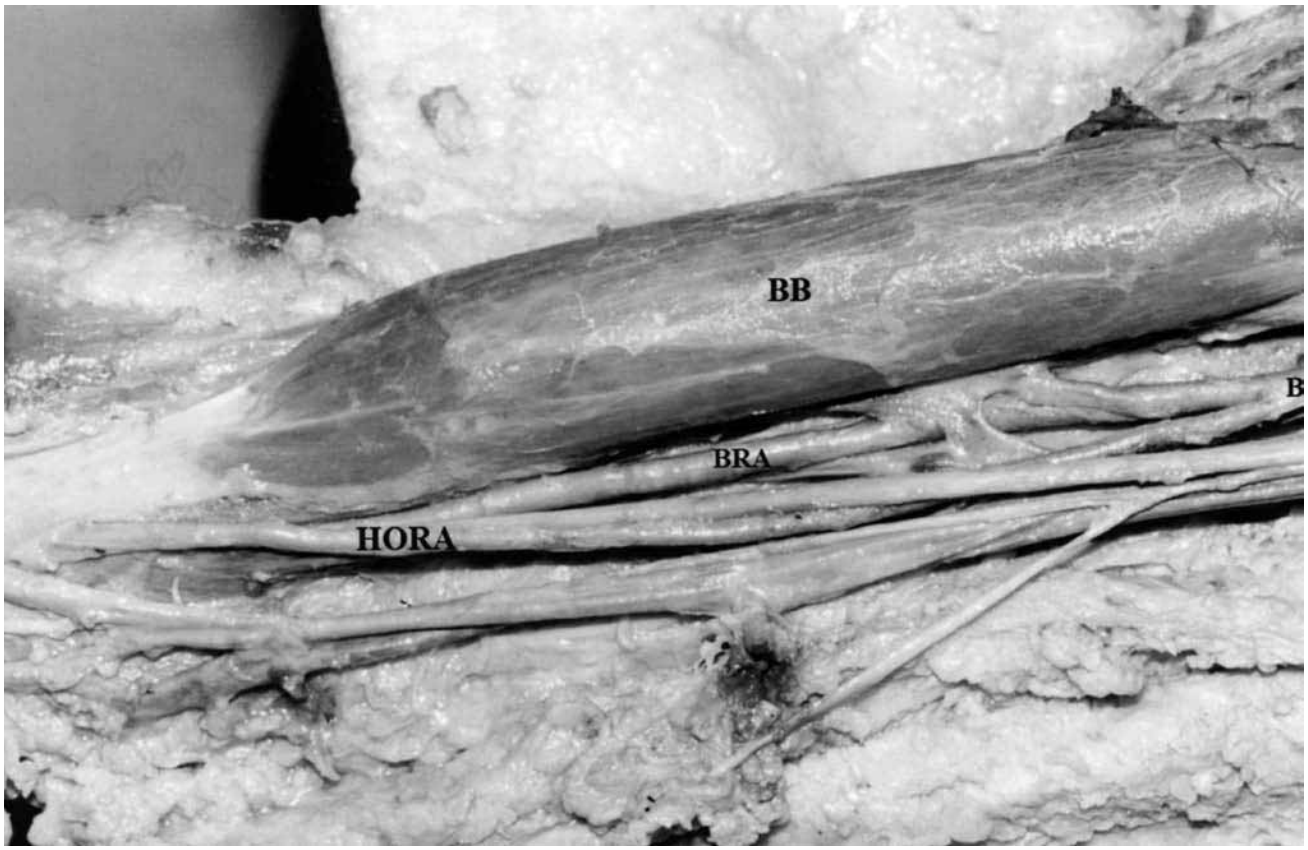

Figure 2A.- Case 2. Course of the radial artery of high origin in the arm. HORA: High origin of radial artery stained; BRA: Brachial artery; BB: Biceps brachii muscle.

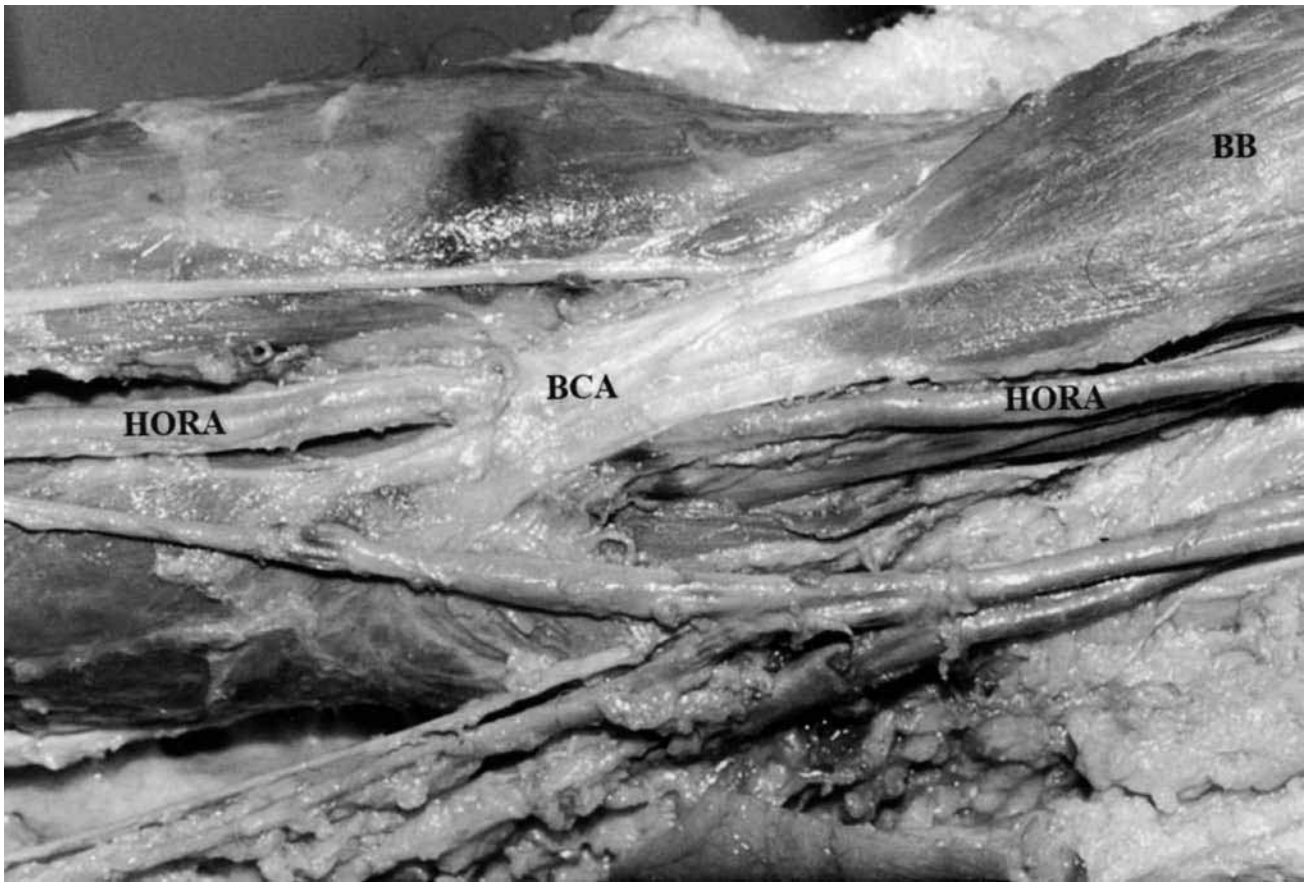

Figure 2B.- Case 2. In the cubital fossa the radial artery passes under the bicipital aponeurosis. HORA: High origin of radial artery stained; BCA: Biceps brachii aponeurosis; BB: Biceps brachii muscle.

rior to it (Drizenko et al., 2000). There is no statistically significant difference regarding the incidence reported in the literature for both males vs females and left vs right side (Rodríguez-Niedenführ et al., 2001b). However, it occurs more often unilaterally (Gruber, 1867; Keen, 1961). Additionally, an anastomotic vessel may exist in the region of the cubital fossa, connecting the radial artery with the brachial artery or more rarely with the median artery. The incidence of this variation ranges from 18.67% to 50% (Adachi, 1928; McCormack et al., 1953; Muller, 1903; Quain, 1844; Rodríguez-Niedenführ et al., 2001b; Wankoff, 1962; Weathersby, 1956). In these cases, the anastomosis passes more frequently in front of the biceps tendon (Gruber, 1867; Ljubomudroff, 1927; McCormack et al., 1953; Muller, 1903; Quain, 1844; Rodríguez-Baeza et al., 1995; Rodríguez-Niedenführ et al., 2001b). Whenever a radial artery of high origin is present, the radial recurrent artery arises most frequently from the variant artery (Rodríguez-Niedenführ et al., 2001b). However, it may also arise from the deep brachial artery or, in those cases where there is an anastomotic vessel in the region of the cubital fossa, the radial recurrent artery arises more frequently from the anastomosis (McCormack et al., 1953). In the forearm, the radial artery of high origin follows the course of a normal radial artery (Drizenko et al., 2000). In our cases, the radial artery originated from the proximal third of the brachial artery. In the first case, the radial artery was superficial to the median nerve and in the cubital fossa passed posterior to the bicipital aponeurosis. In the second case, at the beginning the artery was beneath the median nerve and at the distal third of the arm it ran superficial to it. At the level of the cubital fossa, it passed posterior to the bicipital aponeurosis. In both cases, there was no anastomotic vessel between the radial artery of high origin and the deep brachial artery. Finally, the radial recurrent artery arose from the radial artery of high origin in both cases.

Terminology

In the literature, although there are many studies of the arterial variations of the upper limb, different authors apply different criteria, using many different names to refer to the same artery (Rodríguez-Niedenführ et al., 2003). For example, the high origin of the radial artery was named arteria brachialis superficiallis continuing as the radial, superficial radial artery, type 5 (Fuss et al., 1985), type III, IX, XII, XIV & XV (Wankoff, 1962) and type B1 (Anagnostopoulos and Venieratos, 1999). Rodriguez-Niedefur et al. (2001b), following the Barkow criteria (Barkow, 1869), proposed the term brachioradial artery as the most appropriate. The use of a universally accepted terminology among the anatomists is of great importance. According to the literature, a superficial radial artery has a normal origin but in the antebrachium it lies above the antebrachial fascia, which means that it courses over the brachio-radialis or the extensor tendons of the thumb that define the snuffbox (D'Costa et al., 2004; Sachs, 1987). In these cases, the artery may or may not have a high origin.

Embryology

The understanding of the arterial variations of the upper limb is based on the study of the normal embryological development and the factors that might cause diversions from it. According to the most recent embryological anatomical study, the arteries of the upper limb originate from an initial capillary plexus in a proximal to distal differentiation and this is a result of the maintenance, enlargement and differentiation of certain capillary vessels and the regression of others. This maturation process starts from the aorta at embryonic stage 13 (4-6 mm; 28d), and by embryonic stage 18 (13-17 mm; 44d) it has reached the forearm arteries, except the distal part of the radial artery (Rodríguez-Niedenführ et al., 2001a, 2003). Consequently, the presence of a radial artery of high origin is established by developmental stage 18. Although, it is impossible to know the exact factors responsible for each arterial variation, several modifications may occur due to a differentiated hemodynamic predominance of the deep arterial segments over the superficial arterial network, chemical factors, foetal position in the uterus, developmental arrest in early stages, and genetic predisposition (Natsis et al., 2006; Poteat, 1986).

Clinical Significance

Anatomists usually focus on the rare variants. However, arterial variations that occur more frequently have greater clinical significance, and are consequently important for surgeons and radiologists (Brown et al., 1999). The radial artery is frequently used in surgical

procedures such as when raising a radial forearm flap, as graft for coronary bypass and in transradial approach during coronary interventions (Funk et al., 1995; Pelin et al., 2006, Valsecchi et al., 2006; Yalcin et al., 2006). The transradial approach has gained acceptance over the transfemoral and/or transbrachial techniques for coronary procedures since it reduces dramatically the site complications. The transradial approach is safer because the radial artery is not surrounded by major veins or nerves. Additionally, in case of thrombotic or traumatic occlusion of the radial artery the viability of the hand is not in danger if there is adequate blood supply from the ulnar artery. Moreover, the superficial location of the radial artery facilitates the haemeostasis (Valsecchi et al., 2006). The anatomic variations of the radial artery have great impact on harvesting for coronary bypass grafting. Over the past decades, the radial artery has become a useful vascular conduit for coronary artery bypass grafting, and has very good mid-term patency rate. The preoperative assessments of the ulnar artery collateral blood supply are not sufficient, since it is important to understand the anatomy of the radial artery harvesting site in order to avoid any neurovascular complications of the forearm. The anatomic variations of the radial artery are very common and consequently, the incidence of these complications is even higher (Alameddine et al., 2004). In theory, unusual findings in pulse palpation or Doppler indicate a developmental variation of forearm arterial anatomy. However, negative palpation cannot always exclude the presence of an arterial variation (Alameddine et al., 2004; Chin and Singh, 2005). In our cases, the diagnosis of the radial artery of high origin by palpation of the distal part of the forearm was impossible owing to the normal course of the artery at this part. Since, upper extremity arterial angiography is not frequently performed preoperatively; arterial variations remain intraoperative incidental findings. However, an arterial angiography should be performed when there is difficulty in advancement of the guidewire or the catheter in transradial procedures (Valsecchi et al., 2006).

Moreover, a variant radial artery may complicate angiographic procedures and lead to misinterpretation of incomplete angiographic images (Karlsson and Niechajev, 1982; Keller, 1961; Pelin et al., 2006; Uglietta and Kadir, 1989). Furthermore, an accidental intra-arterial injection may have catastrophic results, leading to gangrene of fingers, muscular contraction, or drug poisoning (D'Costa et al., 2004; Drizenko et al., 2000; Hazlett, 1949; Jurjus et al., 1986; Uglietta and Kadir, 1989). This risk is due to the artery's close proximity to the superficial veins in the cubital fossa where the vast majority of venipuncture is performed. Additionally, the superficial position of the radial artery makes it more vulnerable to trauma resulting in bleeding (Drizenko et al., 2000; Jurjus et al., 1986). The presence of a radial artery of high origin is also important owing to its relationship with the median nerve. Compression of the nerve by the radial artery could be misdiagnosed as radiculopathy and neuropathy (Pelin et al., 2006). This is more likely to happen when the artery passes around the nerve, such as in the second case described in this article. However, its presence can simplify medical procedures such as catheterization of the cardiac cavities (Drizenko et al., 2000; Jurjus et al., 1986).

A high-origin of the radial artery is the most frequent arterial variation of the upper limb (Gonzalez-Compta, 1991, McCormack et al., 1953). Owing to its frequent occurrence, it is of great clinical significance. Its presence may complicate medical procedures, leading to misdiagnosis and easier injury (D'Costa et al., 2004; Funk et al., 1995; Jurjus et al., 1986; Yalcin et al., 2006). In the literature, there are many studies referring to this variant but using different terms, such as high-origin of the radial artery, superficial radial artery, superficial superior radial artery, brachioradial artery, etc (Rodriguez-Niedenfuhr et al., 2003). This problem in terminology, concerning not only this arterial variation, must be solved.

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