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GUIDELINES FOR FIRST AID OF EXTREMITY FRACTURES

Abstract

Bone fractures are a constant occurrence in tactical and civilian settings, and their rapid recognition and treatment allows to avoid potentially disabling or deadly complications. This narrative review draws on international guidelines, literature

reviews, medical textbooks, and original studies to present scientific information on limb fractures, their complications as well as methods of first aid in austere conditions. Particular emphasis was placed on Tactical Combat Casualty Care guidelines as they were most relevant to the topic of this paper. The scope of information presented in this paper encompasses management of fractures after life-threatening conditions and injuries were either ruled out or already addressed in accordance with the MARCH algorithm. Main focus in first aid is placed on fracture recognition, as well as prompt administration of analgesia, early antibiotic prophylaxis, wound dressing, and fracture splinting, as recommended in the PAWS algorithm.

Keywords

fracture, open fracture, closed fracture, tactical medicine

Introduction

Bone fractures are a significant problem in austere settings, as they are among the most common results of traumatic injuries. In the short term, fractures cause pain and impair limb function. They may also damage nerves and blood vessels or lead to infection. These complications can result in permanent disability or even death.To address these risks, adequate pre-hospital care may mitigate pain, bleeding, the risk of further soft-tissue damage, and the possibility of long-term complications, and facilitate faster recovery

The aim of this review is to present science-based methods for first aid for extremity fractures. It will focus on fracture diagnosis, and methods of first aid in accordance with PAWS algorithm.

Methods

This narrative review uses information from international clinical guidelines, medical textbooks, review articles, and original research focused on first aid for extremity fractures. To identify relevant literature, a structured search was conducted using scientific databases, mainly PubMed. The search included terms such as “Fracture”, “First aid”, “tactical medicine”, “Analgesia”, “Antibiotic prophylaxis”, and “Splinting”. Relevant sources were screened for eligibility based on relevance to immediate extremity fracture management.

Due to the narrative nature of this study, a formal systematic meta-analysis protocol was not applied.

Fracture

A fracture is a break in the continuity of a bone. Fractures may be classified into many categories, but are broadly divided into closed fractures, in which osseous fragments do not disrupt the continuity of the skin at the site of injury, and open (compound) fractures, in which osseous fragments penetrate through the skin, resulting in external communication of the fracture site (Bernert, 2024, p 101). Improper post-trauma care may cause the osseous fragments in a closed fracture to pierce the skin, turning it into an open fracture (TCCC,2023b). Open fractures may further be classified by a system proposed by Gustilo and Anderson (1976) into:

- Type I Wound shorter than 1 cm, typically clean, with minimal soft tissue damage, crushing, and contamination.
- Type II Wound more than 1 cm long, without extensive soft tissue damage, flap, or avulsion. Communication is moderate.
- Type III Wound with extensive damage to soft tissue, which includes both local nerves and blood vessels. As a result, these injuries pose significant management challenges.

Type III may be further divided into types A, B, and C. However, this part of the classification is too detailed for this paper.

Fracture complications

Blood Loss and Vascular Damage

Both closed and open fractures are often associated with significant blood loss. The approximate amounts of blood loss in different types of fractures are as follows:

- Rib – 125 ml
- Radius or Ulna – 250-500 ml
- Humerus – 500-700 ml
- Tibia or fibula – 500-1000 ml
- Femur – 1000-2000 ml
- Pelvis – >1000 ml (TCCC, 2023b)

According to Gaździk (2010, p 163), damage to blood vessels is present in approximately 0,2-10% of long bone fractures. The signs of vascular damage include:

- swelling
- pulsating hematoma
- ischemia of the limb distal to the fracture

Infection

The risk of infection in open fractures increases with fracture severity. For type I, risk is 0 to 2%, for type II, it is 2-10%, and for type III, it ranges from 10 to 50% (Zalavras, 2017). Study by Lack et al. (2015) shows that administering antibiotics within 66 minutes after injury reduces infection in type III open fractures. The same

study found that patients who received antibiotics within 60 minutes were much less likely to develop infection than those who received antibiotics between 60 and 90 minutes after the injury.

Nerve damage

According to the results presented by Noble et al. (1998, p. 116–122), based on a prospectively collected database of injuries, the incidence of peripheral nerve injuries associated with traumatic fractures varies widely by anatomical location. Percentage values for damage to the specific nerves are summarized in table 1.

Table 1. Prevalence of nerve injury in different types of fractures

Type of fracture	Prevalence of nerve injury
Humeral fracture	Radial nerve – 9,5% Ulnar nerve – 3,8% Median nerve – 1,4 %
Radial and ulnar fractures	Ulnar nerve – 2,4% Median nerve – 1,3%
Femoral fracture	Sciatic nerve – 1, 1 % Femoral nerve – 0,16%
Tibial and fibular fractures	Peroneal nerve – 2,2% Tibial nerve – 0,5%

Source: Noble et al. (1998, p 116-122)

Fracture identification

To assess a casualty, use the Tactical trauma assessment process. It has two main components: MARCH and PAWS. MARCH focuses on identifying and managing life-threatening conditions immediately. MARCH sequence stands for Massive hemorrhage, Airway, Respiration, Circulation, and Hypothermia/Head injury prevention. PAWS includes actions performed after life-saving steps: Pain, Antibiotics, Wounds, and Splinting. This study will focus on PAWS, as all its steps are relevant during fracture first aid.

Fracture Symptoms

Multiple signs of fracture may be distinguished, with some notable differences between closed fractures and open fractures, but common symptoms of both include:

- Significant pain
- Audible snapping sound during the time of injury
- Crepitus around the injured area

- Abnormal shape of the fractured limb
- Shortening of the fractured limb
- Loss of sensation or pulse distal to the injured area

Pain levels vary by individual; adrenaline can reduce pain, so even pain of low intensity should be considered a sign of potential fracture. Additional symptoms of closed fractures include:

- Hematoma or bruising
- Swelling
- The symptoms of open fractures not present in closed fractures are:
- Visible bone fragments protruding through the skin
- Open wound near the site of injury
- Bleeding

Closed fractures, depending on circumstances, may pose a similar threat to the surrounding tissue as open fractures; however, because there is no visible wound or bleeding, they may be less likely to be detected during a quick examination. Furthermore, soft-tissue damage from a fracture may cause the bone fragments to be displaced back into the wound, making them difficult for a first aid provider to spot. Therefore, any open wound in the vicinity of a suspected fracture should be considered an open fracture (TCCC, 2023b)

Both TCCC (2023b) and Wyatt et al. (2020) stress the need for a thorough limb assessment before splinting. Compare all injuries, skin color, sensorimotor function, and pulses below the fracture with the uninjured limb. It is suggested to take a picture of the limb for documentation, which can be practical in a tactical setting. Wyatt et al. (2020, p 410)

Pain

Study by Baharuddin, K. A. et al. (2020) showed that limb fractures may cause significant pain. Upper limb fractures were rated 6.47 ± 1.70 on the NRS scale. Lower limb fractures rated 7.80 ± 2.53. Mixed fractures rated 7.60 ± 3.36. In relation to pain-induced limitations in functioning these range from mild (<5 NRS) to severe (>/=8) with moderate being 6-7 (Boonstra et al., 2016). If possible, give an analgesic promptly to reduce suffering. During analgesic selection, factors such as pain severity, level of consciousness, route of administration, and contraindications should be considered. TCCC (2023c) recommends the following medications in tactical settings:

- Meloxicam is a nonsteroidal anti-inflammatory drug (NSAID). Unlike other NSAIDs, it does not impair platelet function. It is recommended for mild to moderate pain in conscious patients who can swallow. The oral dose is 15 mg. Contraindications include hypersensitivity to NSAIDs or salicylates, pregnancy, asthma, and severe renal or liver disease.
- Acetaminophen (paracetamol) similarly to meloxicam recommended for mild to moderate pain and is taken orally. The dose is up to 1 g every 8 hours.

Contraindications include hypersensitivity to paracetamol. Using it with alcohol may increase the risk of liver toxicity.

- Fentanyl, an opioid analgesic, is recommended for conscious patients in mild to moderate pain who are not in shock or respiratory distress. TCCC prefers Oral Transmucosal Fentanyl Citrate (OTFC) lozenges. One 800 mcg OTFC lozenge should be placed between the cheek and gum. Pain levels should be reassessed after 15 minutes; another lozenge may be given if needed. Contraindications include hypovolemic shock, respiratory distress, and severe head injury. The casualty's consciousness should be monitored during fentanyl administration.
- Ketamine is recommended for moderate to severe pain, and for casualties in hypovolemic shock, respiratory distress, or at risk for either. It is also used if fentanyl is not effective. Ketamine may be given intravenously or intraosseously at a dose of 20 mg by slow injection (over 1 minute). The dose may be repeated after 20 minutes if needed. Alternatively, the medication may be administered intramuscularly or intranasally at a dose of 50-100 mg. If necessary, repeat the dose after 20-30 minutes. Similarly to fentanyl analgesia levels of consciousness should be controlled after administration of this analgesic. Contraindications include a history of schizophrenia, patients younger than 3 years, or an allergy to ketamine.

Antibiotics

A study by Lack et al. (2015) discussed earlier in this paper and the TCCC (2023a) clearly emphasize the risk of infection in open fractures and the importance of early initiation of antibiotic therapy. Administration of antibiotics should not delay transport (Johnson, J. P. et al., 2024); however in a tactical setting, transport to medical facilities may be difficult or impossible for prolonged periods.

According to TCCC (2023a) conscious casualties who are capable of swallowing should receive prophylactic antibiotic therapy orally, 400 mg of moxifloxacin. If the casualty is, for any reason, incapable of swallowing the medication, 1 g of ertapenem should be administered intravenously, intramuscularly, or intraosseously. Contraindications for both include an allergy to these antibiotics.

Joint COT, OTA, ACEP, NAEMSP and NAEMT statement recommends usage of 1st generation cephalosporin for both responsive and obtunded patients, after management of life threats. An intravenous dose of 2 g of cefazolin is recommended for patients with no history of penicillin allergy. An identical dose may be administered to patients with a documented penicillin allergy; however, it should be performed with close monitoring of the patient's condition (Johnson, J. P. et al., 2024).

Wounds

This review focuses on first aid for fractures. Therefore, the broad topic of wounds will be narrowed to focus mainly on general recommendations for non-life-threatening

wound management. Particular emphasis will be placed on wounds of the fractured limb, as at this point, all life-threatening injuries should already have been addressed.

Firstly, it may be necessary to apply pressure to the wound to reduce or preferably stop the bleeding. The next step should be to irrigate the wound, which includes the open fracture or suspected open fracture. The aim is to remove some contaminants in the form of foreign bodies and to clean the wound. Irrigation should be performed with sterile water; if sterile water is unavailable, clean water may be used. After the wound is irrigated, a sterile dressing may be applied; alternatively, gauze with bandages or tape may be used. If none of those are available, a dressing made of clean, dry cloth may be tied in place or secured with tape (TCCC, 2023d).

It is imperative to treat and record all wounds and injuries on the fractured limb before immobilizing it, as splint application may hide them and hinder access (TCCC, 2023d).

Splinting

According to Eiff and Hatch (2011, p 17), nearly all acute fractures should benefit from immobilization, as it may prevent additional damage to structures near the injury, alleviate pain, and prevent further changes in the position of bone fragments. TCCC (2023b) and Boyd et al. (2009) regard splinting as the preferred method for fracture immobilization in an acute setting.

Benefits of splint application include:

- Splinting is easier and faster than casting, especially in austere conditions.
- Splints are noncircumferential, and as such, they allow the natural swelling to occur.
- Splints are easier to remove, which may be necessary for inspection of the injury site.

Before applying the splint, all personal belongings that may constrict the fractured limb after it swells, such as watches, boots, rings, or bracelets, should be removed (TCCC, 2023b)

Firstly, all necessary materials should be gathered, and the fractured limb should be placed in a neutral or functional position. Splinting materials include: the splint itself, padding, cloth for securing the splint, and a sling or swathe. Splints may be divided into rigid and malleable; the former are less commonly included in first-aid bags but may be improvised with a long object such as a board, broom handle, or even a folded piece of cardboard; the latter may be molded around joints, providing more comfort for the casualty. Both types of splints may already be padded; however, adding additional padding is often necessary. If possible, ask another person to assist with the splint application. Materials should be measured on the opposite extremity to avoid manipulation at the site of injury. The splint is recommended to extend to include the joints above and below the fracture site; it should not extend beyond the extremity itself, e.g., splints in femur fractures should encompass both knee and hip

joints. If any empty space remains between the splint and the body, it is recommended to fill it with padding. Similarly, points of contact should be adequately padded to ensure casualty comfort. The splint should be secured in place by tying it firmly but without excessive force using cravats, cloth strips, or bandages; alternatively, it may be secured by taping. Any loose ends of material used for securing the splint must be tucked in to prevent problems later during transportation. Additionally, a swing or swathe may be used to keep the fractured limb close to the body. (TCCC, 2023b)

After the splint is secured, it is crucial to recheck the pulses and sensorimotor functions of the limb distal to the splint. If any changes occur relative to the pre-splinting condition, the splint must be adjusted. (TCCC, 2023b)

Summary

Fractures are among the most prevalent results of traumatic injury; proper care may mitigate the risk of long-term disability and death. Adequate first aid in fractures consists of: diagnosis of the fracture, pharmacological interventions, wound dressing and splinting.

- Diagnosis – Maintaining a high level of vigilance in the case of any wounds and injury of the extremity is crucial for the early recognition of fractures and the prompt initiation of treatment. Detailed documentation of extremity sensorimotor functions, pulses, skin color, as well as injuries, should be recorded for reassessment after first aid.
- Pain is one of the most distressing aspects of a fracture for the injured individual, effective analgesia should be provided as one of the first measures following the identification of a non–life-threatening fracture.
- Early initiation of antibiotic prophylaxis is crucial to prevent infections in open fractures; it should be started as soon as the circumstances permit
- Dressing wounds is along with antibiotic administration a very important factor in infection rate, irrigation may be performed even using clean, non-sterile water.
- Immobilisation plays a key factor in prevention of further soft tissue injuries, including injuries of blood vessels and nerves (TCCC, 2023b).

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