

Timing of Distal Upper Extremity Arterial Repair in Well-perfused Limb

Min Jung Park, MD, MMSc¹
L. Scott Levin, MD, FACS¹
David J. Bozentka, MD¹
David R. Steinberg, MD¹

¹Division of Hand Surgery
Department of Orthopedic Surgery
University of Pennsylvania
Philadelphia, PA

A 32-year old right-handed male presented to emergency room after going through a glass window during an altercation. At the time of the presentation, the patient admitted to the use of alcohol, and was not able to give clear history. Upon close physical exam, isolated, right distal volar-ulnar forearm laceration was identified with active bleeding (Figure 1). The patient demonstrated stable vital signs without evidence of distress along with well-perfused distal fingertips and palpable radial pulse. On further evaluation, the patient lost resting cascade of ring finger and small finger with no active flexion, but all joints were supple without radiographic evidence of fracture or dislocation (Figure 2). The patient also reported complete numbness on the ulnar digits along with the ulnar border of the hand.

The initial management of the patient consisted of applying direct pressure on the wound with pressure dressing. While mobilizing the operating room for possible exploration, complete hemostasis was achieved approximately 30 minutes after the initiation of the pressure dressing. The patient remained stable throughout the management, and maintained well-perfused distal fingertips. At this



Figure 1. Initial injury picture depicting volar-ulnar forearm laceration with active bleeding

time, decision was made to observe the patient overnight. The patient was kept in ulnar gutter splint in extension block fashion. The patient remained stable overnight, and upon confirming stable hemoglobin in the morning, decision was made to schedule elective exploration of the wound and possible nerve, artery, and tendon repair.

The patient was brought to the operating room approximately 35 hours after the initial presentation. He was prepped and draped in the usual manner. Upon exploration of the wound, complete transection of ulnar artery, flexor carpi ulnaris, flexor digitorum profundus and flexor digitorum superficialis to small and ring finger were identified. Approximately 80 percent transection of flexor digitorum superficialis to middle finger and 90 percent laceration of ulnar nerve were identified as well. After irrigation and debridement, all distal and proximal structures were identified. The profundus tendons were repaired, followed by superficialis tendons. After the flexor tendon repairs, ulnar nerve was repaired, followed by ulnar artery and flexor carpi ulnaris. The patient tolerated the procedure well, and the total tourniquet time was 135 minutes.

The patient was kept in dorsal blocking splint post-operatively. At 3-month follow up, the patient demonstrated full grip with mild stiffness of the repaired fingers, improvement in ulnar-sided sensation, and well-perfused distal fingertips with palpable ulnar pulse.

Discussion

When a patient presents to emergency room or trauma bay with brisk pulsatile bleeding around the wrist or forearm, initial responders have the tendency to expect an immediate trip to the operating room for either hemostasis or arterial repair. Although this may be the treatment of choice in avascular limbs, there is little evidence in the literature regarding the management of the well-perfused limb with a single artery injury, especially with regards to timing of the definitive exploration and possible repair. Gelberman et. al. reported 47.0% patency rate after single artery repair at minimum of 6 months follow up, but no patient with non-patency had adverse symptoms unless there had been an associated nerve injury¹. The same

Corresponding author:
David R. Steinberg, MD
Penn Presbyterian Medical Center
1 Cupp Pavilion
Philadelphia, PA 19104



Figure 2. Loss of resting cascade for ring finger and small finger

group also reported that 27 patients were treated within 36 hours and had comparable results, but seven patients who were treated between 8 days to 8 months had a patency rate of 28.5%. More recently, a patency rate of up to 74.5% was reported for radial and/or ulnar artery repair². Another study reported 85.7% overall patency rate after arterial repair at forearm level, but only 49.2% of the patients regained pre-injury level of function, not because of arterial injury, but because of associated nerve (56.1%) and tendon (54.5%) injuries³. Ring et al. reported 6 patients with distal radius fracture associated with single arterial injury; the outcomes of 3 patients without

any arterial repair were equal to the patients who had their vessels repaired or reconstructed with vein graft⁴.

Most of the available evidence in the literature points to associated nerve and tendon injuries, rather than arterial injury, as the cause of morbidity following forearm injury with arterial bleeding^{1,3,5-8}. The treatment strategy should be geared more towards addressing the issues that affect ultimate outcome of the patients, nerve and tendon repair, rather than the more immediately apparent arterial bleeding, especially if only a single artery is involved and the distal limb is well perfused. Careful neurovascular evaluation, with subsequent nerve, tendon, and arterial repair in the controlled setting, should theoretically lead to a better outcome. Management of these injuries during normal daytime working hours by a well-rested hand/microsurgical team can potentially improve ultimate function in these individuals, rather than subjecting the patient to a rushed trip to the operating room for non-emergent arterial repair and/or tendon/nerve repair with staff who may not be used to performing such intricate and demanding procedures.

Further clinical studies are necessary to evaluate clinical outcome of the patients who sustained forearm arterial injury with respect to their time to definitive exploration and arterial repair.

References

1. Gelberman RH, Nunley JA, Koman LA, et al. The results of radial and ulnar arterial repair in the forearm. Experience in three medical centers. *The Journal of bone and joint surgery* 1982;64(3):383-7.
2. Daoutis N, Gerostathopoulos N, Bouchlis G, et al. Results after repair of traumatic arterial damage in the forearm. *Microsurgery* 1992;13(4):175-7.
3. Lee RE, Obeid FN, Horst HM, Bivins BA. Acute penetrating arterial injuries of the forearm. Ligation or repair? *The American surgeon* 1985;51(6):318-24.
4. de Witte PB, Lozano-Calderon S, Harness N, Watchmaker G, Green MS, Ring D. Acute vascular injury associated with fracture of the distal radius: a report of 6 cases. *Journal of orthopaedic trauma* 2008;22(9):611-4.
5. Joshi V, Harding GE, Bottoni DA, Lovell MB, Forbes TL. Determination of functional outcome following upper extremity arterial trauma. *Vascular and endovascular surgery* 2007;41(2):111-4.
6. Ftridge RA, Raptis S, Miller JH, Faris I. Upper extremity arterial injuries: experience at the Royal Adelaide Hospital, 1969 to 1991. *J Vasc Surg* 1994;20(6):941-6.
7. Stricker SJ, Burkhalter WE, Ouellette AE. Single-vessel forearm arterial repairs. Patency rates using nuclear angiography. *Orthopedics* 1989;12(7):963-5.
8. Borman KR, Snyder WH, 3rd, Weigelt JA. Civilian arterial trauma of the upper extremity. An 11 year experience in 267 patients. *American journal of surgery* 1984;148(6):796-9.

Commentary

by Dr. Richard Goldner

Professor, Department of Orthopedic Surgery, Duke University

It makes a difference whether the “active” bleeding is arterial or venous. Usually, if the ulnar artery is transected completely, pressure will control the bleeding. At times, however, with a partial laceration, the arterial bleeding can be more difficult to control. If the “active” bleeding does not cease after pressure has been applied, then operative intervention is more urgent.

It is possible to palpate an ulnar pulse even with a thrombosed ulnar artery. If the artery is palpated distal to the occluded segment, the palpable pulse is from backflow from the normal radial artery. This could be checked by occluding the radial artery and assessing the capillary refill of the digits and the ulnar pulse.

Prior studies suggest that outcomes from single artery injuries are related to associated nerve and tendon injuries rather than the arterial injury itself. If that is true, what is the justification for repairing a lacerated ulnar artery if the radial artery is functioning normally and the patient has a complete arch and a well vascularized hand?

The patency rates documented in prior studies vary a lot and therefore, it is difficult to ascertain the “true” patency rate after repair of a lacerated artery when the uninjured artery is normal. The patency rate, in my opinion, is dependent on the type of injury, the zone of injury, the quality of the injured artery, the tension on the artery after debridement, whether or not a vein graft is used in addition to the technique of the operating surgeon.

Some individuals have postulated that arterial repair improves nerve regeneration. I do not believe that this has been proven.

If prior studies suggest that arterial repair at 36 hours is suitable, but repair at eight or more days is not, that doesn't mean that there is any benefit to waiting 36 hours. If the idea is to wait until daytime when the team is rested, that should be achieved in 12-18 hours. In my opinion, waiting 12-18 hours for a properly skilled and rested team is preferable to waiting 36 hours. Although it might not affect the patency of the arterial repair, infection rate theoretically could increase by waiting 36 instead of 18 hours prior to debriding and irrigating the wound.

I agree with the conclusion that the benefit of waiting for a properly skilled and rested team is more important than performing the procedure emergently, as long as the “active” bleeding has been controlled. However, as noted above, a moderate number of unanswered questions remain..