

Does the Brachial Artery Lack Effective Collaterals?

To the Editor:

We read with interest the recent article by Singh *et al.*¹ We place many brachial artery catheters in our practice and find them useful.

It would be interesting to know whether ultrasound guidance was used for some or all of the brachial artery arterial catheterizations reported by Singh *et al.*¹ Ultrasound guidance has been shown to reduce the complications from femoral artery access performed for cardiology and vascular surgery interventions.^{2,3} The same might be true for brachial catheterization.

It would also be interesting to know what infection-prevention measures were taken by Singh *et al.*¹ in the context of the infection rate (0.04%) they report. The Centers for Disease Control and Prevention recommends that the infection-prevention measures taken for arterial catheterization should be similar to those for central venous catheters,⁴ although anecdotally it appears that in many anesthesia practice settings, arterial catheterization is performed without all of the recommended precautions.

Despite documenting a relatively low rate of vascular complications of brachial artery catheters, Singh *et al.*¹ state, "...forearm and hand perfusion *via* collaterals usually is insufficient if acute occlusion of the brachial artery occurs." There is a common notion that the brachial artery lacks effective collaterals, but is it correct? Wong *et al.*⁵ reviewed the angiographic anatomy and concluded that "routes of collateral flow enable the distal extremity to be perfused even in the face of brachial artery laceration, thrombosis, or external compression."

Anecdotal reports tend to support the conclusion of Wong *et al.*⁵ Schanzer *et al.*⁶ reported a series of 21 patients in whom the brachial artery was deliberately ligated in the treatment of infected arteriovenous dialysis grafts. No patients suffered ischemic complications. Wolfswinkel *et al.*⁷ reported a case of a 6-yr-old child with a supracondylar humeral fracture that resulted in complete brachial artery transection. The patient's hand remained pink and well perfused, and angiograms shown in this report demonstrated the collateral circulation around the transected artery. There are other reports of supracondylar humerus fractures with interruption of the brachial artery, suggesting that the collateral circulation may be adequate to prevent hand ischemia.⁸

If there is adequate collateral circulation to prevent ischemia with brachial occlusion, what is the mechanism of ischemic complications after brachial artery catheterization, as affected 33 of 21,597 of the patients (0.15%) reported by Singh *et al.*¹? It is important to distinguish between embolic

and purely local thrombotic events at the catheter site. This is because embolic events may result in impaired flow in multiple vessels and may impair collateral vessel flow as well as flow in the index vessel, whether radial or brachial. In the setting of emboli, the arterial catheter may be a contributing factor in producing ischemia or may simply be an innocent bystander.

Embolic events may be difficult to recognize. The near simultaneous appearance of ischemia in multiple vascular beds is suggestive that embolization has occurred. For example, Lee *et al.*⁹ reported a case of simultaneous embolic occlusion of brachial and cerebral arteries, resulting in a stroke and limb ischemia (there was no brachial artery catheter in this case).

It is impossible to know how many of the cases of ischemia in the report by Singh *et al.*¹ were due to embolic events; however, given that many of the patients were very sick, it seems likely that many were embolic. Patients with brachial artery complications had prolonged hospital stays, greater in-hospital mortality, and a "much greater incidence of severe life-threatening postoperative complications, including cardiac arrest, kidney injury requiring dialysis, multiorgan failure, and use of extracorporeal membrane oxygenation for severe cardiac or pulmonary failure."¹

Singh *et al.*¹ have identified an incidence of ischemic complications of brachial artery catheterization that is similar to radial artery catheterization.¹⁰ We believe this should cause reexamination of the common notion that the brachial artery lacks effective collateral circulation.

Competing Interests

The authors declare no competing interests.

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In Reply:

We thank Drs. Bowdle and Sheu for their interest and thoughtful comments on our recent article,¹ which reported a low risk of complications from intraarterial brachial pressure monitoring during cardiac surgery.

Although use of ultrasound is increasing, we typically use direct palpation of the brachial arterial pulse for our first attempt at arterial catheter insertion. Ultrasound for vascular cannulation was not available during the early years of our study period, and our current practice reserves this technology for difficult arterial cannulation. It is possible, however, that increasing use of ultrasound may lower the rate of complications even further than our initial report.

We follow guidelines established by the Centers for Disease Control² to prevent intravascular catheter-related infections. Our standard practice includes proper hand hygiene and aseptic technique, preparation of clean skin with a more than 0.5% chlorhexidine preparation with alcohol, use of sterile gloves and drape, and a sterile, transparent, semipermeable dressing to cover the catheter site. Appropriate sterile dressing regimens are continued postoperatively by the nursing staff. Nonetheless, our low incidence of infection was likely overestimated because we conservatively reported bloodstream infections as “possibly associated” with brachial arterial catheterization, although the more likely cause was an infection related to a coexisting central venous catheter.³

We appreciate the suggestion from Drs. Bowdle and Sheu that an adequate collateral circulation may explain the low rate of brachial artery complications leading to hand ischemia and that embolic phenomena may have impaired the collateral circulation causing ischemia of the upper limb. Certainly, evidence of a collateral arterial network around the elbow exists,⁴ but whether this network is sufficient to adequately perfuse the hand after complete

brachial artery occlusion in all patients is uncertain. It is possible that an adequate collateral circulation may have allowed a brachial arterial injury to remain undetected in some patients. However, multiple reports document hand ischemia as a result of reduced brachial arterial flow with inadequate collateral circulation, including patients suffering from supracondylar fracture with brachial arterial injury⁵ and after creation of a brachial-cephalic/basilic fistula,^{6,7} thus providing evidence that collateral circulation is not adequate in all patients. Later development of adequate collaterals in patients with arteriovenous fistulas explains why some patients tolerate brachial arterial ligation,^{8,9} although similar conditions do not occur in most elective cardiac surgical patients.

Although injury to the arterial wall during cannulation may create conditions conducive to thrombus formation,¹⁰ acute occlusion of the brachial artery may occur as a result of thrombus or emboli. It is thus unclear whether the collateral circulation was compromised in patients with an ischemic upper limb due to multiple emboli or whether its anatomical distribution was insufficient. Nevertheless, our data document that a thrombectomy of an occluded brachial artery restored perfusion to the hand and that the collateral circulation was inadequate in 18 patients.¹

Competing Interests

The authors declare no competing interests.

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