**Chapter 36  
Orthopedic injuries**

**Sean Kivlehan, Benjamin T. Friedman, and Mary P. Mercer**

**Introduction**

**Epidemiology**

Trauma is the leading cause of death worldwide and in the United States for people under the age of 44 [1]. Blunt trauma from motor vehicle accidents, falls, or other mechanisms can result in a range of orthopedic injuries. Recognition and management of orthopedic injuries is an essential component of any EMS system.

**General approach to management**

The prehospital management of a suspected orthopedic injury begins with assessment of potential life threats. Obtaining a history that includes the mechanism of injury is important to develop an index of suspicion for associated injuries. Prehospital providers should first assess and address the airway, breathing, circulation, and disability of any injured patient. Once the primary survey is complete, an orthopedic evaluation is part of a comprehensive secondary survey. Open fractures and injuries with neurovascular compromise require special attention. Acute hemorrhage control is the first priority for the open fracture in the field and can generally be accomplished with direct pressure. Any exposed bone should be dressed with a sterile saline moistened dressing. The decision to reduce a fracture or dislocation in the field is situation dependent, and should be based on presence of neurovascular compromise, anticipated extrication and transport duration, and provider training and experience [2]. Pain management is an important component of the prehospital care for any orthopedic injury and should ideally be addressed prior to moving the patient to the ambulance. Pain management modalities include immobilization of the affected limb and intravenous opiates [3,4].

**Anatomy, fractures, and dislocations**

**Upper extremity**

**Upper extremity neurovascular exam**

For all upper extremity injuries, both nerve function and vascular patency must be assessed early and repeated frequently, particularly after any manipulation, splinting, or patient movement. The radial, ulnar, and median nerves should be assessed for both motor and sensory function in all injuries. The axillary and musculocutaneous nerves should be assessed in more proximal injuries ([Table 36.1](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#c36-tbl-0001)). The vascular exam consists of palpating both the radial and ulnar pulses as well as the brachial artery in more proximal injuries. For injuries distal to the wrist, nailbed capillary refill should be assessed.

[**Table 36.1**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#R_c36-tbl-0001) Upper extremity neurological examination

| **Nerve** | **Motor** | **Sensory** |
| --- | --- | --- |
| Radial | Wrist or finger extension | First dorsal web space |
| Ulnar | Index finger abduction | Pinky finger |
| Median | Thumb and index finger opposition | Index finger |
| Axillary | Deltoid | Lateral shoulder |
| Musculocutaneous | Elbow flexion | Lateral forearm |

**Clavicle**

Clavicular fractures are generally uncomplicated and can be managed in the field with sling and swathe placement ([Table 36.2](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#c36-tbl-0002)). Assessment should include a complete neurovascular exam of the limb on the affected side as there is a risk of damage to the underlying subclavian vessels and brachial plexus as well as possibility of pneumothorax.

[**Table 36.2**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#R_c36-tbl-0002) Upper extremity immobilization approach

| **Bone** | **Approach** |
| --- | --- |
| Clavicle, scapula, shoulder | Sling and swathe |
| Humerus | Sling and swathe, short board |
| Elbow | Short board A-splint (bent) or straight with short boards |
| Forearm | Short board with sling |
| Wrist, hand | Short board or pillow in position of function with sling |
| Finger | Malleable metal splint or tongue depressor with buddy splinting |

Short or long board splints are generally interchangeable with air or vacuum splints.

The clavicular articulations to the sternum (sternoclavicular [SC] joint) and acromion (acromioclavicular [AC] joint) should be assessed as well. AC joint injury can be diagnosed clinically and should be managed with a sling and swathe in the field. SC joint injuries most commonly occur as a result of vehicle accidents or sports injuries and are divided into less serious anterior dislocations and more serious posterior dislocations. While field treatment for both is immobilization, prehospital providers should have a heightened index of suspicion for serious intrathoracic injury with a posterior dislocation, in particular pneumothorax, great vessel injury, and tracheal injury [5].

**Scapula**

A patient with a scapular fracture will generally present protecting the arm on the affected side and with local tenderness. Management consists of sling and swathe placement and analgesia. Up to 75% of patients with scapular fractures will have additional injuries due to the significant mechanism of injury. Providers should carefully examine the patient for rib fractures, pneumothorax, or upper arm injuries [6].

**Shoulder**

Glenohumeral joint dislocations are the most common major joint dislocation encountered, and are generally the result of an indirect blow with the arm in abduction, extension, and external rotation [7]. Anterior dislocations are the most common and can be identified clinically in the field with some reliability. In general, the patient will present guarding the affected arm with mild abduction and external rotation. Posterior dislocations are rare, usually the result of a mechanism of injury such as a seizure, electrical shock, or direct anterior blow to the shoulder, and while carrying a similar associated fracture rate they are less likely to have neurovascular injury. Inferior and superior dislocations are even less common.

When examining a suspected shoulder dislocation, close attention should be paid to the axillary nerve. Vascular injuries are rare but when they do occur, will generally involve the axillary artery [8]. Associated fractures occur in 15–35% of shoulder dislocations and can include the humeral head (Hill–Sachs lesion), anterior glenoid lip, and greater tuberosity. Although these fractures generally do not change management, prereduction x-rays are recommended, and field reduction should typically not be attempted [9]. There are exceptions to this rule, in particular for patients with known recurrent dislocations and athletes on the field with appropriately trained staff [10,11]. Providers should splint the extremity in the position found with a sling and swathe. A short board splint can be placed along the medial upper arm for extra stability, particularly in the presence of a suspected humeral head fracture [9]. In the event of a spontaneous reduction, providers should still splint and transport, as radiographs and follow-up will be needed.

Rotator cuff injuries may be associated with shoulder dislocations or may present independently. Complete evaluation of the rotator cuff could become more commonplace prehospital practice, particularly within a community paramedicine setting. However, no validated rules currently exist to exclude fracture or dislocation, and a patient with an acute shoulder injury would likely benefit from transport to the hospital [9].

**Humerus**

Fractures of the humerus can be divided into three categories: proximal, midshaft, and distal. Axillary nerve and artery injuries have been recognized in up to 50% of displaced humeral fractures. Humeral shaft injuries are most common in active young men and elderly osteoporotic patients and can be associated with radial nerve injuries or vascular injuries to the brachial artery or vein [7]. Field management is the same as for other shoulder injuries.

**Elbow**

The elbow joint is composed of the articulations of the distal humerus, proximal radius, and ulna. The brachial artery and the nerves of the forearm and hand travel in close proximity. It is the third most commonly dislocated joint after the shoulder and knee. Supracondylar fractures are among the most common fractures in children [12]. The primary fracture patterns in adults include flexion and extension, the latter being more common. The majority of elbow dislocations (90%) are posterolateral, with the mechanism of injury being fall on an outstretched hand. Commonly associated neurovascular injuries include entrapment of the ulnar nerve and the brachial artery [13].

It is difficult to differentiate an elbow fracture from a dislocation in the field without x-rays, and as such, it is recommended that EMS providers splint all suspected fractures or dislocations in the position found. However, gentle reduction is recommended in a severely angulated fracture or one with significant neurovascular compromise. If reduction is attempted, the elbow then should be splinted at 90° with the forearm in supination with a posterior moldable splint and a sling and swathe placed.

**Forearm**

While the unique fracture and dislocation patterns of the forearm are of interest to the emergency physician in determining definitive management, they are less important to the prehospital provider. Field management involves splinting with a posterior mold or short boards in the position found. Indications for attempted field reduction are similar to other fractures, although neurovascular compromise in these fractures is less common than in injuries of the humerus or elbow. Fractures to the proximal ulnar, olecranon, and radius are treated similarly to other fractures and dislocations about the elbow.

**Wrist**

Fractures of the distal radius and ulna are the most common wrist fractures, followed by the carpal bones, notably the scaphoid and triquetrum [14]. Distal forearm fractures should be immobilized in the position of function, if tolerated, or the position found. Carpal fractures can be immobilized in either a short board or commercial wrist splint. Once splinted, the extremity may be placed in a sling and swathe to further reduce movement. Distal neurovascular assessment should be documented. EMS providers may be trained to assess for snuff box tenderness to assist in identifying potential scaphoid fractures [15]. Carpal ligamentous injury frequently occurs in conjunction with bony injury and should be splinted similarly based on physical exam findings of tenderness.

**Hand/fingers**

Hand and finger injuries are rarely life threatening but can be emotionally disturbing to the patient and provider. Once attention is appropriately turned to the hand injury, function of the median, radial, and ulnar nerves should be assessed as previously outlined. Vascular status can be assessed through capillary refill, which should be less than 2 seconds. Flexor and extensor tendon function should be tested in each finger and compared between hands.

Fractures and dislocations of the phalanx should be splinted as found, and buddy taping can be used to stabilize the finger itself prior to placing the affected hand in a wrist or short board splint. Field reduction may be appropriate in some situations. However, ideally the patient should be transported to the emergency department for a peripheral nerve block prior to reduction. Case reports do exist of successful paramedic performance of a digital block and subsequent reduction, and this is a potential future expansion of practice [16]. While metacarpal fracture management and follow-up vary depending on radiographic findings and patient activity, field management is unchanged and involves splinting. One hand injury that deserves special mention is the high-pressure injection injury, which always requires transport to the ED for evaluation and possible surgical intervention [17].

**Pelvis**

Although pelvic fractures are relatively rare among orthopedic injuries, they are associated with high mortality (10–15%) due to both the presence of concurrent severe traumatic injuries and the pathophysiology of unstable pelvic fractures [18]. The most common mechanisms associated with pelvic fractures involve the transmission of significant amounts of force such as through high-speed motor vehicle collisions, pedestrians hit by automobiles, or significant falls [19].

Anterior-posterior compressive forces are often associated with the highest degree of hemodynamic instability and mortality [19]. Such fractures cause significant disruption to the pelvic ring, resulting in widening of the pelvis, tearing of the iliac ligaments and shear force injuries of the iliac vessels. The predominantly venous hemorrhage spills into the retroperitoneum and expanded pelvic cylinder. If left uncontrolled, this hemorrhage can be fatal due to the large potential space of the unstable pelvic vault.

Pelvic injury should be suspected in any patient with significant traumatic injuries of the head, spine, thorax, abdomen, or multiple extremities. Signs of shock should raise suspicion of an unstable pelvic fracture in patients without outward signs of fracture. Other signs and symptoms of pelvic fractures may include perineal or flank hematoma, or blood at the penile meatus or vaginal introitus. Obvious bony instability of the pelvis with light palpation is a clear finding of pelvic fracture. However, the absence of external findings does not exclude the presence of an unstable pelvic fracture [20]. The examiner may gently compress the pelvis to test for stability, but caution is advised, as this may exacerbate an unstable fracture or concomitant bleeding.

Clinical management of the suspected pelvic fracture, as with other major trauma, includes immobilization and rapid transport to a trauma center. Given the risk of vascular and hemodynamic compromise, vital signs and distal neurovascular status should be monitored closely during transport. In addition to general immobilization techniques, use of a pelvic binder may be indicated. Whether it is a commercial product or an improvised sheet, the principle behind the use of a pelvic binder is to reduce the potential space of the pelvis and to tamponade the associated venous bleeding. Epidemiological and biometric data suggest that the application of a pelvic binder reduces mortality [21]. Although routinely used in prehospital care in the past, there is a theoretical concern for worsening of vascular injury and hemorrhage due to vessel laceration by bony fragments. Therefore, care should be taken when applying a binder.

**Lower extremity**

**Lower extremity neurovascular exam**

Similar to the upper extremity, a thorough lower extremity neurovascular exam should be completed and documented before and after any intervention or patient movement. The tibial, sural, superficial peroneal, and deep peroneal nerves should be assessed for both motor and sensory function. The femoral and obturator nerves should be assessed when there is concern for pelvic and hip fractures ([Table 36.3](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#c36-tbl-0003)). The vascular exam involves palpation of the popliteal, dorsal pedal, and posterior tibial pulses.

[**Table 36.3**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#R_c36-tbl-0003) Lower extremity neurological examination

| **Nerve** | **Motor** | **Sensory** |
| --- | --- | --- |
| Tibial | Toe flexion | Plantar foot surface |
| Sural | N/A | Posterolateral calf and foot |
| Superficial peroneal | Ankle eversion | Dorsal foot surface |
| Deep peroneal | Ankle dorsiflexion | First dorsal web space |
| Femoral | Knee extension | Anterior thigh and knee |
| Obturator | Hip adduction | Medial thigh |

**Hip**

Hip fractures are common, accounting for more than 300,000 hospitalizations per year in the United States [22]. Age and sex are major risk factors: 80% of hip fractures occur in patients aged 75 or over, and nearly three out of every four patients are female [23]. More than 90% of hip fractures are due to elderly falls but may also result from high-energy trauma (such as from a motor vehicle collision) [24]. Classically, patients present with pain, and shortening and external rotation of the affected limb [25]. However, these findings can be inconsistent depending on the anatomical location of the fracture.

Prehospital providers should rely on their standard trauma assessments to assess injuries to the hip. As a large amount of force is needed to fracture a hip in younger patients, concomitant injuries are found in 40–75% of cases [26]. Among the elderly, providers should evaluate for precipitating factors, other fall-related injuries, and conditions related to delays in accessing care. Depending on patient condition, further prehospital management could include general orthopedic trauma care, appropriate splinting ([Table 36.4](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#c36-tbl-0004)), and aggressive analgesia as tolerated. While it is possible to provide skin traction using a commercial device for hip fractures, a 2011 Cochrane review found no benefit from preoperative traction of any sort [27].

[**Table 36.4**](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c36.xhtml?favre=brett#R_c36-tbl-0004) Lower extremity immobilization approach

| **Bone** | **Approach** |
| --- | --- |
| Hip | Backboard or long board splints, pillows |
| Femur | Traction splint |
| Knee | Short board A-splint (bent) or long board splints (straight) |
| Tibia, fibula | Long board splints |
| Ankle, foot | Pillow splint |
| Toe | Buddy taping |

Short or long board splints are generally interchangeable with air or vacuum splints.

Hip joints are inherently stable. Dislocations are generally caused by high-energy trauma, most often motor vehicle crashes. The force required to dislocate a hip is so great that 95% of these patients will have other major injuries as well [28]. Ninety percent of hip dislocations are posterior dislocations of the femoral head, while the remaining 10% are either anterior or medial (associated with acetabular fractures) [29]. Patients will most commonly complain of severe hip pain and limb deformity in the setting of a significant mechanism of injury.

Due to the high rate of concomitant injuries, prehospital providers should generally approach those with suspected hip dislocations as major trauma patients. The focus of care should be on prompt packaging and transport, as these patients have significantly increased rates of serious neurovascular complications if the dislocation is not reduced within 6 hours [30]. However, appropriate splinting and analgesia should not be ignored.

#### Femur

As with hip dislocations, femoral shaft fractures are often seen in younger patients as a result of major trauma [29]. Of note, large volume hemorrhage can occur in the thigh, with potential development of distal limb ischemia or clinically significant hypovolemia [31]. Owing to the large size of the thigh, compartment syndrome is rare [32].

These fractures can be readily diagnosed in the field, as the thigh is generally painful, swollen, and deformed, while the affected limb appears shortened. Although there are limited data pertaining to their application in the prehospital setting, commercial traction splints have long been the standard of care used by EMS personnel in the management of isolated femoral shaft fractures [25,33,34]. Their use is discussed later in this chapter.

#### Knee

Knee injuries include fractures, dislocations, and damage to the supporting structures of the joint, including all ligaments and menisci. When splinting knee injuries, it is often best to immobilize the limb in the position found or in the position of comfort [33]. Care should be taken not to splint the leg fully extended, as this may compress the neurovascular bundle against the posterior tibia [35].

Although relatively uncommon, knee dislocations require additional care in the prehospital setting. Tibiofemoral dislocations can result from motor vehicle collision, sports injuries, and even falls [36]. These injuries have the potential to cause severe vascular damage at the site of the popliteal artery, leading to distal ischemia [35]. Prompt treatment and transport are crucial to prevent long-term damage to the affected limb. In extreme cases (such as severely delayed transport or other extenuating conditions significantly delaying definitive care), properly trained and authorized prehospital providers may consider attempting reduction in the field, if necessary to restore distal circulation. Of note, up to 50% of knee dislocations spontaneously reduce prior to ED presentation [37].

Fractures of the tibial plateau can occur from both low- and high-energy trauma and are seen in both young adults and the elderly [38]. Those occurring at the medial plateau have the potential to damage the peroneal nerve and/or the popliteal artery, leading to distal neurovascular impairment [35]. Further complications can include the development of compartment syndrome, although this generally occurs 24–48 hours after the time of injury [39].

#### Leg injuries

The tibia is the most commonly fractured of all long bones [40]. Eighty percent of the time there is an associated fibular fracture, due to their adjacent positioning and attachment via the syndesmotic ligament [41]. This ligament can transmit energy between the bones such that they may be fractured at non-adjacent sites [35].

The lower leg can be immobilized with a variety of devices, including cardboard, padded wood, and vacuum splints [33]. Similar to the knee, it is best to immobilize the leg with a slight amount of flexion [35]. Care should be taken to also immobilize the ipsilateral knee and ankle, as the long bones of the leg play an important role in stabilizing the adjacent joints [42]. Compartment syndrome is once again a concern, occurring in 8.1% of tibial shaft fractures [43].

#### Ankle and foot injuries

When splinting ankle or foot injuries, consider pillow splints, air splints, or any other method that avoids pressure on the bony prominences [33]. As with knee dislocations, if patient transport is to be significantly prolonged, properly trained and authorized prehospital personnel may consider reducing dislocated ankle joints that show signs of distal neurovascular compromise.

Many foot and ankle injuries can be subtle and difficult to identify solely on clinical exam, but may be at risk for long-term complications if not evaluated early [44]. To aid in triage of these patients, criteria such as the Ottawa decision rules have been developed to help ED providers determine the need for radiographs [45,46]. However, such methods have not been validated in the prehospital setting. Without a validated method to rule out severe injury in the field, every effort should be made to transport these patients for further evaluation.

### Spine

Injuries of the bony spine and spinal column are of concern in patients with multiple system trauma. The cervical spine is the most commonly injured area of the spine, followed by the thoracolumbar spine, lumbar, and thoracic spine, respectively [47]. The incidence of cervical spine fractures in trauma has been estimated to be approximately 4% [48]. However, the incidence of cervical spine injuries is higher (5–10%) in patients with head trauma or trauma above the clavicles [49]. While the overall incidence of concomitant spinal cord injuries in all blunt trauma has been estimated to be less than 2%, it is the possibility of severe neurological impairment, including paralysis, lasting disability, or death that raises the level of concern and caution in the prehospital and acute care environment [48].

Patients with vertebral spine or spinal cord injury can present with a variety of symptoms, from obvious paralysis to subtle neurological deficits or simply neck or back pain. The primary trauma survey may reveal clues to high cervical spine trauma. For example, patients with high cervical injuries may have impairment of the phrenic nerve, presenting with abnormal breathing or respiratory failure that can rapidly progress to death. Neurogenic shock due to impairment of the autonomic pathways presents with hypotension refractory to fluids and is often accompanied by bradycardia.

Assessment of neurological disability may further raise suspicion of severe vertebral column injury. Patients with diminished sensorium have higher potential for harboring occult spinal cord trauma. A careful secondary survey should include a more thorough assessment of neurological status including motor and sensory testing. Further, prehospital providers should be alert for neurological symptoms indicative of central cord, anterior cord, and Brown-Séquard syndromes. The most common of these, central cord syndrome, occurs frequently in the elderly and classically presents with bilateral weakness, most severe in the distal upper extremities.

Spinal injury should be suspected in any patient with any of the following findings.

* Evidence of multiple traumatic injuries
* Focal neurological symptoms such as weakness or numbness
* Neck pain, back pain, or midline spine tenderness
* Head injuries with significant mechanism AND altered mental status or evidence of significant intoxication
* Distracting painful injuries in the setting of a suspicious mechanism

Maintenance of neutral immobilization of the spine is the standard of care for any patient with suspected spinal injury. Two large, multicenter studies were conducted to explore predictors for safely clearing patients from spinal immobilization without radiographic imaging [50,51]. However, it is important to note that these studies were not conducted in the prehospital setting. Additionally, each study asked the question whether or not to image the spine prior to clearing spinal immobilization, not whether to immobilize the spine during initial assessment.

The most common technique for spinal immobilization includes placing the patient in a hard cervical collar and on a backboard. Once immobilization is initiated, the average amount of time patients spend on a backboard has been estimated to be over 1 hour [52]. Prolonged use of a rigid backboard is associated with several complications such as pain and pressure ulcers as well as respiratory compromise and aspiration events. Additionally, there are several special circumstances of prehospital care, such as wilderness or search and rescue settings, in which total spinal immobilization carries substantial risks of injury to the first responders and is therefore used more judiciously than in standard practice. Given the range of significant complications associated with full spinal immobilization, there is growing interest in the prehospital and trauma literature regarding the utility of limited use of both full spine and cervical spine immobilization [53]. There is increasing utilization of selective spinal immobilization policies among EMS systems (see Volume 1, [Chapter 40](https://jigsaw.vitalsource.com/books/9781118990827/epub/OPS/c40.xhtml)) Some systems have examined the outcomes associated with these policies, with promising results indicating that such policies could be implemented safely in the prehospital setting [54–56]. More research should be conducted to validate these preliminary studies and to create standardized guidelines for selective immobilization policies.

## Splinting

### Indications and basic technique

Splinting is the mainstay of emergency immobilization of an injured extremity. Whether the injury is a fracture, dislocation, or sprain, immobilization in the position of comfort will help to reduce pain and chance of further injury. Other indications for splinting include reduction of hemorrhage and maintenance of alignment after reduction of a fracture or dislocation [33,57].

The basic technique for splinting an injured extremity includes protecting the skin and soft tissue, applying a rigid material to immobilize the painful extremity, and securing the rigid material with a flexible material. While immobilization is essential, a splint should also not be applied tightly or circumferentially to the limb, in order to avoid neurovascular compression and compromise. The general rule of thumb is to leave at least one surface of a limb exposed to allow for continued swelling and to prevent complications [33].

### Splinting materials

There are many commercial materials made of fiberglass or other durable components. These are primarily used in the ED or wilderness settings for longer term splinting. In the prehospital setting, where transport time is limited to generally less than 1 hour, and patient function and mobility are also limited, temporary materials such as cardboard secured by tape will provide sufficient immobilization and pain control. In austere settings, such as the wilderness or during a disaster response, non-traditional items can easily be repurposed to create a variety of splints or slings. For example, a large sheet or piece of clothing can be tied tightly as a pelvic binder. Hiking backpacks with a hard frame can serve as a partial backboard. Any large stick can be fastened to an extremity with tape or clothing for immobilization [58]. Even prefabricated extremity splints (e.g. fiberglass) can be fashioned into effective, temporary cervical collars [59]. Additionally, larger water bottles or jugs, when filled with water and fastened with rope, can provide the weighted component for a makeshift traction splint [58].

### Traction splints

Prehospital use of traction devices for orthopedic trauma has been considered standard treatment of femoral shaft fractures [25,33,34]. Commercial traction splints are considered required ambulance equipment by the American College of Surgeons, the American College of Emergency Physicians, the National Association of EMS Physicians, the Emergency Medical Services for Children Program, and the American Academy of Pediatrics [60]. These recommendations posit that traction reduces pain and limits further blood loss, neurovascular damage, or soft tissue injury.

However, there are downsides to prehospital traction splinting. Proper splint application takes two trained providers approximately 5–6 minutes to perform, contributing to EMS on-scene delays [61]. Case studies have identified episodes of transient peroneal nerve palsies, compartment syndrome, urethral injury, pressure ulcers, and distal ischemia as a result of prolonged use of EMS traction devices [62]. Further research has demonstrated suboptimal rates of proper splint application, much of which is attributed to the infrequency of its usage [63,64]. Additionally, a Cochrane review found no benefit or significant analgesia related to preoperative hip traction [27]. Further research is needed to better guide prehospital usage of these devices.

## Reductions with (and without) medications

### Field reduction versus definitive care

The decision to allow field reductions of extremity fractures and dislocations is specific to the individual EMS system and each clinical scenario. There are widely accepted indications for one attempt at gentle reduction, which include distal neurovascular deficit or severe angulation [65]. However, even these should generally be deferred if anticipated transport time is minimal (e.g. less than 10 minutes).

System-specific variations in protocol should be considered for regions with large rural areas and extended transport times. Further, programs that regularly staff large sporting events may provide additional training to their providers that could allow for more aggressive field reduction techniques. When considering implementation of such protocols, availability of both on-scene supervisory personnel (e.g. EMS physician or sports medicine physician) and analgesia should be considered [11].

There are good reasons not to allow field reductions except for the most critical circumstances (e.g. pulse deficit), which include converting a dislocation to a fracture-dislocation, causing further neurovascular compromise, or converting a closed fracture to an open one. Without prereduction films, there is no proof that a fracture preceded a reduction attempt. If a reduction is performed, the extremity should be splinted immediately after in the position of function, distal neurovascular status reassessed, and the patient should always be transported to the emergency department.

## Special considerations: partial or complete amputations and neurovascular injuries

Emergency medical services providers are often the first medical personnel to encounter a patient suffering from a traumatic amputation and must be prepared to care for the amputated part as well as the patient. Once priorities such as bleeding control are addressed through either direct pressure or a tourniquet, attention should be turned to recovering and preserving the amputated part in addition to obtaining a thorough history that includes time of amputation, mechanism of injury, and the patient’s handedness and occupation. EMS providers should not prognosticate likelihood of replantation.

The stump can be gently cleaned of debris and gross contamination with sterile saline and then covered with saline moistened sterile gauze. The blood vessels of the stump should not be clamped, nor should the stump be manually debrided. An underlying fracture should be assumed, and the extremity should be splinted as such; this is particularly important in the setting of a partial amputation. Efforts should be made by the EMS crew on scene to locate the amputated part, and if the patient is not stable enough to await locating it, then another responder should be instructed to locate, store, and transport it to the hospital urgently.

The amputated part should be wrapped in a saline moistened gauze pad and placed in a plastic bag, which then should be placed in a container of ice. The goal temperature is 4 ºC and care should be taken to not freeze the part. The part should not be placed directly on ice or be immersed in saline [66]. The patient should be transferred urgently to a replantation-capable hospital, if available. If the patient meets major trauma criteria and the trauma center is not a replantation center, the patient should preferentially go to the trauma center [66].

**Conclusion**

Orthopedic injuries commonly present in the prehospital setting. EMS physicians, providers, and systems must be prepared to evaluate and treat these injuries appropriately. EMS physicians can provide a benefit to their systems by understanding the current evidence and best practices.

**References**

1. 1 Schopper D, Lormand JD, Waxweiler R (eds). *Developing Policies to Prevent Injuries and Violence: Guidelines for Policy Makers and Planners*. Geneva: World Health Organization, 2006.
2. 2 Melamed E, Blumenfeld A, Kalmovich B, Kosashvili Y, Lin G, IDF Medical Corps Consensus Group on Prehospital Care of Orthopedic Injuries. Prehospital care of orthopedic injuries. *Prehosp Disaster Med* 2007;22:22–5.
3. 3 McManus JG, Sallee DR. Pain management in the prehospital environment. *Emerg Med Clin North Am* 2005;23:415–31.
4. 4 Soriya GC, McVaney KE, Liao MM, et al. Safety of prehospital intravenous fentanyl for adult trauma patients. *J Trauma Acute Care Surg* 2012;72:755–9.
5. 5 Groh GI, Wirth MA. Management of traumatic sternoclavicular joint injuries. *J Am Acad Orthop Surg* 2011;19:1–7.
6. 6 Baldwin KD, Ohman-Strickland P, Mehta S, Hume E. Scapula fractures: a marker for concomitant injury? A retrospective review of data in the National Trauma Database. *J Trauma* 2008;65:430–5.
7. 7 Rudzinski JP, Pittman LM, Uehara DT. Shoulder and humerus injuries. In: Tintinalli JE, Stapczynski JS, Ma OJ, Cline DM, Cydulka RK, Meckler GD (eds) *Tintinalli’s Emergency Medicine: A Comprehensive Study Guide*, 7th edn. New York: McGraw-Hill, 2011.
8. 8 Beason MS. Complications of a shoulder dislocation. *Am J Emerg Med* 1999;17:288–95.
9. 9 Horn AE, Ufberg JW. Management of common dislocations. In: Roberts JR, Custalow CB, Thomsen TW, et al. (eds) *Roberts & Hedges’ Clinical Procedures in Emergency Medicine*, 6th edn. Philadelphia: Saunders Elsevier, 2014.
10. 10 Dudkiewicz I, Arzi H, Salai M, Heim M, Pritsch M. Patients education of a self-reduction technique for anterior glenohumeral dislocation of shoulder. *J Trauma* 2010;68:620–3.
11. 11 Norte GE, West A, Gnacinski M, van der Meijden OA, Millett PJ. On-field management of the acute anterior glenohumeral dislocation. *Phys Sportsmed* 2011;39:151–62.
12. 12 Abzug JM, Herman MJ. Management of supracondylar humerus fractures in children: current concepts. *J Am Acad Orthop Surg* 2012;20:69–77.
13. 13 Bredenkamp JH, Jokhy BP, Uehara DT. Injuries to the elbow and forearm. In: Tintinalli JE, Stapczynski JS, Ma OJ, Cline DM, Cydulka RK, Meckler GD (eds) *Tintinalli’s Emergency Medicine: A Comprehensive Study Guide*, 7th edn. New York: McGraw-Hill, 2011.
14. 14 Escarza R, Loeffel MF, Uehara DT. Wrist injuries. In: Tintinalli JE, Stapczynski JS, Ma OJ, Cline DM, Cydulka RK, Meckler GD (eds) *Tintinalli’s Emergency Medicine: A Comprehensive Study Guide*, 7th edn. New York: McGraw-Hill, 2011.
15. 15 Shehab R, Mirabelli MH. Evaluation and diagnosis of wrist pain: a case-based approach. *Am Fam Physician* 2013;87:568–73.
16. 16 Simpson PM, McCabe B, Bendall JC, Cone DC, Middleton PM. Paramedic-performed digital nerve block to facilitate field reduction of a dislocated finger. *Prehosp Emerg Care* 2012;16:415–17.
17. 17 Pappou IP, Deal DN. High-pressure injection injuries. *J Hand Surg Am* 2012;37:2404–7.
18. 18 Patterson LA. Pelvic fractures. In: Adams JG (ed) *Emergency Medicine*. Philadelphia: Saunders Elsevier, 2008.
19. 19 Dalal SA, Burgess AR, Siegel JH, et al. Pelvic fracture in multiple trauma: classification by mechanism is key to pattern of organ injury, resuscitative requirements, and outcome. *J Trauma* 1989;29(7):981–1000.
20. 20 Gonzalez RP, Fried PQ, Bukhalo M. The utility of clinical examination in screening for pelvic fractures in blunt trauma. *J Am Coll Surg* 2002;194:121–5.
21. 21 Krieg JC, Mohr M, Ellis TJ, Simpson TS, Madey SM, Bottlang M. Emergent stabilization of pelvic ring injuries by controlled circumferential compression: a clinical trial. *J Trauma* 2005;59:659–64.
22. 22 Buie VC, Owings MF, DeFrances CJ, Golosinskiy A. *National Hospital Discharge Survey: 2006 Summary, Vital Health Stat 13(168)*. Atlanta, GA: National Center for Health Statistics, 2010.
23. 23 Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. *JAMA* 2009;302:1573–9.
24. 24 Cummings SR, Kelsey JL, Nevitt MC, O'Dowd KJ. Epidemiology of osteoporosis and osteoporotic fractures. *Epidemiol Rev* 1985;7:178–208.
25. 25 Murray BL. Femur and hip. In: Marx JA, Hockberger RS, Walls RM (eds) *Rosen’s Emergency Medicine: Concepts and Clinical Practice*, 8th edn. Philadelphia: Saunders Elsevier, 2014.
26. 26 Sahin V, Karakas ES, Aksu S, Atlihan D, Turk CY, Halici M. Traumatic dislocation and fracture-dislocation of the hip: a long term follow-up study. *J Trauma* 2003;54:520–9.
27. 27 Handoll HH, Queally JM, Parker MJ. Pre-operative traction for hip fractures in adults. *Cochrane Database Syst Rev* 2011;12:CD000168.
28. 28 Hak DJ, Goutlet JA. Severity of injuries associated with traumatic hip dislocation as a result of motor vehicle collisions. *J Trauma* 1999;47:60–3.
29. 29 Anwar R, Tuson K, Khan SA. *Classification and Diagnosis in Orthopaedic Trauma*. New York: Cambridge University Press, 2008.
30. 30 Clegg TE, Roberts CS, Greene JW, Prather BA. Hip dislocations – epidemiology, treatment, and outcomes. *Injury* 2010;41:329–34.
31. 31 Smith RM, Giannoudis PV. Femoral shaft fractures. In: Browner BD, Jupiter JB, Levine AM, Trafton P, Krettek C (eds) *Skeletal Trauma: Basic Science, Management and Reconstruction*, 4th edn. Philadelphia: Saunders Elsevier, 2009.
32. 32 Mithöfer K, Lhowe DW, Vrahas MS, Altman DT, Altman GT. Clinical spectrum of acute compartment syndrome of the thigh and its relation to associated injuries. *Clin Orthop Relat Res* 2004;425:223–9.
33. 33 Klimke A, Furin M. Prehospital immobilization. In: Roberts JR, Custalow CB, Thomsen TW, et al. (eds) *Roberts & Hedges’ Clinical Procedures in Emergency Medicine*, 6th edn. Philadelphia: Saunders Elsevier, 2014.
34. 34 National Association of Emergency Medical Technicians and American College of Surgeons Committee on Trauma. *Prehospital Trauma Life Support*, 7th edn. Burlington, MA: Jones and Bartlett Learning, 2011.
35. 35 Pallin DJ. Knee and lower leg. In: Marx JA, Hockberger RS, Walls RM (eds) *Rosen’s Emergency Medicine: Concepts and Clinical Practice*, 8th edn. Philadelphia: Saunders Elsevier, 2014.
36. 36 Robertson A, Nutton RW, Keating JF. Dislocation of the knee. *J Bone Joint Surg Br* 2006;88:706–11.
37. 37 Wascher DC, Dvirnak PC, DeCoster TA. Knee dislocation: initial assessment and implications for treatment. *J Orthop Trauma* 1997;11:525–9.
38. 38 Cole P, Levy B, Schatzker J, Watson JT. Tibial plateau fractures. In: Browner BD, Jupiter JB, Levine AM, Trafton P, Krettek C (eds) *Skeletal Trauma: Basic Science, Management and Reconstruction*, 4th edn. Philadelphia: Saunders Elsevier, 2009.
39. 39 Chang YH, Tu YK, Yeh WL, Hsu RW. Tibial plateau fracture with compartment syndrome: a complication of higher incidence in Taiwan. *Chang Gung Med J* 2000;23:149–55.
40. 40 Russell TA. Fractures of the tibial diaphysis. In: Levine AM (ed) *Orthopedic Knowledge Update: Trauma*. Rosemont, IL: American Academy of Orthopedic Surgeons, 1996, pp.171–9.
41. 41 Court-Brown CM, McBirnie J. The epidemiology of tibial fractures. *J Bone Joint Surg Br* 1995;77:417–21.
42. 42 Trafton PG. Tibial shaft fractures. In: Browner BD, Jupiter JB, Levine AM, Trafton P, Krettek C (eds) *Skeletal Trauma: Basic Science, Management and Reconstruction*, 4th edn. Philadelphia: Saunders Elsevier, 2009.
43. 43 Park S, Ahn J, Gee AO, Kuntz AF, Esterhai JL. Compartment syndrome in tibial fractures. *J Orthop Trauma* 2009;23:514–18.
44. 44 Abu-Laban RB, Rose NG. Ankle and foot. In: Marx JA, Hockberger RS, Walls RM (eds) *Rosen’s Emergency Medicine: Concepts and Clinical Practice*, 8th edn. Philadelphia: Saunders Elsevier, 2014.
45. 45 Bachmann LM, Kolb E, Koller MT, Steurer J, ter Riet G. Accuracy of Ottawa ankle rules to exclude fractures of the ankle and mid-foot: systemic review. *BMJ* 2003;326:417.
46. 46 Dowling S, Spooner CH, Liang Y, et al. Accuracy of Ottawa Ankle Rules to exclude fractures of the ankle and midfoot in children: a meta-analysis. *Acad Emerg Med* 2009;16:277–87.
47. 47 Lin M, Mahadevan SV. Spine trauma and spinal cord injury. In: Adams JG (ed) *Emergency Medicine*. Philadelphia: Saunders Elsevier, 2008.
48. 48 Grossman MD, Reilly PM, Gillett T, Gillett D. National survey of the incidence of cervical spine injury and approach to cervical spine clearance in U.S. trauma centers. *J Trauma* 1999;47:684–90.
49. 49 Marion DW. Head and spinal cord injury. *Neurol Clin* 1998;16:485–502.
50. 50 Hoffman JR, Mower WR, Wolfson AB, Todd KH, Zucker MI. Validity of a set of clinical criteria to rule out injury to the cervical spine in patients with blunt trauma. National Emergency X-Radiography Utilization Study Group. N Engl J Med 2000;343:94–9.
51. 51 Stiell IG, Clement CM, McKnight RD, et al. The Canadian C-spine rule versus the NEXUS low-risk criteria in patients with trauma. *N Engl J Med* 2003;349:2510–18.
52. 52 Cooney DR, Wallus H, Asaly M, Wojcik S. Backboard time for patients receiving spinal immobilization by emergency medical services. *Int J Emerg Med* 2013;20:17.
53. 53 National Association of Emergency Medical Services Physicians. EMS spinal precautions and the use of the long backboard. *Prehosp Emerg Care* 2013;17:392–3.
54. 54 Domeier RM, Frederiksen SM, Welch K. Prospective performance assessment of an out-of-hospital protocol for selective spine immobilization using clinical spine clearance criteria. *Ann Emerg Med* 2005;46:123–31.
55. 55 Stroh G, Braude D. Can an out-of-hospital cervical spine clearance protocol identify all patients with injuries? An argument for selective immobilization. *Ann Emerg Med* 2001;37:609–15.
56. 56 Burton JH, Dunn MG, Harmon NR, Hermanson TA, Bradshaw JR. A statewide, prehospital emergency medical service selective patient spine immobilization protocol. *J Trauma* 2006;61:161–7.
57. 57 Fitch MT, Nicks BA, Pariyadath M, McGinnis HD, Manthey DE. Videos in clinical medicine: basic splinting techniques. *N Engl J Med* 2008;359:e32.
58. 58 Kassel MR, Gianotti A. Splints and slings. In: Auerbach PS (ed) *Wilderness Medicine*, 6th edn. Philadelphia: Elsevier Mosby, 2012.
59. 59 McGrath T, Murphy C. Comparison of a SAM splint-molded cervical collar with a Philadelphia cervical collar. *Wilderness Environ Med* 2009;20:166–8.
60. 60 American College of Surgeons Committee on Trauma, American College of Emergency Physicians, National Association of EMS Physicians, Pediatric Equipment Guideline Committee–Emergency Medical Services for Children Partnership for Children Stakeholder Group, American Academy of Pediatrics. Equipment for ambulances. *Prehosp Emerg Care* 2009;13:364–9.
61. 61 Hedges JR, Feero S, Moore B, Shultz B, Haver DW. Factors contributing to paramedic onscene time during evaluation and management of blunt trauma. *Am J Emerg Med* 1988;6:443–8.
62. 62 Agrawal Y, Karwa J, Shah N, Clayson A. Traction splint: to use or not to use. *J Perioper Pract* 2009;19:295–8.
63. 63 Abarbanell NR. Prehospital midthigh trauma and traction splint use: recommendations for treatment protocols. *Am J Emerg Med* 2001;19:137–40.
64. 64 Daugherty MC, Mehlman CT, Moody S, LeMaster T, Falcone RA Jr. Significant rate of misuse of the hare traction splint for children with femoral shaft fractures. *J Emerg Nurs* 2013;39:97–103.
65. 65 Limmer DJ, O’Keefe MF, Grant HT, et al. (eds) *Emergency Care*, 12th edn. Upper Saddle River, NJ: Prentice Hall, 2011.
66. 66 Moorell D. Management of amputations. In: Roberts JR, Custalow CB, Thomsen TW, et al. (eds) *Roberts & Hedges’ Clinical Procedures in Emergency Medicine*, 6th edn. Philadelphia: Saunders Elsevier, 2014.