

CURRENT MANAGEMENT OF MAJOR UPPER AND LOWER EXTREMITY VASCULAR TRAUMA

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Summary

Vascular trauma has a significant impact on the care of the trauma patient. Advancements in the treatment of upper and lower extremity arterial and venous injuries have occurred including open and endovascular techniques. However, open vascular surgery has remained the gold standard. Multidisciplinary surgical care is the new norm. This chapter describes treatment algorithms for upper and lower extremity vascular trauma. Outcomes and review of the literature are also included.

1. Introduction

Arterial injuries to the extremities account for 50% of all arterial traumas, with 64% to 82% resulting from a penetrating injury (Diamond et al, 2003; Modrall et al, 1998; Weaver et al, 1996). The incidence of upper extremity vascular trauma in the United States from all modern wars and civilian trauma is estimated at 30% (Fields et al, 2002). A general estimation by Diamond et al (2003) is that all vascular injuries to the extremities account for <1% of all traumatic injuries. Upper extremity arterial injuries are more common in civilian populations; lower extremity vascular injuries are more frequent among military personnel (Weaver et al, 1996). Although relatively uncommon, injuries to the arteries of the upper extremity and lower extremity are serious and have the potential to significantly impact the outcome of the trauma patient. According to Dowrick et al (2005), for patients suffering from major trauma, the presence of an extremity injury is a significant predictor of hospital length of stay, which translates into greater complexity and cost of care. As in all traumas, because surrounding tissue damage tends to be less severe with penetrating wounds, they tend to have better outcomes than blunt injuries (Frykberg, 2002; Moniz et al, 1997). In an analysis of patients with traumatic popliteal vascular injuries from the National Trauma Data Bank, patients with penetrating trauma had higher rates of limb salvage, shorter hospital stays, and a better functional outcome than patients with blunt trauma, despite higher rates of nerve injury, combined artery and venous injury, and worse initial base deficits (Mullenix et al, 2006). If not properly managed, such injuries can lead to limb loss or death (Weaver et al, 1996).

2. General Management of Upper and Lower Extremity Arterial Injuries

The management philosophy for extremity arterial injuries involves a multidisciplinary team approach and is based upon injury location (Figures 1 and 2). Vascular surgeons manage arterial and venous injuries; plastic or hand surgeons address nerve, tendon and soft tissue injuries, as well as arterial injuries below the antecubital crease; orthopedic surgeons address bony injury; and trauma surgeons are responsible for the overall care of the patient. Because trauma patients are evaluated according to the principles of advanced trauma life support, the extremity evaluation typically is performed as a secondary survey, unless the injury is life-threatening exsanguinating hemorrhage (Pillai et al, 1997). Successful vascular management is based on prompt diagnosis and treatment (Sise and Shackford, 2004). In addition to assessing the extremity for pulse pressures by physical examination and continuous-wave Doppler, neuromuscular function, soft-tissue involvement, and skeletal integrity should be evaluated (Pillai et al, 1997; Sise and Shackford, 2004; Weaver et al, 1996). Although successful vascular reconstruction is essential for limb salvage, other factors, including concomitant vein and nerve injury, soft tissue loss, fasciotomy site healing and associated orthopedic trauma greatly influence outcome. This integration of other specialty surgeons with the vascular team ensures that all factors are cohesively managed.

Mechanisms of injury for upper extremity arterial trauma include lacerations, gunshot wounds, stabbings, assaults, and motor vehicle accidents. Laceration by glass is one of the most common etiologies (Franz et al, 2012; Franz et al, 2009). In general, upper extremity management consists of bypass or endovascular repair in axillary arteries,

bypass or primary repair in brachial artery injuries, and repair or ligation in radial or ulnar injuries. Whereas, lower extremity arterial injuries are caused by gunshot wounds, motorcycle and motor vehicle accidents, lacerations, and other mechanisms such as crush injuries or falls.

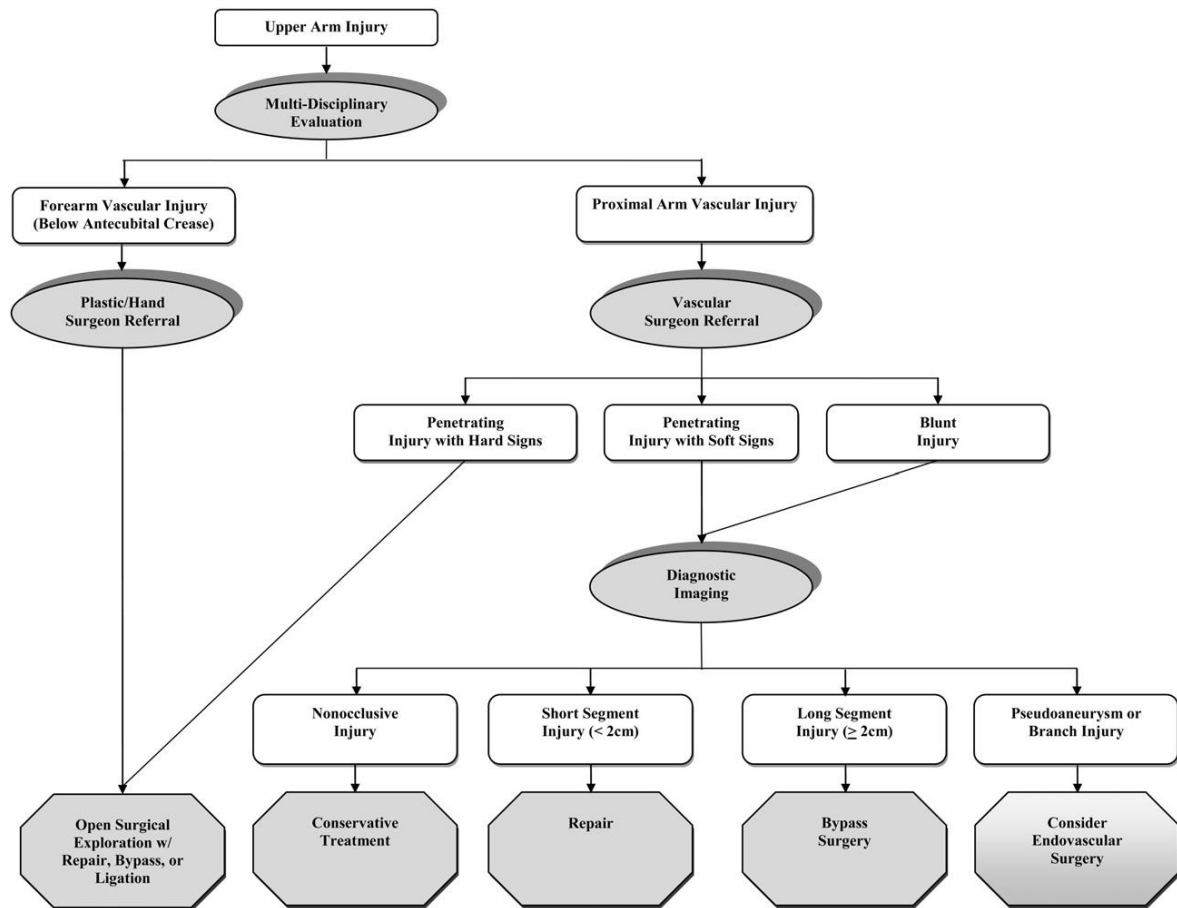


Figure 1. Standardized protocol for patients with suspected upper extremity vascular injury (Franz et al, 2012)

For extremity injuries associated with acute hemorrhage or severe limb ischemia, immediate open surgical exploration with subsequent repair or bypass is performed (Diamond et al, 2003; Pillai et al, 1997; Sise and Shackford, 2004; Rowe et al, 2005). Penetrating injuries also are managed with immediate surgical explorations for patients presenting with clinical hard signs of arterial injury (Table 1) (Diamond et al, 2003; Pillai et al, 1997; Sise and Shackford, 2004; Rowe et al, 2005; Cikrit et al, 1990). Such signs include absent or diminished distal pulses, distal ischemia, arterial bleeding from open wound, expanding or pulsatile hematoma, bruit or thrill, and profound neurological deficit (Fields et al, 2002; Diamond et al, 2003; Pillai et al, 1997; Sise and Shackford, 2004; Weaver et al, 1996; Cikrit et al, 1990; Frykberg, 1995). For these cases of significant trauma, a positive physical presentation reliably predicts the presence of major vascular injury, as well as location, mandating immediate surgical exploration without further time-consuming diagnostic evaluation (Frykberg, 1995). Surgical management of the arterial injuries is performed by vascular surgeons within

six hours or a fasciotomy is performed. Vein graft bypasses are performed most frequently in lower extremity arterial injuries. Examining management strategies by arterial involvement reveals that bypasses are most often performed for superficial femoral and popliteal arterial injuries, primary repair is performed mainly for common femoral arterial injuries, ligation is required primarily for tibial arterial injuries, and endovascular repair is limited to profunda femoris and superficial arterial injuries.

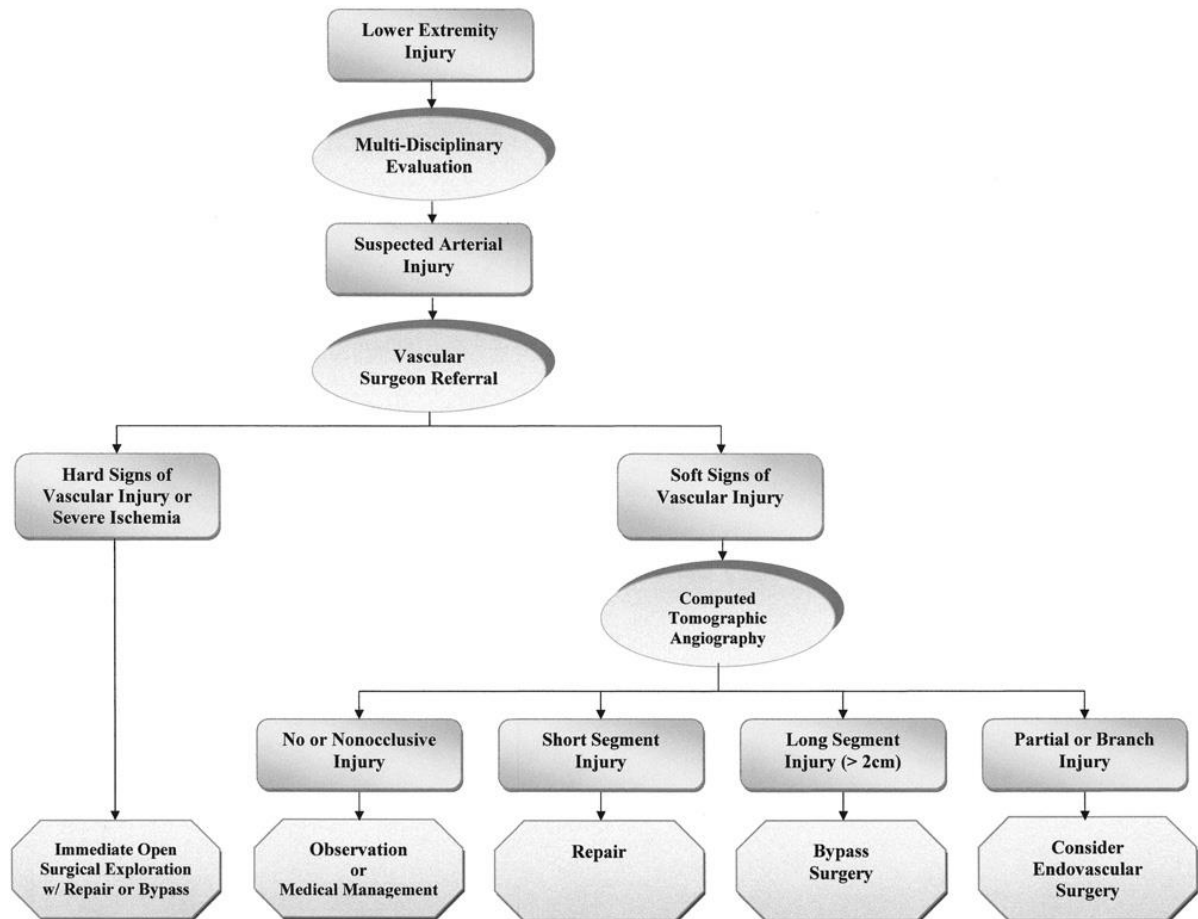


Figure 2. Standardized protocol for patients with suspected lower extremity vascular injury (Franz et al, 2012)

“Hard” Clinical Signs	“Soft” Clinical Signs
Active arterial bleeding from open wound	History of significant bleeding
Absent or diminished distal pulses	Weak distal pulses
Expanding or pulsatile hematoma	Non-expanding hematoma
Profound neurological deficit	Isolated neurological deficits
Distal ischemia (pain, pallor, paralysis, paresthasias, pulselessness, coolness)	Unexplained hypotension
Bruit or thrill	Proximity of injury to major vessel

Table 1. “Hard” versus “Soft” clinical manifestations of extremity vascular injury

3. Surgical Management of Arterial Injuries

Surgical management decisions are determined after isolation of the desired artery and careful assessment of the extent of artery, vein, and nerve injury. Treatment often is dictated by the extent and location of the injured artery, as described below. The uninjured contralateral extremity should be prepared in case autogenous vein harvesting is necessary (Weaver et al, 1996; Frykberg, 2002; Carrillo et al, 2002). Systematic heparin should be used during vascular repair to reduce distal thrombosis and maximize successful revascularization unless contraindicated by concomitant injuries (Weaver et al, 1996; Frykberg, 2002; Carrillo et al, 2002; Cakir et al, 2005; Martin et al, 1994; Melton et al, 1997; Rowe et al, 2002). Adherent thrombus typically is present at the site of injury and in the adjacent arterial lumens (Rowe et al, 2002). Balloon catheter thrombectomy should be performed in the proximal and distal vessel segments before artery repair until good backward and forward bleeding is achieved (Frykberg, 2002). This should be followed by injection of heparinized saline into the distal arterial segment to further retard thrombus (Frykberg, 2002). Debridement of all macroscopically-injured or contused tissue should be conducted. At the conclusion of vascular repair, angiography is used to visualize the entire arterial segment to confirm the technical adequacy of both the anastomosis site and the absence of distal embolic debris. If a potential problem with the anastomosis site or inadequate runoff is detected, the procedure is revised accordingly (Hafez et al, 2001). Postoperatively, traumatic vascular repair surveillance is identical to that of elective vascular reconstruction –wrist/ankle brachial indexes and vascular duplex ultrasonography are performed every three months for the first year, every six months for the second year, and annually thereafter for the life of the graft.

4. Medical Management of Arterial Injuries

Nonocclusive arterial injuries, such as intimal defects, partial lacerations, pseudoaneurysms, and arteriovenous fistulas are not an immediate threat to limb viability. These conditions are promptly addressed with appropriate management, such as initial observation, embolization, thrombectomy, or repair (Cikrit et al, 1990; Frykberg, 1995).

In the past, patients with minimal arterial lesions, which account for approximately 10% of all arterial injuries, routinely underwent surgical exploration and “repair” to minimize complications of missed vascular injuries (Frykberg, 2002, 1995). Because these clinically occult arterial injuries typically have a benign natural history, they may be safely observed (Modrall et al, 1998; Frykberg, 2002, 1995; Dennis et al, 1998). Therefore, patients with nonocclusive injuries may be managed nonoperatively if they fulfill the following criteria: (1) < 5 mm intimal disruption; (2) adherent intimal flaps; (3) intact distal circulation; and (4) no active hemorrhage (Modrall et al, 1998; Rowe et al, 2002; Rowe et al, 2005). Should lesions persist or worsen, as detected by routine vascular duplex ultrasonography scan, wrist or ankle brachial indexes, CTA, or serial angiography, surgery is warranted (Rowe et al, 2002). Approximately 10% of these lesions may deteriorate into false aneurysms, at which time they can be repaired without adverse complications (Frykberg, 2002, 1995). Medication management consists of

either a combination of daily clopidogrel (75mg) and aspirin (75mg) or aspirin (75mg) alone if clopidogrel was contraindicated.

5. Diagnostic Imaging

The role of imaging has had an obvious impact on vascular surgery and the management of vascular extremity trauma, specifically. For blunt extremity injuries and penetrating injuries with soft clinical signs, computed tomographic or conventional angiography is recommended to assist in injury location and extent and to aid in staged planning for reconstruction (Diamond et al, 2003; Modrall et al, 1998; Carrillo et al, 2002; Frykberg, 1995; Rowe et al, 2005; Nair et al, 2000; Bandyk, 1995; Mavili et al, 2007). Angiography (CTA or conventional) and plain radiography particularly is useful in blunt trauma due to the high incidence of associated bone, nerve, and soft tissue injuries that could be responsible for clinical hard signs and obscure an accurate diagnosis (Diamond et al, 2003; Modrall et al, 1998). Diagnostic imaging also is indicated for penetrating injuries with clinical soft signs, including proximity injury, small or moderately stable hematoma, adjacent neurological injury, and unexplained hypotension (Fields et al, 2002; Pillai et al, 1997; Sise and Shackford, 2004; Weaver et al, 1996; Cikir et al, 1990; Frykberg, 1995). Occasionally, it is warranted for penetrating arterial injuries with clinical hard signs when the existence or location of the injury is unclear (Frykberg, 1995). Examples of such instances include delayed presentation, severe bone fracture or soft-tissue injury, chronic vascular disease, and gunshot wounds (Frykberg, 1995). Vascular duplex ultrasonography is useful as a screening tool, if available. Immediate postoperative angiography at the conclusion of surgical intervention allows visualization of the entire arterial segment to confirm technical adequacy of the anastomosis site and absence of distal embolic debris.

6. Associated Orthopedic Injuries

The combined presence of vascular and orthopedic injuries is one of the most significant challenges in the management of extremity injuries (Rowe et al, 2005). When bone involvement is suspected; plain radiography and orthopedic consultation are warranted. Because minimizing ischemia duration is critical to overall outcome, artery repair typically precedes orthopedic stabilization to restore limb circulation (Fields, et al. 2002; Sise and Shackford, 2004; Rowe et al, 2005). For forearm arterial injuries, orthopedic stabilization of associated bony injuries typically is performed prior to vascular reconstruction. Several lower extremity orthopedic injuries, including knee dislocations, displaced medial tibial plateau fractures, other displaced bicondylar fractures around the knee, open or segmental distal femoral shaft fractures, and mangled extremities, are associated with a high index of suspicion for vascular injuries (Bandyk, 1995; Doody et al, 2008). When an isolated knee dislocation causes distal ischemia or when an unstable tibial fracture is present, reduction generally is performed before vascular reconstruction (Cakir et al, 2005; Bechara et al, 2007). In rare instances when external fixation is required to immediately stabilize the limb after massive musculoskeletal trauma, temporary selective use of shunts to restore circulation allows rapid later vascular and orthopedic repair (Modrall et al, 1998; Weaver et al, 1996; Rowe et al, 2005; Bandyk, 1995). Regardless of sequence, vascular reconstruction should be inspected before final wound closure during any orthopedic procedure to

verify patency of repair (Modrall et al, 1998; Weaver et al, 1996; Rowe et al, 2005; Nair et al, 2000).

7. Venous Injury Repair

If upper extremity venous injury can be repaired easily, repair is performed; alternatively, ligation is performed, given adequate venous collaterals in the upper extremity (Diamond et al, 2003). Whenever possible, venous injury repair enhances successful outcomes in lower extremity trauma, especially when popliteal and more proximal veins are involved (Modrall et al, 1998; Weaver et al, 1996; Frykberg, 2002; Cakir et al, 2005; Rowe et al, 2002; Rowe et al, 2005). When indicated, venous repair should precede artery repair to enhance venous drainage of the limb during artery reconstruction (Frykberg, 2002; Carrillo et al, 2002; Rowe et al, 2002). Vein repair using a non-reversed autogenous vein interposition graft or vein patch should be performed in stable patients, but vein ligation may be indicated in unstable patients (Huynh et al, 1994; Yelon and Scalea, 1992). Because vein repair is associated with a high likelihood of postoperative deep vein thrombosis, postoperative treatment with heparin, transitioning to warfarin for 3 months, if able, is recommended.

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Biographical Sketches

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