

# Upper Extremity Vascular Trauma: Our Experiences

Dr. Anant Sinha<sup>1</sup>, Dr. Raj Kumar Pathak<sup>1</sup>, Dr. Tanmay Prasad<sup>1</sup>

<sup>1</sup>Devkamal Hospital, Ranchi, India

**Corresponding Author:** Dr. Tanmay Prasad : Tanmay\_hfh@rediffmail.com

## Abstract

Upper extremity arterial injuries constitute up to 50% of peripheral vascular injuries. Musculotendinous and nerve structures are also commonly injured (complex trauma). Forearm and wrist vascular trauma are common (35-40% of complex trauma) in patients who present to the emergency with upper extremity wounds. Patients may present with a wide spectrum of clinical signs. They are assessed, evaluated and managed accordingly. Arterial trauma is multi-faceted in the upper limb. Exploration of the wound, adequate debridement, delineation of anatomical structures, planned surgical technique with post-operative physiotherapy and medications are the cornerstones of obtaining a good result and consequently a viable functioning hand. Our study aims at highlighting few of these important principles of hand surgery.

## Keywords

1. Upper extremity
2. Vascular injuries
3. Exploration
4. Postoperative physiotherapy

## Introduction

Upper extremity arterial injuries constitute up to 50% of peripheral vascular injuries.[1] Musculotendinous and nerve structures are also commonly injured (complex trauma). Forearm and wrist vascular trauma is common (35-40% of complex trauma). Accidental, homicidal and suicidal trauma - all have specific clinical characteristics. Trauma surgeons constitute the front-line providers. Availability of hand subspecialty provides an additional level of expert care. About

70% of vascular trauma that we receive at our center is upper limb trauma. Division of both the radial and ulnar arteries generally renders the hand acutely ischemic, and revascularization is mandatory.[2]

When a single wrist artery is lacerated, hand ischemia rarely results, but reasons to do a repair are:

1. Concerns about later hand claudication,
2. Cold sensitivity, or
3. Impaired wound healing

Approach to a patient of Upper extremity Trauma:

Initial examination is done with 'CABC' protocol. A thorough history should be taken considering type and time of trauma. The nature of the injury (crush-cut, cut, laceration, avulsion etc) should be identified before undertaking the surgery. Control of the visible external bleeding is done. Intravenous access, IV fluids, hypovolemic shock treatment are initiated. The patients' hands are clinically examined and a careful Doppler Allen's test are performed as well as handheld Doppler interrogation of the digital arteries (if feasible) is done. The procedure is planned accordingly. One should aim for the complete functioning hand and not just at a single aspect of trauma and be prepared for the complete sphere of trauma even in the most unassuming of injuries.[3]

"CABC"

1. C - Control bleeding— control a visible and life-threatening hemorrhage.
2. A - Airways—secure the airways and evaluate

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possible causes of obturation

3. B - Breathe—ventilation rate, volume, and effectiveness
4. C - Circulation—central and peripheral circulation assessment, blood pressure, capillary flow, and skin perfusion. [4]

In a study by Tessa Breeding et al it was found out that hypotensive trauma patients, especially those with active haemorrhage, may benefit more from a CAB approach to resuscitation, as early intubation may increase mortality secondary to PIH. However, patients with critical hypoxia or airway injury may still benefit more from the ABC sequence and prioritization of the airway. Future prospective studies are needed to understand the benefits of CAB with trauma patients and identify which patient subgroups are most affected by prioritizing circulation before airway management. [4]

As with all the trauma patients, advanced trauma life support (ATLS) protocol should be followed as with any other patient that presents to the emergency. After completion of airway and breathing evaluation, assessment of circulation is next. The management of vascular injuries has its basis on the concept of hard or soft signs. The

WTA (Western Trauma Association) has definitions of hard signs and soft signs. The WTA defines hard signs as expanding hematoma, bruit, thrill, external bleeding, pulselessness, pallor, paraesthesia, paralysis or pain. The WTA recommends using the hard signs for major named arteries. “Hard signs” (Active pulsatile bleeding, rapidly expanding hematoma, Pulselessness, Acute ischemia, Vascular thrill, Bruit) of vascular trauma require an immediate operation with sensitivity above 90%. “Soft signs” (Pulse deficit, Neurological deficit, Paleness of the extremity, Nonexpanding hematoma) are not so specific in the prediction of the vascular injuries, and immediate open repair usually is not necessary. [5-7]

### Few Clinical Scenarios:

**CASE 1:** A case of sharp cut from a knife, 55 years female, came to ER with arterial bleed. Hypertensive on medication. Wound was explored. Flexor carpi ulnaris (FCU), ulnar artery and ulnar nerve were found to be cut. The wound was debrided, assessed and repaired. After repair: a clearly pulsating vessel is seen. It is extremely essential to confirm the free flow for proper vascularity. After vascular repair, FCU and Ulnar nerve were repaired. Look for all adjoining anatomical structures even in sharp cut injuries.



**Fig. 1** Sharp cut ulnar border of hand, transversely

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**CASE 2:** 25-year-old male presented with a sharp cut at radial side of the wrist from a knife with an arterial bleed. After examining the hand, the wound was explored. There was a longitudinal sharp cut of the volar aspect of the radial artery sparing the dorsal wall as shown. The artery was alone traumatized sparing all other structures. Repaired with polypropylene 9-0

**CASE 3:** A 25-year-old male patient with cut injury right forearm. There was loss of sensation, finger flexion was impaired. On examination the radial pulse was absent, ulnar pulse was weak. Right hand was colder compared to the contralateral limb. Due to the above signs and based on clinical examination, a neurovascular trauma was suspected and a decision was made to explore.

Exploration revealed multiple flexor compartment muscles and tendons traumatized. Debridement was done. Radial artery was found to be ligated.

Ulnar artery was extremely feeble on palpation. Hand pallor beyond the wrist was evident. Capillary flow on needle prick at finger tips was unsatisfactory. Decision was made to repair radial artery if possible. All tendons and muscle bellies were repaired first. The hand was stabilized in a flexed position. The Median nerve was repaired. The radial artery was repaired and a proper flow was established. A thorough clinical examination reveals the inside picture. One must be prepared for the complete sphere of polytrauma in all cases. Sequence of repair should be planned (eg. tendon repair before vascular repair, prevents traction on vessels). Intensive post-operative monitoring is a must in all cases, may need re-exploration.

A full range of movement was finally obtained in this case. Both flexion and extension were balanced. Scars were reasonably well settled. A good active and passive physiotherapy is the key.

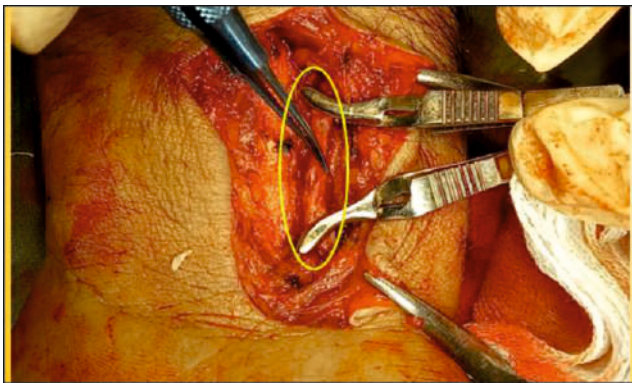


Fig 2 Sharp cut radial artery, longitudinal

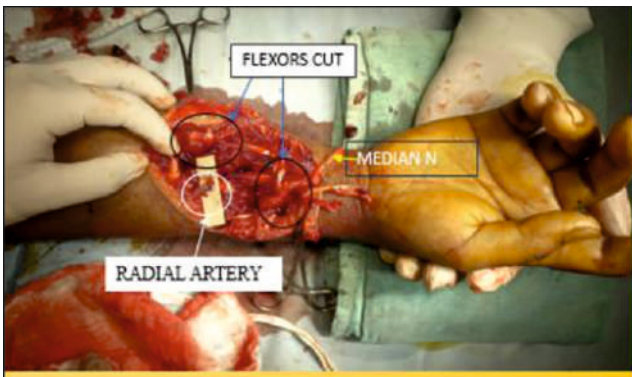
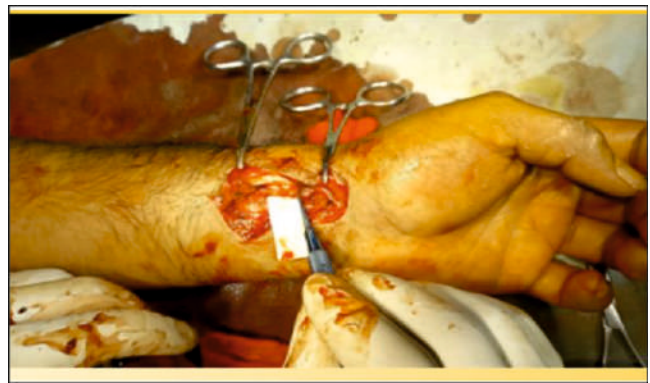


Fig. 3 Exploration Right hand post trauma from factory cutter machine. Repaired in sequence.

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Fig. 4 Post operative physiotherapy with balanced hand function

**CASE 4:** A 35-year-old with suicide attempt. Both wrists were slashed with a sharp knife. Right wrist was bleeding profusely. Right hand Ulnar Pulsation was absent. Radial pulsations were weak. Patient was prepared for emergency operation for both upper limbs with pre-operative preparation which included laboratory investigation, radiographs and a Doppler test. Hesitation marks were seen and noted. A detailed anatomical exploration of the trauma specific region was done. Flexor carpi ulnaris, ulnar nerve and the ulnar vessels were repaired.

**CASE 5:** 45-year-old male with subtotal amputation extending from radial to ulnar side on the cubital fossa with arterial bleed. Debridement done, anatomical structures were defined first and tagged accordingly thereafter Proper definition of anatomy is absolutely essential in planning a repair. There was a discrepancy post debridement in the vessel length which was managed with dissection. If required, a vein graft could have been planned.

**CASE 6:** 26-year-old male presented with crush cut injury from rotating circular saw in a factory.

**Discussion and conclusion:** Peripheral vascular traumas of the upper limb are increasing with advent of more and more machinery. Isolated vascular trauma are the subset of hand injuries. It needs a thorough debridement, reassessment of the

trauma and then plan the procedure. We try to repair all vascular trauma if amenable to repair. One should reestablish good arterial flow if there is any doubt in vascularity Repairing under magnification has several advantages such as clarity of vision, definition of anatomical details, managing complex trauma with vascular elements. Anticoagulation protocols (LMWH- enoxaparin / Heparin/ Clopidogrel + Aspirin) given as per surgeon's experience and preference.[8]

**Post-operative tendon repair Physiotherapy Protocol:** 'The Washington Regimen': Chow reported his results with a modified Kleinert splint.<sup>9</sup> A safety pin is attached at the level of distal palmar crease. It acts as a palmar pulley. Nylon fishing line run from the finger nails, under the palmar pulleys and are attached proximally to rubber bands secured at the distal end of the forearm. The therapists conduct passive flexion and passive extension in a controlled manner.

This 6-week period of postoperative rehabilitation is distributed into three stages of 2 weeks' duration each. During the first week, the therapist focuses on full passive extension and passive flexion of the IP joints. This is combined with active extension against rubber band traction. Approximately, by the 14th day, full extension of the PIP and DIP joints is achieved passively, with no lag, and therapist-assisted range of motion is discontinued.[9]

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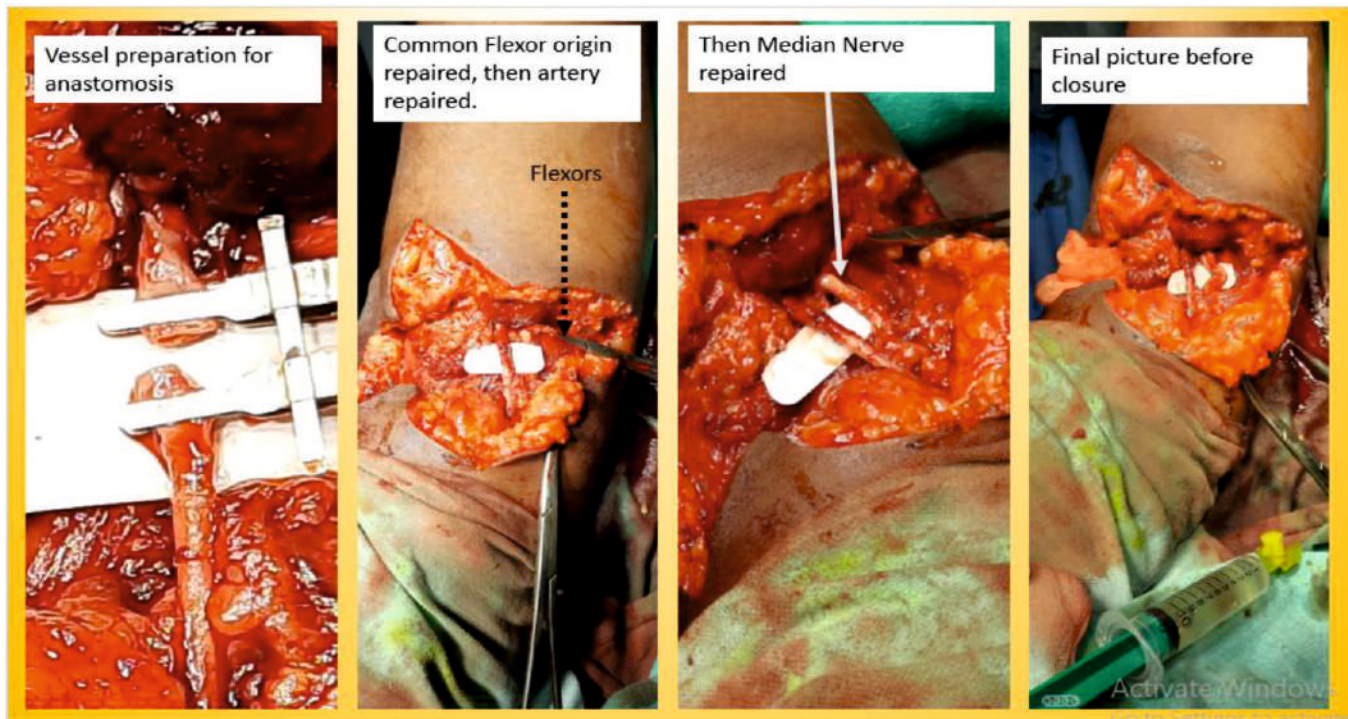


Fig. 6 : Subtotal amputation, Brachial artery, Median nerve, Flexor muscles with bony trauma at elbow

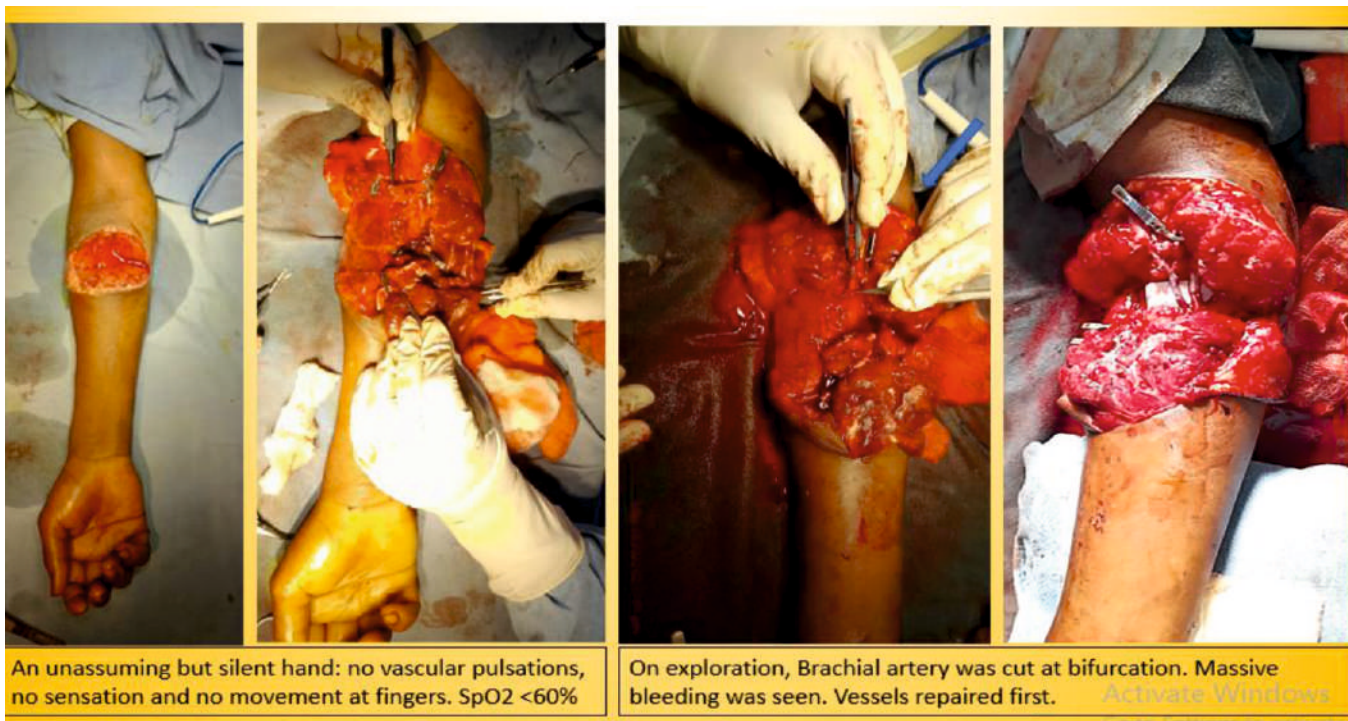


Fig. 7 A crush cut injury from a rotating saw

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Fig. 8 Debrided, repaired, Postoperative recovery

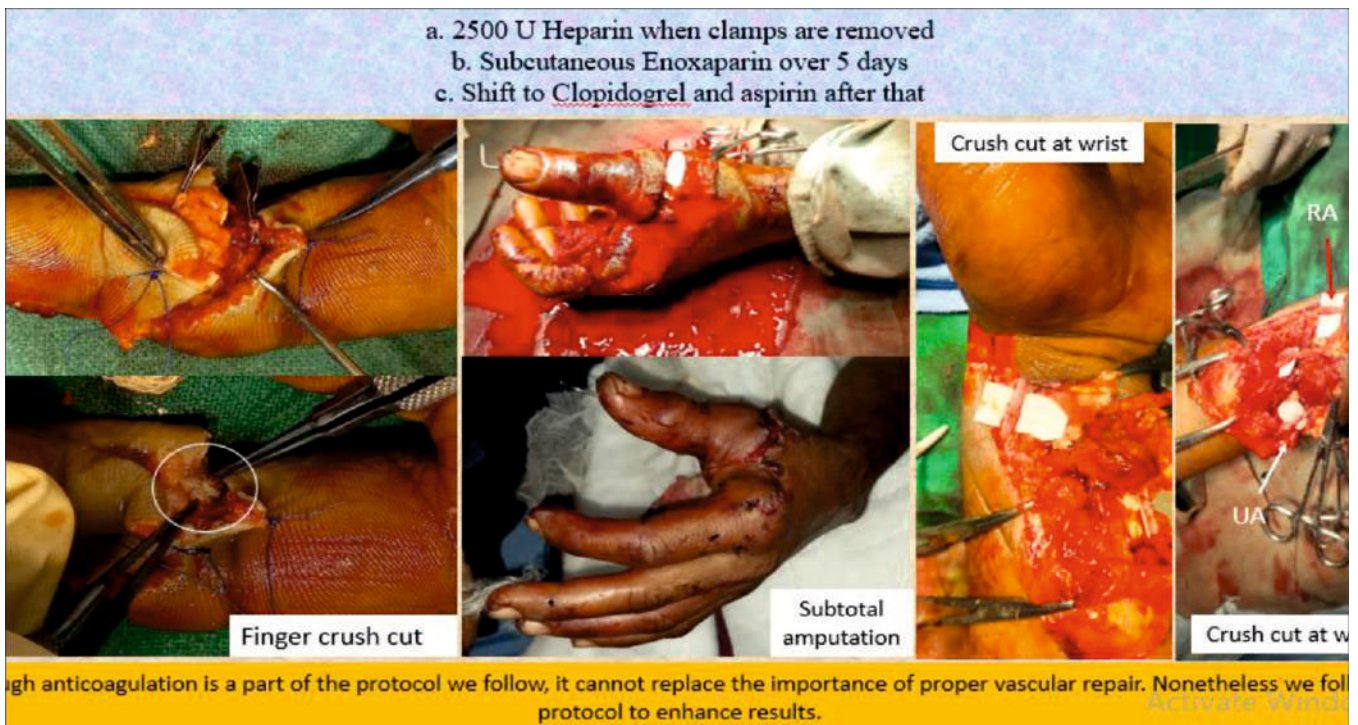


Fig. 9 A compendium of hand trauma with benefit from anticoagulation therapy at our centre

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The hourly regimen of active extension and passive flexion is continued during 3rd and 4th weeks. At weeks 4 to 6, the rubber bands are disconnected and the patient performs hourly exercises of active flexion, then passive flexion, followed by active extension. By the 8th week, Bunnell blocking exercises and resistive flexion exercises are performed. The results of this regimen, the Washington regimen, are better comparing those originally reported from Louisville. It is important to note that, in this series, the patient group should be more compliant with postoperative rehabilitation with good access to postoperative therapy. The Washington regimen demands a high involvement of the hand therapist, daily in the first 2 to 3 weeks, then three times a week thereafter.[9,10]

### **Another commonly used protocol is Duran and Houser protocol:**

**Early stage (from 0 to 4.5 weeks):** The wrist is held in 20 degrees of flexion and the MP (metacarpophalangeal) joints in a relaxed position of flexion. Duran and Houser determined through clinical and experimental observation that 3 to 5 mm of glide was sufficient to prevent formation of firm tendon adhesions; the exercises (6 to 8 repetitions twice a day) are designed to achieve this. With MP and PIP (proximal interphalangeal) joints flexed, the DIP (distal interphalangeal) joint is passively extended, thus moving the FDP (flexor digitorum profundus) repair distally, away from an FDS (flexor digitorum superficialis) repair. Then with DIP and MP joints flexed, the PIP is extended; both repairs glide distally away from the site of repair and any surrounding tissues to which they might otherwise form adhesions.

**Intermediate stage (from 4.5 weeks to 7.5 or 8 weeks):** After 4.5 weeks, the splint is replaced with a wrist band to which rubber band traction is attached. Active extension exercises begin within the limitations imposed by the wrist band. Active flexion (blocking, FDS gliding, and fisting) is initiated on removal of the wrist band at 5.5 weeks.

**Late stage (starting at 7,5 to 8 weeks):** Resisted flexion starts at 8 weeks. Blocking exercises are performed 4-6 times a day with 10 repetitions. [9-11]

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