6.1 Emergency department management

6.1.1 Introduction

Soft-tissue trauma—including thermal injury—embraces a wide range of lesions from minor to life-threatening, which necessitate immediate and coordinated action by all surgical specialties involved. Prehospital assessment and decision for or against referral to the trauma center can sometimes be subject to an over- or underestimation of the severity of a trauma, which needs to be corrected within the treatment algorithm.

The situation in a trauma bay is often filled with action, adrenaline, and agitation when trauma patients arrive. There is often a flurry of activity, which, if uncoordinated, can waste valuable time and resources. Crucial to the care of severely injured or critically-ill patients is a well-rehearsed plan of action, which begins even before the patient arrives at the hospital.

6.1.2 Organizational aspects of the emergency department

Communication with emergency department personnel should begin prior to the patient’s arrival at the hospital. Skilled first responders should have radio contact with the receiving hospital and should provide an accurate field assessment of the extent of injuries, or at least the mechanism of injury. The mechanism of injury (eg, high-energy trauma versus low-energy, blunt trauma versus penetrating trauma) (chapter 3) may determine the destination of the patient, eg, patients with high-energy injuries should preferably be diverted to specialized (level I) trauma centers. This early triage can help avoid unnecessary delays in definitive treatment, which occur when patients are first taken to a lower-level care facility, where they are evaluated, and then have to be transferred to a higher-level care facility [1]. While the mechanism of injury itself is not diagnostic, it may heighten awareness of the trauma team regarding unrecognized injury [2], and eventually reduce the economic costs resulting from complex injuries of the extremities that affect bone and soft tissues [3].

Upon arrival at the trauma center, every patient admitted to the emergency department should be seen and managed primarily by an experienced general or trauma surgeon, who is in charge of the evaluation, resuscitation, and coordination efforts [4]. As a matter of course, the evaluation of the patient and the injuries varies, based on the available resources and the extent of suspected injury.

In emergency management, it is the duty of the team leader to involve the consulting experts from other specialties according to the different injuries (Fig 6.1-1). In case of severe soft-tissue injury—either as an isolated trauma or poly-trauma—it is essential to include a soft-tissue specialist, preferably the plastic surgeon as early as possible [5, 6]. Even though such organizational structures are not always available in every trauma center, there is evidence that an early interdisciplinary approach will help to correctly diagnose and classify the severity of soft-tissue lesions, thus preventing a delay in the appropriate treatment [7, 8].

Depending on the infrastructure of the hospital and the availability of qualified personnel, the trauma leader must decide whether the hospital is capable of taking care of certain types of injuries or whether a referral to a specialized
Isolated extremity trauma

The focus of an isolated extremity trauma in an otherwise healthy patient should be on the assessment of the severity of the injury. Good communication with the prehospital care team and collection of all available information about the mechanism of injury is of highest priority \[^5\]. The type of injury to be expected varies, depending on whether the patient sustained a car or a skiing accident, a gunshot wound, or, as a pedestrian, was hit by a car. The mechanism of injury provides important clues as to the location (eg, fracture of the proximal third of the tibia in a pedestrian struck by a car) and the potential severity of the lesions. The rescue team transporting the patient to the emergency department should further supply information about the initial condition of the patient as well as the time interval since the accident.

In patients with closed and benign-appearing soft tissues, the condition and real extent of the injury must be assessed carefully (chapter 5.1). In alert patients, the clinical evaluation with respect to pain, perfusion, and peripheral movement, eg, the ability to flex and extend the toes, most often is sufficient in order to detect or exclude compartment syndrome. In case of doubt, the additional measurement of compartment pressure can be helpful, especially if the measurements are repeated during the clinical course or performed on an unconscious patient (chapter 5.1, 11.1).

In open injuries, a primary inspection must be performed in the trauma bay. However, everybody involved must respect the local guidelines regarding sterility (ie, face masks as well as sterile gloves, cloth, bandages, and instruments). The size of the wound and the involvement of bone, muscles and/or neurovascular structures must be assessed, recorded, and adequately documented during the primary survey. Thereafter, a sterile wound dressing is mandatory, which should not be removed again until further treatment in the operating room is initiated. Inspection and evaluation of the structures peripheral to the injury is the next step.

Pallor of the skin and/or unequal palpation of the peripheral pulses when compared to the uninjured side are suspicious signs of vascular compromise. This condition mandates immediate assessment of the peripheral circulation, which means checking temperature, capillary refill, making use of Doppler sonography or angiography in order to confirm any vascular lesion, as well as to determine its extent and location. Furthermore, asymmetrical pulses after reduction of an articulation (eg, knee dislocation) as well as bluish discoloration and swelling of the extremity, which may indicate impaired venous drainage, are conditions that warrant a vascular study. If not already involved, the vascular or plastic surgeon needs to be informed and included in the decision-making process.

X-rays of the injured area are mandatory and can be obtained during the initial evaluation. Exceptionally, one x-ray plane may give sufficient information in case of total or subtotal amputations for primary diagnostics, whereas CT scans are sometimes necessary to adequately evaluate comminuted fractures with involvement of a joint. Beside the bone structures, special attention should be given to shadows and foreign bodies within the soft tissue, while the extent of the injury may often be judged on plain x-rays indicating the severity of the injury.

The information obtained at this point of the evaluation is sufficient to begin the multidisciplinary planning process, which will determine the time and nature of treatment.

Polytrauma

The basic approach to the evaluation of extremity injuries in a polytrauma patient is the same when compared to isolated injuries of the extremity, including the soft tissues. The soft-tissue injury should be incorporated into the polytrauma algorithm, and assessed and managed according to the priorities set by the overall patient condition. Soft-tissue trauma due to high-velocity/severe deceleration events are often associated with abdominal or cerebral injuries, which necessitate immediate surgical intervention after clinical and radiological diagnostics and stabilization of the vital parameters. An organized trauma team with well-defined roles and protocols for every single member of the trauma team or the emergency department staff will allow efficient assessment and rapid treatment of critically-injured patients, leading to a reduction in the rate of morbidity and mortality. In busy trauma centers, individual team members have preassigned roles and the initial resuscitation and evaluation proceeds automatically, with little direction from the team leader. It is important to have a person assigned to record vital signs and interventions as they occur, who does not have to participate directly in the starting of intravenous medication or any other tasks.
Together, the anesthesiologist, the intensivist and all consulting specialists who will be involved according to the type of injury, will follow the polytrauma algorithm for primary evaluation as defined by the advanced trauma life support (ATLS) criteria [5]. Initially, the goal is to resuscitate and stabilize the patient, which requires that primary evaluation and decision making must be fast and precise. This includes a check and record of all vital signs, such as airway and circulation. Problems are addressed as they are identified. Simultaneously, the primary clinical survey from head to toe is directed to find obvious instabilities that might include the pelvic ring, fractures of the long bones, and injuries of the soft tissues. Initial diagnostics such as x-ray (chest, pelvis, lateral cervical spine), blood tests including hematocrit, blood type and cross-match, and electrolytes, abdominal ultrasound or rapid-sequence CT scans are carried out in parallel in order to detect or exclude sources of major bleeding and potentially life-threatening injuries. The degree of consciousness is documented using the Glasgow coma scale (GCS), if the patient has not yet been intubated.

At this point, obvious diagnoses are summarized and recorded, while treatment priorities are set. With a successfully resuscitated and stabilized patient, further diagnostic steps may now be performed as clinically indicated. Severe soft-tissue injuries need to be included in the decision-making process as well.

### 6.1.4 Debridement and irrigation in the trauma bay

Radical debridement and irrigation of the wound usually are procedures to be performed in the operating room under anesthesia and sterile conditions (chapter 7.1)(eg, chapter 12.2). In the trauma bay only emergency procedures may be carried out. In open injuries with severe contamination an initial irrigation (chapter 7.2) and disinfection as well as a careful removal of foreign bodies and obviously devitalized or contaminated tissue can be performed during the initial wound inspection before sterile wound coverage (eg, chapter 12.2). This will not cause any additional pain, since only devitalized tissue is removed. In open wounds with significant blood loss, obvious sources of bleeding such as lacerated small vessels can be cauterized or ligated, while major vessels can even be tamponaded temporarily or closed definitively using microclamps, thereby stabilizing the general condition of the patient. As a general rule, thorough irrigation and debridement of the wound should only be performed in the trauma bay in exceptional situations. Definitive irrigation and debridement requires adequate sterility, anesthesia, lighting and instruments—conditions only rarely given in the trauma bay.

### 6.1.5 Role of microbiological cultures, antibiotics, and tetanus

In open injuries, swabs of the wounds can be taken during wound assessment. However, they need to be taken under strictly sterile conditions. Instead of swabs, it is recommended to take several bits of representative wound tissue in order to obtain a suitable microbiological work-up. Many surgeons therefore postpone the initial bacteriological wound assessment until the patient is in the operating room.

Short-term antibiotic prophylaxis is to be initiated as early as possible and according to the specific protocol used in the hospital. Generally, first- or second-generation cephalosporins are considered adequate for simple wounds, while penicillin should be added for farmyard injuries, and an aminoglycoside for Gustilo type III fractures. Antibiotic prophylaxis should be limited to 24–48 hours. Thereafter, therapeutic coverage—if indicated—is best administered based on the results of cultures. In all patients with insufficient or questionable tetanus status, an immunization is to be initiated immediately.

### 6.1.6 Field coverage of the wound

If the rescue team reported an open wound or open fracture, and the wound was primarily covered with a sterile dressing, the dressing should be left in place in the trauma bay if the patient is expected to go to the operating room regardless of the findings. However, if there is any question about whether the wound requires operative management, wound inspection is allowed by an experienced senior surgeon under strictly sterile precautions. After inspection and photographic documentation, the wound is disinfected and covered with sterile dressings. In addition to wound coverage, the injured extremity should temporarily be immobilized with a splint and only removed for x-ray evaluation and further treatment.
6.2  Interdisciplinary decision making and staging of treatment

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6.2.1  Introduction

Despite technological progress in the surgical management of fractures and reconstruction of soft-tissue injuries, patients with severe, traumatic soft-tissue defects still represent a major surgical challenge, requiring an interdisciplinary approach [9]. Due to the etiology of trauma (e.g., high-velocity accidents) (chapter 3), the soft-tissue damage in many cases is more extensive than initially apparent and equals the zone of injury (chapter 10.3.3). Especially inexperienced colleagues or residents tend to underestimate soft-tissue injuries and direct patients on to an inadequate therapeutic path [10].

It has been demonstrated that decision making and treatment plans for an individual patient are often incorrect and that correction often comes too late, when the patient has already left the emergency department. Such mismanagement often delays the start of treatment, which may result in more complicated surgical and postoperative courses, prolonged hospitalization time, and ultimately higher costs [11]. The multidisciplinary treatment strategy—including timing for complex injuries of the extremities—is guided by the injury pattern, the ischemia time of the tissues, and the general condition of the patient (e.g., additional injuries, polytrauma, shock).

6.2.2  Role of the trauma/orthopaedic surgeon

Depending on the educational background and national differences, it will either be an orthopaedic surgeon with special interest in extremity trauma or a trauma/general surgeon with an interest in fracture management, who will be taking care of the injured patient in the emergency department. Regardless of specialization—orthopaedic or trauma surgeon—it appears crucial that a single physician, preferably a senior colleague, is responsible for a specific patient—as a “trauma team leader”. This person should be the first one to see and examine the patient in the trauma bay. During primary survey, the trauma team leader must assess the patient as a whole, recognizing the injury pattern and the severity of each injury, and will then decide which specialty consultants (burn specialist, gynecologist, hand surgeon, ophthalmologist, oral and maxillofacial surgeon, oto-rhino-laryngologist, urologist, vascular surgeon, etc (Fig 6.1-1)) to call in. They will then establish the initial treatment plan and priorities based on the ATLS trauma protocol.

In patients with soft-tissue trauma, the severity and extent of the soft-tissue injury should ideally be assessed by the trauma surgeon in charge and a plastic surgeon. Special attention should be paid to muscles, fascia, tendons, and neurovascular structures. Injuries of the hand nearly always require primary consultation of a hand surgeon. In consultation with subspecialists and based on available resources, the trauma team leader will guide the timing and set the priorities for planned surgical interventions. The decision to include a specialist for the management of the soft tissues should be made liberally and as early as possible. Likely indications for an early interdisciplinary management of soft-tissue injuries are Gustilo type IIIC fractures, extended soft-tissue defects with or without segmental bone loss, and amputation injuries with the option of replantation (Fig 6.2-1) (chapter 5.2).

6.2.3  Role of the plastic surgeon

If available and in house, a plastic surgeon should immediately be included in the decision-making process while the patient is in the emergency department. Because of their expertise in the treatment of extended soft-tissue injuries, an early involvement to formulate a detailed treatment plan is of crucial importance and will improve outcome.

Today, technology-supported decision-making tools such as teleconsulting may help to fill such a gap if properly used. A telemedicine system using a mobile camera-phone as communication tool has been suggested as feasible and valuable alternative for early diagnosis and triaging of soft-tissue injury in emergency cases, with online verbal communication and review of the image transmitted [12]. Although such systems have the advantages of easy use, low cost, and high mobility, they cannot substitute the personal physical examination by the experienced clinician. Even with the appropriate clinical expertise and use of the relevant scores such as the mangled extremity severity score (MESS) (chapter 5.3), interdisciplinary decision making for amputation will be necessary in selected cases of severe soft-tissue injuries in order to preserve the patient’s “life before limb”.

Next, if necessary, the type of fracture fixation has to be decided upon—either by internal or external fixation. Today, in diaphyseal fractures, intramedullary nailing is clearly preferred. In articular fractures of major joints, temporary bridging with an external fixator will be the primary option. The same applies to fractures with complex vascular and/or soft-tissue defects. However, it is very important that the placement of the fixator pins is well planned as they should not impede secondary debridements, nor interfere with later reconstructive procedures (ie, pedicled or free flap surgery). In some cases, primary shortening of the bone may be chosen. Nevertheless, early stabilization of the fracture has to be performed (chapter 7.3).

In the presence of compartment syndrome or after a successful vascular reconstruction, it is mandatory to perform an adequate release of the different muscle compartments in order to avoid muscle damage. Nerve lesions will only exceptionally be approached at this early stage. However,
the specialist should be consulted with regard to how the severed nerve ends should be tagged in order that they can be easily relocated during subsequent surgery. Their exact position must be recorded in the operating room report, preferably together with a drawing.

Although the different options of wound closure and coverage will be discussed in detail in the following chapters, this question must be addressed from the very beginning in the decision making and treatment plan (chapter 10.1 to 10.6).

### 6.2.5 Staging of therapeutic procedures

Several reasons may lead to a staged treatment of a complex injury of the extremity:

- The severity of the bone or joint injury and/or soft tissue is such that a primary definitive repair appears too extensive and risky.
- The patient’s condition—usually due to multiple concomitant injuries—does not allow any prolonged surgical procedure, but, nevertheless, requires stabilization of the long bones and large joints according to the principle of damage-control surgery.
- The infrastructure is not suitable, eg, unavailability of an experienced surgical team, inadequate equipment in the operating room, lack of postoperative treatment capacity, ie, intensive care unit.

A well-defined treatment plan that may include a staged therapeutic approach is therefore a prerequisite. This plan should, whenever possible, be established together with all subspecialists that are needed. Basically, the approach is identical in comparison to one-stage surgery, including intraoperative survey of the injury, wound irrigation and debridement. However, the stabilization of the fractured bone or bones that may include joints will often be achieved by external fixation—either within a long bone or by bridging a major joint. Again the placement of pins is crucial, as it should not interfere with any subsequent surgical procedure of the treatment plan. Depending on the general recovery of the patient and the local conditions (ie, swelling of the soft tissues), the second stage is usually planned for 3–5 days after the accident, while second-look debridement is usually performed earlier, after 24–72 hours [13].

The second stage may include definitive stabilization of the open fracture, including bone replacement with nonvascularized or vascularized bone. In such cases, consulting a plastic surgeon may be particularly helpful in order to decide upon the most adequate soft-tissue coverage (eg, local versus free flap) to be used so that bone healing and stable wound closure can be achieved. If the type of fixation has to be changed from an external to an internal fixator (eg, intramedullary nail or plate osteosynthesis), it should be done as early as possible—ideally within the first 10 days after the injury—as this will reduce the risk of osteitis. If the soft-tissue defect does not yet appear ready for closure, wound conditioning may be performed before the next stage (chapter 9.3), always taking into account that the true zone of injury extends beyond the visibly damaged tissue (chapter 10.3.3).

The third stage of reconstruction should be delayed until wound healing appears complete and the patient has recovered fully, including the completion of an early rehabilitation period. This stage will include secondary bone grafting, nerve reconstruction, or tendon/muscle transfers for the restoration of motor function as well as refinement surgery of the soft tissues in order for footwear to fit as well as to be aesthetically pleasing.
References and further reading


