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Anastomosis at the level of the elbow joint connecting the deep, or normal, brachial artery with major arterial variations of the upper limb

Major variations of the principal arteries of the upper limb have long received the attention of anatomists. These variations can be summarised as the presence of 2 main arteries traversing the cubital fossa, a deep (or normal) brachial artery in coexistence with a superficial brachial, radial or ulnar artery. Anastomosis between these arterial trunks at elbow level has been reported in 1–6% of cases as an incidental finding in studies on the major arterial variations of the upper limb (Quain, 1844; Müller, 1903; Poynter, 1922; Adachi, 1928; McCormack et al. 1953; Wankoff, 1962; Rodríguez-Baeza et al. 1995). Only a single report (Ljubomudroff, 1927) has dealt specifically with the anastomosis.

The anatomical pattern of the anastomosis has been classified into 2 or 3 types depending on different morphological details. Three types have been described, taking into account its length, calibre and form (Quain, 1844) or the positions of the origin and number of recurrent radial arteries (Ljubomudroff, 1927). Two types have been described on the basis of whether the anastomosis coursed anterior or posterior to the bicipital tendon (McCormack et al. 1953). The aim of this study was to revisit these specific morphological details in a statistically reliable sample in order to catalogue the variations of the anastomosis and to provide an embryological explanation.

A total of 79 embalmed cadavers were examined (35 male, 44 female) with an age at death ranging from 57 to 101 y. They had been partly dissected by Cambridge preclinical students in Autumn 1996 and 1997. Statistical comparisons between percentages were performed by the χ^2 test; $P < 0.05$ was regarded as statistically significant.

Our results confirm the descriptions of other authors reporting that when there are 2 main arteries in the cubital fossa (a deep, or normal, brachial coexisting with a superficial brachial, radial or ulnar artery), an anastomosis between them may be present (Quain, 1844; Baader, 1866; Charles, 1873, 1875; Müller, 1903; Forster, 1917; Michelsson, 1920; Poynter, 1920; Ljubomudroff, 1927; Adachi, 1928; McCormack et al. 1953; Weathersby, 1956; Skopakoff, 1959; Wankoff, 1962; Rodríguez-Baeza et al. 1995). The anastomosis has been reported with a frequency ranging from less than 1% to 6% (Quain, 1844; Müller, 1903; Chouéki-Guttenbrunner et al. 1990; Rodríguez-Baeza et al. 1995).

In 38 (24%) of the 158 upper limbs studied there were arterial variations (Table 1) connected by an anastomotic branch at elbow level in 14 cases, 9% of the total sample (Table 2). These anatomoses, in relation to the major arterial variations, showed a similar distribution to the values reported by other authors (Table 3). The fact that the superficial radial artery is the most frequently involved in the anastomosis is a direct consequence of the higher frequency of its presence compared with others, as has

previously been described (Lippert & Pabst, 1985; Bergman et al. 1988; Tountas & Bergman, 1993). The anastomosis appeared bilaterally in 2 and unilaterally in 10 cases (Table 2). The χ^2 test ($P < 0.05$) did not show statistically significant differences between male and female subjects ($\chi^2 = 3.25$; $P = 0.071$), or right and left sides ($\chi^2 = 2.84$; $P = 0.093$). However, there were statistically significant differences between unilateral and bilateral presence. Those

Table 1. Arterial variations found in 158 upper limbs and the related anastomosis at the cubital fossa

	Cases	Cases with anastomosis
SRA	29 (18.4%)	12 (41%)
SUA	8 (5%)	1 (13%)
SBA	1 (0.6%)	1 (100%)
Total (n = 158)	38 (24%)	14 (37%)

SRA, superficial radial artery; SUA, superficial ulnar artery; SBA, superficial brachial artery.

Table 2. Distribution of the anastomosis between the deep (normal) brachial artery and the arterial variations of the upper limb related to sex and side

	Left	Right
Male (n = 35)	1 (2.9%)	2 (5.7%)
Female (n = 44)	3 (6.9%)	8 (18.2%)
Total (n = 79)	4 (5.1%)	10 (12.7%)

Table 3. Distribution of the anastomosis in relation to the variation present in the upper limb shown by different authors and compared with the present report

	Superficial radial (%)	Superficial ulnar (%)	Superficial brachial (radial branch) (%)
Quain (1844)	94	6	—
Müller (1903)	80	—	20
Ljubomudroff (1927)	90	10	—
McCormack et al. (1953)	95	5	—
Wankoff (1962)	91	6	3
Rodríguez-Baeza et al. (1995)	100	—	—
Present report	86	7	7



Fig. 1. Anterior view of the antecubital fossa showing a superficial radial artery with a sling-like loop anastomosis (arrows) connecting it with the deep or normal brachial artery. (a) Anastomosis coursing in front of the bicipital tendon. (b) Anastomosis coursing behind the bicipital tendon. b, brachial artery; sr, superficial radial artery; m, median nerve; p, pronator teres; br, brachioradialis muscle; rr, recurrent radial artery/ies.

aspects have not been mentioned previously in the literature consulted.

In some cases with 2 brachial arteries (superficial and deep), a fusion of both vessels (as opposed to the anastomotic vessel connecting both arteries) to create a single brachial artery (Quain, 1844; Adachi, 1928; Keen, 1961; Rodríguez-Baeza et al. 1995) has also been described as island formation or 'Inselbildung' (Ruge, 1884). This was not found in the present study.

It is necessary to review the previous classifications of the anastomosis based on its morphology (Quain, 1844), relations (McCormack et al. 1953) and associations with the origin of the recurrent radial artery (Ljubomudroff, 1927).

Morphology. The anastomosis showed different patterns based on its form (sling-like loop or rectilinear), calibre (large or slender) and length (long or short). The anasto-

moses with a sling-like loop form were thick and long in all 9 (64%) cases (Fig. 1a, b) whereas the remaining 5 (36%) cases adopted a rectilinear form (Fig. 2a, b). These incidences differ from those previously described by other authors who reported a 20% to 50% occurrence of a sling-like loop, thick and long vessel, and a 50% to 80% occurrence of a rectilinear vessel varying in length and calibre (Quain, 1844; Müller, 1903; McCormack et al., 1953).

In the rectilinear form it was large and short in 2 cases (Fig. 2a) and slender and long in 3 cases (Fig. 2b). In the former type it connected the superficial ulnar and radial arteries with the deep brachial artery (Fig. 2a) while in the latter it connected the superficial radial artery (1 case as a branch of the superficial brachial artery) with the deep brachial artery (Fig. 2b). The sling-like loop anastomosis,

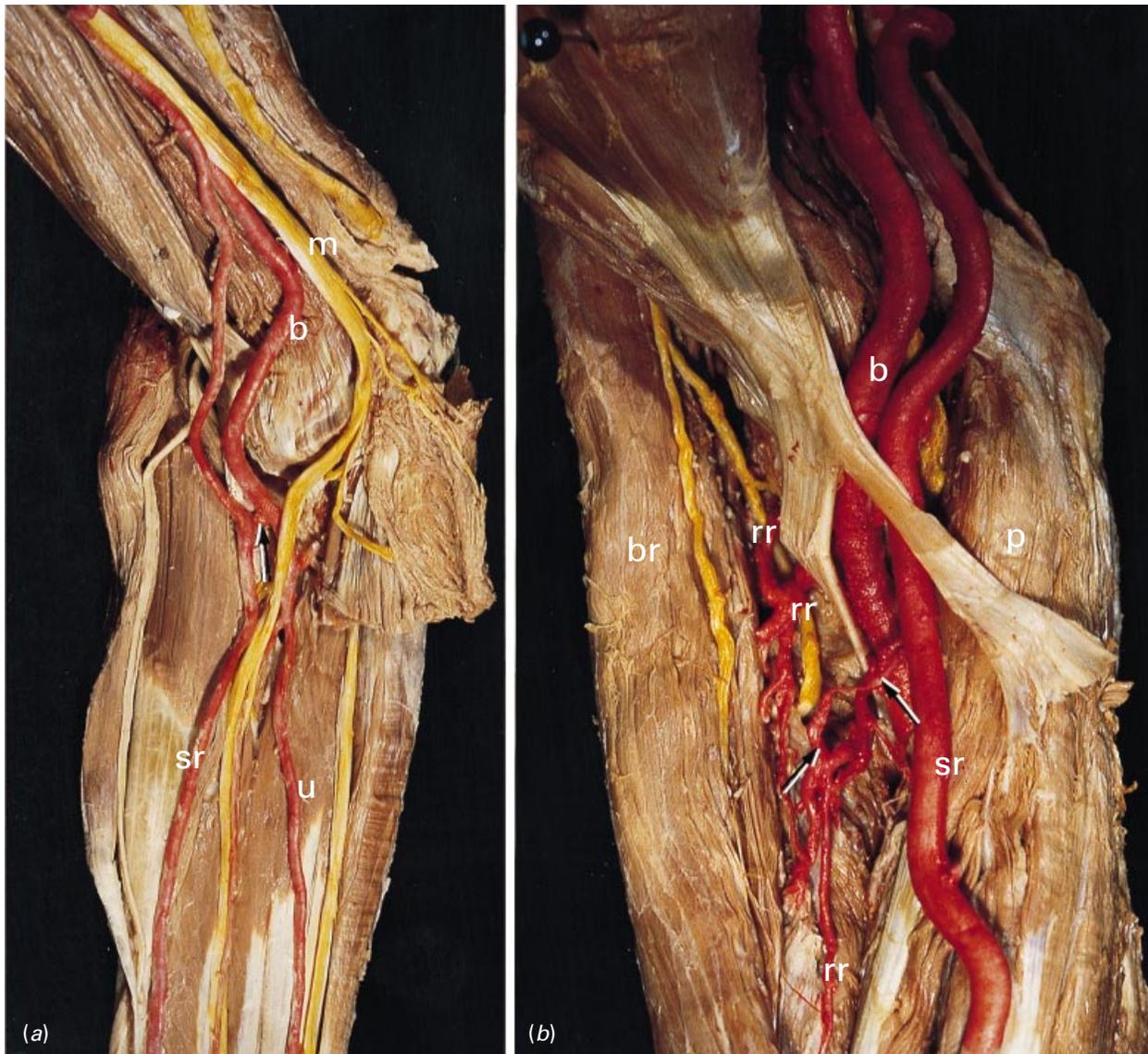


Fig. 2. Anterior view of the antecubital fossa showing a superficial radial artery anastomosed (arrows) with the deep or normal brachial artery. (a) Short and large anastomosis. (b) Thin and long anastomosis. b, brachial artery; sr, superficial radial artery; m, median nerve; p, pronator teres; br, brachioradialis muscle; rr, recurrent radial artery/ies.

after its origin from the deep brachial artery, made 2 loops, cranial and caudally, before connecting, in all cases, with the superficial radial artery (Fig. 1a, b).

The fact that the superficial radial artery increases its calibre after receiving the anastomosis, while in its proximal segment it appears as a slender vessel (Fig. 1a), has led to that artery being reported with a different terminology. The proximal segment has been described as a 'vas aberrans' (Quain, 1844; Ljubomudroff, 1927), a 'collateral trunk' (Ruge, 1884) or a slender superficial brachial artery (Adachi, 1928), while the distal segment, including the anastomosis, has been considered as an unusual origin of the radial artery (Chouéki-Guttenbrunner et al. 1990).

This confusing terminology could be clarified by embryological studies. An anastomosis between the superficial and deep brachial arteries at elbow level has been described during embryonic development (De Vriese, 1902; Müller, 1903; Singer, 1933) (Fig. 3a, 1). The cases presented here

may represent the retention of this primitive anastomosis, which for a superficial radial artery with a sling-like loop anastomosis, remains as a more significant blood pathway than its proximal segment (Fig. 3c).

Relations. The anastomosis adopted 2 different relationships with the bicipital tendon, passing either in front of or behind. The frequency of the anastomotic vessel passing in front of the tendon has been reported as ranging from 74% (McCormack et al. 1953) to 100% (Müller, 1903) while our results show an equal ratio. The sling-like loop anastomosis passed in front of the bicipital tendon in 5 cases (Fig. 1a) and behind it in 4 cases (Fig. 1b) while the rectilinear anastomosis passed in front of the tendon in 2 cases (Fig. 2a, b) and behind in 3 cases.

The reports studying the development of the arterial patterns failed to explain the anastomoses that take place behind the bicipital tendon as they described the anastomotic vessel as always being in front of the bicipital tendon

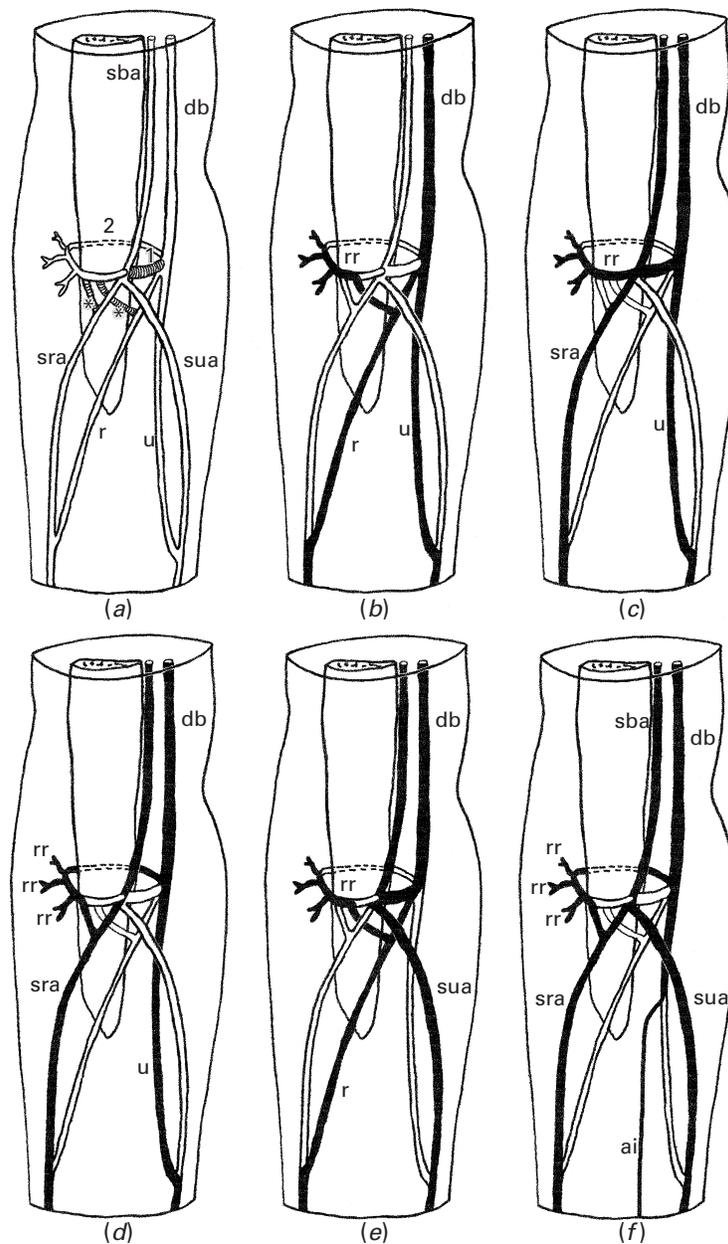


Fig. 3. Diagram of the arterial development to justify the anastomoses observed at the elbow level between the major arterial variations of the upper limb (adapted from Müller). (a) Embryonic arterial pattern showing the superficial and deep major arteries with the suggested anastomosis at the elbow level. 1 & 2, ring-like anastomosis around the bicipital tendon between the deep (db) and superficial brachial artery (sba); asterisk shows, anastomosis between the superficial (sra) and deep radial arteries (r) with the ring-like anastomosis. u, ulnar artery; sua, superficial ulnar artery. (b) Normal arterial pattern by atrophy or enlargement of the vascular channels. rr, recurrent radial artery. (c) Anastomosis between the superficial radial and deep brachial arteries in front of the bicipital tendon. The recurrent radial artery originates from the anastomosis. (d) Anastomosis between the superficial radial and the deep brachial arteries behind the bicipital tendon. The recurrent radial artery originates as several branches from the anastomosis. (e) Anastomosis between the superficial ulnar and the deep brachial arteries. The recurrent radial artery originates from the radial artery. (f) Anastomosis between the superficial and deep brachial arteries. The recurrent radial artery originates as several branches from the anastomosis.

(De Vriese, 1902; Müller, 1903). However, the results presented here and described by other authors (McCormack et al. 1953) imply that during embryonic development there has been an arterial ring network around the bicipital tendon (Fig. 3a, 1, 2). This could explain the existence of an anastomosis behind the tendon connecting the major arterial vessels (Fig. 3d, f).

Recurrent radial artery. The origin of the recurrent radial artery from the anastomosis has been described in 71% (McCormack et al. 1953) or 90% (Ljubomudroff, 1927) of cases, while we found this origin in 12 (86%) (Fig. 1a, b) without any variation in the calibre of the anastomosis along its length. However, a reduction of the calibre of the anastomotic branch after giving off the recurrent radial

artery has been described (McCormack et al. 1953). Other authors, therefore, considered this pattern as an anastomosis between a recurrent radial artery, which had originated from the deep brachial artery, and a superficial vessel (Adachi, 1928; Skopakoff, 1959). In 3 of the cases (2%), a second recurrent radial artery arose from the deep brachial artery and passed behind the bicipital tendon (Fig. 2*b*) as previously described in 2.6% of cases (Adachi, 1928).

There has been no embryological consideration as to the origin of the recurrent radial artery. However, if we consider that the arterial ring-like network around the bicipital tendon is connected during embryonic development with the superficial and deep radial arteries (Fig. 3*a*, asterisk), we can explain the normal origin of the artery and the variations both in origin and course. It is currently accepted that the establishment of the final arterial pattern occurs as a result of the most appropriate channels enlarging whilst others retract and disappear (Arey, 1963). On the basis of both the aforementioned considerations, we might justify the origin of the recurrent radial artery both in normal patterns (Fig. 3*b*) and cases associated with major arterial variations when the artery is described as arising from a common trunk (Fig. 3*c, e*) or as several branches arising from the anastomosis (Fig. 3*d, f*).

The old age of the cadavers with this form of anastomosis, and the absence of any clinical reference to this effect, indicate that it has no critical implication and that it only represents an atavistic character in relation to the embryological development of the arteries of the upper limb. However, its presence in almost 1 in 10 of the population suggests that it must be taken into account during any form of surgery on the upper limb.

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