Absence of the brachial artery: Report of a rare human variation and review of upper extremity arterial anomalies

Alfonso Ciervo, MD, Mark Kahn, MD, Audwin J. Pangilinan, MD, and **Herbert Dardik, MD,**
Englewood, NJ

Variations in the arterial anatomy of the upper extremities, although uncommon, occur in up to one in five patients. Most of these variants occur in either the radial or ulnar artery; brachial artery variations are less common. The case we report is a rare anomaly consisting of brachial artery agenesis or regression. The brachial artery was absent from its origin but reconstituted as a normal-appearing vessel 3 cm above the antecubital fossa. The profunda brachii artery and the superior and inferior ulnar collateral arteries were also absent in this patient. The axillary artery served as the main collateral to the forearm. This constellation of anomalies has not been previously described or explained by developmental models in humans and other primates. We speculate that failure of development or arrest of specific vascular anlage in the upper extremity occurs at particular embryological stages because of unknown factors. (J Vasc Surg 2001;33:191-4.)

Although sporadic accounts of arterial anomalies of the upper extremity have been reported since the 17th century, systematic description did not occur until Quain's[1] review of the literature and analysis of cadaver dissections and angiographic studies. Four main groups of anomalies exist: (1) failure of the primitive artery to recede, (2) failure of the primitive artery to form, (3) aberrant origin of the native vessel, and (4) ectopic location of an otherwise normal vessel. Appreciation of variations in the upper extremity vasculature is essential to prevent injury, particularly in patients requiring dialysis or undergoing arteriography.

CASE REPORT

L. T., a 63-year-old woman, required a brachiocephalic arteriovenous fistula (AVF) in the right upper extremity. There was no history of trauma or surgery in that limb. Pulses in both upper limbs were normal. The cephalic vein and brachial artery were exposed, and after the anastomosis between these vessels was completed, it was noted that flow through the AVF was poor. Distal pulses were no longer palpable. The brachial artery field was then completely dissected and revealed total absence of the brachial artery beyond its origin (Fig 1). An unnamed tortuous branch in the upper third of the arm, 3 mm in diameter, coursed between the coracobrachialis muscle and the triceps brachii muscle. It continued in the mid arm between medial and long heads of the triceps brachii muscle and in the distal third of the arm, divided into an anterior and posterior branch. The anterior branch, 2 mm in diameter, reconstituted as a brachial artery 3 cm above the antecubital space. This entire collateral vessel was in separate from the median nerve, which was lateral and anterior. Because of the compromised flow to the hand, a brachio-brachial bypass graft with reversed greater saphenous vein was performed (Fig 2). Distal pulses were restored, and fistula flow was normalized. The patient has undergone dialysis successfully on follow-up to 1 year.

Arteriography. Arteriography of the arch and both upper extremities was performed 1 year after AVF reconstruction. The right brachial artery, absent from below its origin, reconstituted above the bifurcation into normal-appearing ulnar and radial arteries through a patent brachio-brachial bypass graft. A radial collateral was reconstituted from a branch of the circumflex humeral artery. Another branch originating from the proximal brachial artery served as a collateral to the distal brachial artery. The brachiocephalic fistula was visualized during early and late phases of arterial injection. The deep brachial artery and the superior and inferior ulnar collaterals were not seen and presumed to be absent along with the mid brachial artery. In the left upper extremity, the axillary, brachial and ulnar arteries were normal. The radial artery originated from the upper segment of the brachial artery, but otherwise followed a normal path into the hand (Fig 3).

Embryology. The embryological development of limb buds begins with the development of the axial artery from the seventh cervical intersegmental artery.[2] The brachial artery itself originates from the proximal axial artery distal to the teres major muscle. In the arm, the brachial artery develops three major branches: the profunda brachii artery, the superior ulnar collateral artery, and the inferior ulnar collateral artery. The brachial artery then continues as the anterior interosseous artery (Fig 4, Stage I). The median artery develops from the brachial artery and connects to the deep palmar arch (Fig 4, Stage II). At the same time, the interosseous connection with the palmar arch regresses. The next phase of development describes the formation of the ulnar and radial arteries. The former originates from the brachial artery and attaches to the superficial palmar arch. The radial artery originates near the origin of the brachial artery and traverses the lateral forearm without attaching into the hand (Fig 4, Stage III). The next

From the Vascular Surgical Service at Englewood Hospital and Medical Center.
Competition of interest: nil.
Reprint requests: Herbert Dardik, MD, Chief, Vascular Surgery Service, Englewood Hospital and Medical Center, 350 Engle Street, Englewood, NJ 07631.

0741-5214/2001/$35.00 + 0 **24/6/112212**
doi:10.1067/mva.2001.112212

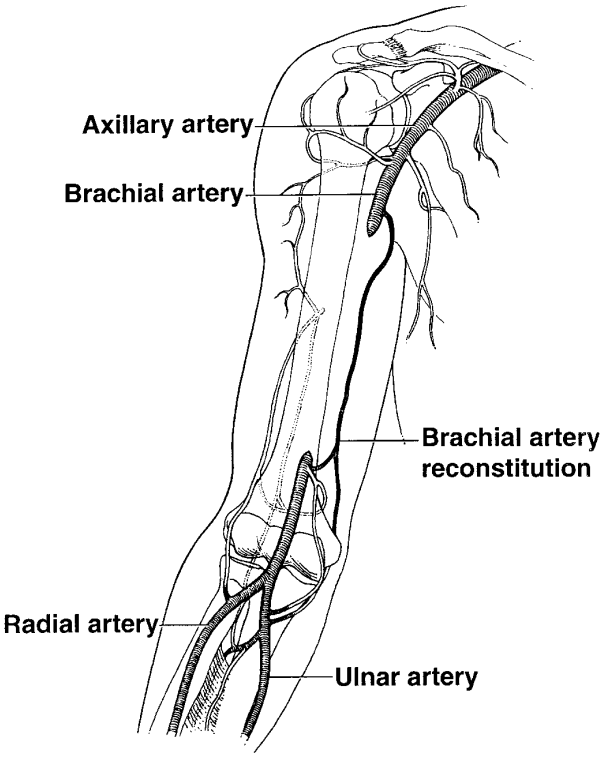

Fig 1. Absent brachial artery.

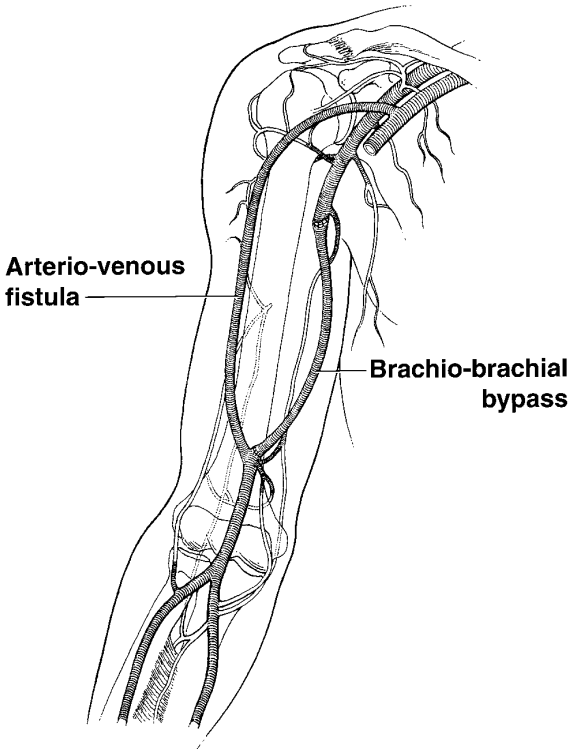

Fig 2. AVF and brachio-brachial bypass graft.

Fig 3. A, Origin of radial artery (*r*) from upper segment of brachial artery (*b*) in left upper extremity. **B,** Course of radial artery in left forearm. *u,* Ulnar artery.

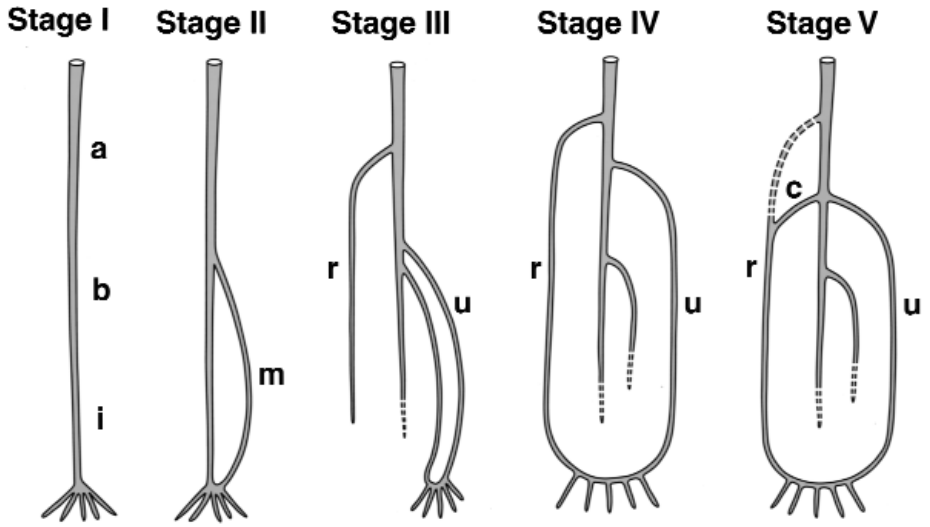

Fig 4. Stages of enbryological patterns of upper extremity arterial system. The potential for agenesis or regression of brachial artery with dominance of collateral flow is evident in Stage V. *a,* Axillary artery; *b,* brachial artery; *i,* anterior interosseous artery; *m,* median artery; *r,* radial artery; *u,* ulnar artery; *c,* collateral. Modified with permission from Icten N, Süllü Y, Tuncer I. Variant high-origin radial artery: a bilateral case. Surg Radiol Anat 1996;18:63-6.

Table I. Number and percentage of anomalous arteries in the upper extremity

Reference	*No. of extremities*	*Anomalous radial arteries*	*Anomalous ulnar arteries*	*Anomalous brachial arteries*	*Total (%)*
McCormack[3]	750	107	23	9	139 (18.5)
Karlsson[4]	82	8	1	0	9 (10.8)
Uglietta[5]	100	8	1	0	9 (9.0)
Total (%)	932	123 (13)	25 (3)	9 (1)	157 (16.8)

major change is the regression of the median artery and the connection of the radial artery in the forearm to the deep palmar arch (Fig 4, Stage IV). The last developmental phase is the new attachment of the proximal radial artery, near the level of the ulnar artery, with regression of its upper brachial connection (Fig 4, Stage V) and results in the normal fully developed pattern of the upper extremity arterial circulation.

DISCUSSION

The brachial artery in our patient was absent below its origin and reconstituted as a normal-appearing brachial artery 3 cm above the antecubital fossa. Neither the profunda brachii artery, which arises at the origin of the brachial artery, nor the superior and inferior ulnar collateral arteries were present in this patient. Proximally, the brachial artery passed between the coracobrachialis and the triceps brachii muscles. It continued in the mid arm as a collateral branch between the long and medial heads of the triceps brachii muscle. The aberrant location of the collateral branch and its divergent course in a different plane from the median nerve, medial and posterior, distinguish this variant from that of the "superficial brachial artery." This constellation of anomalies has not been previously described or explained by developmental models in humans or other primates. We speculate that this defect in the formation of the brachial artery occurred during Stage V or later because the radial and ulnar attachments were anatomically normal. With the regression of the radial artery near its origin from the brachial artery (Stage V), synchronous regression of the brachial artery and its branches could have occurred. The mechanism and factors responsible for agenesis or regression are unknown.

McCormack et al[3] examined 750 extremities in 386 cadavers. Deviations from normal anatomy occurred in 139 (18.5%) of these limbs. Unilateral abnormalities were more common than bilateral (24.5% and 6.3%, respectively). Similar findings were reported by Karlsson and Niechajev[4] and Uglietta and Kadir.[5] Table I summarizes these data, describing the prevalence of various upper extremity anomalies at a rate of 9% to 18.5% (mean, 16.8%). Table II categorizes the forearm arteries on the basis of origin from the brachial or axillary artery. High origin of the radial, ulnar, and superficial brachial vessels occurred almost five times more often from the brachial artery than from the axillary artery.

Table II. Origins of anomalous arteries in the upper extremity

Reference	*No of extremities*	*Brachial origin of*			*Axillary origin of*			*Other*
		Radial	*Ulnar*	*Sup brach*	*Radial*	*Ulnar*	*Sup brach*	
McCormack[3]	750	91	10	7	16	7	1	7
Karlsson[4]	82	7	1	–	1	–	–	–
Uglieta[5]	100	7	–	–	1	1	–	–
Subtotals	–	105	11	7	18	8	1	7
Totals(%)	932	123 (13)			27 (3)			7 (< 1)

Sup brach, Superficial brachial.

With the increased number of access cases being performed annually, appreciation of vascular anomalies is paramount. For both surgical intervention and routine patient care, accurate knowledge of the course and the relationship to surrounding structures are of great practical importance. Inappropriate cannulation of these arteries due to aberrant locations in or near the antecubital fossa can result in thrombosis, gangrene, and even amputation of the limb.[6] Recognition of anomalous anatomy is possible with arteriography, but in practice, the routine use of arteriography for this reason alone is impractical and not cost-effective. We continue to depend on awareness for the potential of anatomic variation and recognition during manipulation and operative intervention of these vessels. Noninvasive imaging is emerging as an important modality to identify arterial anomalies and variations. We agree with Silva et al[7] that preoperative imaging be considered routine for patients requiring access procedures.

REFERENCES

1. Quain R. The anatomy of the arteries of the human body. London: Taylor and Walter; 1844.
2. Singer E. Embryology pattern persisting in the arteries of the arm. Anat Rec 1926:55;403-9.
3. McCormack L, Cauldwell E, Anson B. Brachial and antebrachial patterns: a study of 750 extremities. Surg Gynecol Obstet 1953;96:43-54.
4. Karlsson S, Niechajev I. Arterial anatomy of the upper extremity. Acta Radiol Diagn (Stockh) 1982;23:115-21.
5. Uglietta J, Kadir S. Arteriographic study of variants arterial anatomy of the upper extremities. Cardiovasc Intervent Radiol 1989;12:145-8.
6. Hazlett JW. The superficial ulnar artery with reference to accidental intra-arterial injection. CMAJ 1949;61:289-93.
7. Silva MB Jr, Simoniam GT, Hobson RW II. Increasing use of autologous fistula in selection of dialysis access sites by duplex scanning and transposition of forearm veins. Semin Vasc Surg 2000;13:44-8.

Submitted May 10, 2000; accepted Sep 26, 2000.