Pre-hospital management, transportation and emergency care
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Introduction

Advances in trauma and burn management over the past three decades have resulted in improved survival and reduced morbidity from major burns. The cost of such care, however, is high; it requires conservation of resources such that only a limited number of burn intensive care units with the capabilities of caring for such labor-intensive patients can be found — hence regional burn care has evolved. This regionalization has led to the need for effective pre-hospital management, transportation, and emergency care. Progress in the development of rapid, effective transport systems has resulted in marked improvement in the clinical course and survival for victims of thermal trauma.

For burn victims, there are usually two phases of transport. The first is the entry of the burn patient into the emergency medical system with treatment at the scene and transport to the initial care facility. The second phase is the assessment and stabilization of the patient at the initial care facility and transportation to the burn intensive care unit. With this perspective in mind, this chapter reviews current principles of optimal pre-hospital management, transportation, and emergency care.

Pre-hospital care

Prior to any specific treatment, a patient must be removed from the source of injury and the burning process stopped. As the patient is removed from the injuring source, care must be taken so that a rescuer does not become another victim. All caregivers should be aware of the possibility that they may be injured by contact with the patient or the patient’s clothing. Universal precautions, including wearing gloves, gowns, masks, and protective eye wear, should be used whenever there is likely contact with blood or body fluids. Burning clothing should be removed as soon as possible to prevent further injury. All rings, watches, jewelry, and belts should be removed as they can retain heat and produce a tourniquet-like effect with digital vascular ischemia. If water is readily available, it should be poured directly on the burned area. Early cooling can reduce the depth of the burn and reduce pain, but cooling measures must be used with caution, since a significant drop in body temperature may result in hypothermia with ventricular fibrillation or asystole. Ice or ice packs should never be used, since they may cause further injury to the skin or produce hypothermia.

Initial management of chemical burns involves removing saturated clothing, brushing the skin if the agent is a powder, and irrigation with copious amounts of water, taking care not to spread chemical on burns to adjacent unburned areas. Irrigation with water should continue from the scene of the accident through emergency evaluation in the hospital. Efforts to neutralize chemicals are contraindicated due to the additional generation of heat, which would further contribute to tissue damage. A rescuer must be careful not to come in contact with the chemical, i.e. gloves, eye protectors, etc. should be worn.

Removal of a victim from an electrical current is best accomplished by turning off the current and by using a non-conductor to separate the victim from the source.

On-site assessment of a burned patient

Assessment of a burned patient is divided into primary and secondary surveys. In the primary survey, immediate life-threatening conditions are quickly identified and treated. The primary survey is a rapid, systematic approach to identify life-threatening conditions. The secondary survey is a more thorough head-to-toe evaluation of the patient. Initial management of a burned patient should be the same as for any other trauma patient, with attention directed at airway, breathing, circulation, and cervical spine immobilization.

Primary assessment

Exposure to heated gases and smoke from the combustion of a variety of materials results in damage to the respiratory tract. Direct heat to the upper airways results in edema formation, which may obstruct the airway. Initially, 100%-humidified oxygen should be given to all patients when no obvious signs of respiratory distress are present. Upper airway obstruction may develop rapidly following injury, and the respiratory status must be continually monitored in order to assess the need for airway control and ventilator support. Progressive hoarseness is a sign of impending airway obstruction. Endotracheal intubation should be done early before edema obliterates the anatomy of the area.
The patient’s chest should be exposed in order to adequately assess ventilatory exchange. Circumferential burns may restrict breathing and chest movement. Airway patency alone does not assure adequate ventilation. After an airway is established, breathing must be assessed in order to insure adequate chest expansion. Impaired ventilation and poor oxygenation may be due to smoke inhalation or carbon monoxide intoxication. Endotracheal intubation is necessary for unconscious patients, for those in acute respiratory distress, or for patients with burns of the face or neck which may result in edema which causes obstruction of the airway. The nasal route is the recommended site of intubation. Assisted ventilation with 100%-humidified oxygen is required for all intubated patients.

Blood pressure is not the most accurate method of monitoring a patient with a large burn because of the pathophysiologic changes which accompany such an injury. Blood pressure may be difficult to ascertain because of edema in the extremities. A pulse rate may be somewhat more helpful in monitoring the appropriateness of fluid resuscitation.

If a burn victim was in an explosion or deceleration accident, there is the possibility of a spinal cord injury. Appropriate cervical spine stabilization must be accomplished by whatever means necessary, including a cervical collar to keep the head immobilized until the condition can be evaluated.

Secondary assessment

After completing a primary assessment, a thorough head-to-toe evaluation of a patient is imperative. A careful determination of trauma other than obvious burn wounds should be made. As long as no immediate life-threatening injury or hazard is present, a secondary examination can be performed before moving a patient; precautions such as cervical collars, backboards, and splints should be used. Secondary assessment should examine a patient’s past medical history, medications, allergies, and the mechanisms of injury.

There should never be a delay in transporting burn victims to an emergency facility due to an inability to establish intravenous (IV) access. If the local/regional emergency medical system (EMS) protocol prescribes that an IV line is started, then that protocol should be followed. The American Burn Association recommends that if a patient is less than 60 min from a hospital, an IV is not essential and can be deferred until a patient is at a hospital. If an IV line is established, Ringer’s lactate solution should be infused at:

- 14 years and older: 500 mL LR per hour
- 6–14 years old: 250 mL LR per hour
- 5 years and younger: 125 mL LR per hour.

Pre-hospital care of wounds is basic and simple, because it requires only protection from the environment with an application of a clean dressing or sheet to cover the involved part. Covering wounds is the first step in diminishing pain. If it is approved for use by local/regional EMS, narcotics may be given for pain, but only intravenously in small doses and only enough to control pain. Intramuscular (IM) or subcutaneous routes should never be used, since fluid resuscitation could result in unpredictable patterns of uptake. No topical antimicrobial agents should be applied in the field. The patient should then be wrapped in a clean sheet and blanket to minimize heat loss and to control temperature during transport.

Transport to hospital emergency department

Rapid, uncontrolled transport of a burn victim is not the highest priority, except in cases where other life-threatening conditions coexist. In the majority of accidents involving major burns, ground transportation of victims to a hospital is available and appropriate. Helicopter transport is of greatest use when the distance between an accident and a hospital is 30–150 miles or when a patient’s condition warrants. Whatever the mode of transport, it should be of appropriate size, and have emergency equipment available as well as trained personnel, such as a nurse, physician, paramedic, or respiratory therapist.

Assessment at the initial care facility

The assessment of a patient with burn injuries in a hospital emergency department is essentially the same as outlined for a pre-hospital phase of care. The only real difference is the availability of more resources for diagnosis and treatment in an emergency department. As with other forms of trauma, the primary survey begins with the ABCs, and the establishment of an adequate airway is vital. Endotracheal intubation should be accomplished early if impending respiratory obstruction or ventilatory failure is anticipated, because it may be impossible after the onset of edema following the initiation of fluid therapy. Securing an endotracheal tube may be difficult because traditional methods often do not adhere to burned skin, and tubes are easily dislodged. One method of choice includes securing an endotracheal tube with woven tape, umbilical cord, under the ears as well as over the ears. While doing assessments and making interventions for life-threatening problems in the primary survey, precautions should be taken to maintain cervical spine immobilization until injuries to the spine can be ruled out.

Following a primary survey, a thorough head-to-toe evaluation of a patient should be done. This includes obtaining a history as thorough as circumstances permit. The history should include the mechanism and time of the injury and a description of the surrounding environment, such as whether injuries were incurred in an enclosed space, the presence of noxious chemicals, the possibility of smoke inhalation, and any related trauma. A complete physical examination should include a careful neurological examination, as evidence of cerebral anoxic injury can be subtle. Patients with facial burns should have their corneas examined with fluorescent staining. Routine admission laboratories should include a complete blood count, serum electrolytes, glucose, blood urea nitrogen (BUN), and creatine. Pulmonary assessment should include arterial blood gases, chest X-rays, and carboxyhemoglobin.

Emergency treatment at the initial care facility

All extremities should be examined for pulses, especially with circumferential burns. Evaluation of pulses can be assisted by use of a Doppler ultrasound flowmeter. If pulses
sedation using electrocautery. Midaxial incisions are made through the eschar but not into subcutaneous tissue of the eschar in order to assure adequate release. Limbs should be elevated above the heart level. Pulses should be monitored for 48 h. If pulses are still present, but appear endangered, chemical escharotomy with enzymatic ointments (Accuzyme, collagenase, Elase) can be effective. Enzymatic escharotomy in hand burns may be preferred since surgical incisions risk exposure of superficial nerves, vessels, and tendons. Enzymatic escharotomy is indicated only during the first 24–48 h post-burn, and it should be used only in combination with a topical antimicrobial agent or sepsis can occur. With enzymatic escharotomy, there is usually a spike in temperature, which subsides after the enzyme is removed.

**Evaluation of wounds**

After the primary and secondary surveys are completed and resuscitation is underway, a more careful evaluation of burn wounds is performed. The wounds are gently cleaned, and loose skin and in large wounds blisters greater than 2 cm are debrided (see Ch. 6). Blister fluid contains high levels of inflammatory mediators, which increase burn wound ischemia. The blister fluid is also a rich media for subsequent bacterial growth. Deep blisters on the palms and soles may be aspirated instead of debrided in order to improve patient comfort. After burn wound assessment is complete, the wounds are covered with a topical antimicrobial agent and appropriate burn dressings or a biological dressing is applied. An estimate of burn size and depth assists in making a determination of severity, prognosis, and disposition of a patient. Burn size directly affects fluid resuscitation, nutritional support, and surgical interventions. The size of a burn wound is most frequently estimated by using the Rule-of-Nines method (Fig. 7.2). A more accurate assessment can be made of a burn injury, especially in children, by using the Lund and Browder chart, which takes into account changes brought about by growth (Fig. 7.3). The American Burn Association identifies certain injuries as usually requiring a referral to a burn center. Patients with these burns should be treated in a specialized burn facility after initial assessment and treatment at an emergency department. Questions about specific patients should be resolved by consultation with a burn center physician (Box 7.1).

**Fluid resuscitation**

Establishment of IV lines for fluid resuscitation are necessary for all patients with major burns including those with inhalation injury or other associated injuries. These lines are best started in the upper extremity peripherally. A minimum of two large-caliber IV catheters should be established through non-burned tissue if possible, or through burns if no unburned areas are available. The ABLS 2010 Fluid Resuscitation Formula of Ringer’s lactate solution should be infused at 2 mL/kg/% total body surface area (TBSA) which is burned. Children must have additional fluid for maintenance.

Taking into account the increased evaporative water loss in the formula for fluid resuscitation for pediatric patients, the initial resuscitation should begin with 5000 mL/m²/%
Total Burn Care

TBSA burned/day + 2000 mL/m²/BSA total/day 5% dextrose in Ringer’s lactate. This formula calls for one-half of the total amount to be given in the first 8 h post-injury with the remainder given over the following 16 h.

**Box 7.2** Burn fluid resuscitation formula

**Fluid administration – Ringer’s lactate:**

**First 24 h**

- 5000 mL/m² burn + 2000 mL/body area m², administer half in 8 h and the remaining half in 16 h.

**Second 24 h**

- 3750 mL/m² + 1500 mL/body area m², administer half in 8 h and the remaining half in 16 h.

Adjust the above rates to maintain a urine output of 1 mL/kg/h.

All resuscitation formulas are designed to serve as a guide only. The response to fluid administration and physiologic tolerance of a patient is the most important determinant. Additional fluids are commonly needed with inhalation injury, electrical burns, associated trauma, and delayed resuscitation. The appropriate resuscitation regimen administers the minimal amount of fluid necessary for maintenance of vital organ perfusion; the subsequent response of the patient over time will dictate if more or less fluid is needed so that the rate of fluid administration can be adjusted accordingly. Inadequate resuscitation can cause diminished perfusion of renal and mesenteric vascular beds. Fluid overload can produce undesired pulmonary or cerebral edema.

**Urine output requirements**

The single best monitor of fluid replacement is urine output. Acceptable hydration is indicated by a urine output of more than 30 mL/h in an adult (0.5 mL/kg/h) and 1 mL/kg/h in a child. Diuretics are generally not indicated during an acute resuscitation period. Patients with high-voltage electrical burns and crush injuries with myoglobin and/or hemoglobin in the urine have an increased risk of renal tubular obstruction. Sodium bicarbonate should be added to IV fluids in order to alkalinize the urine, and urine output should be maintained at 1–2 mL/kg/h as long as these pigments are in the urine. Additional osmotic diuretic such as mannitol may also be needed to assist in clearing the urine of these pigments.

**Additional assessments and treatments**

**Decompression of stomach**

To combat the problem of gastric ileus, a nasogastric tube should be inserted in all patients with major burns in order to decompress the stomach. This is especially important for patients being transported at high altitudes. Additionally, all patients should be restricted from taking anything by mouth until after the transfer has been completed.
Transferring a burn patient

The appearance of burn skin is rather obvious and has the potential to mask or cover any other potential injuries that the burn patient could have. The burn patient is a trauma patient with burns and should be promptly and effectively evaluated to include other potential injuries. It is important to establish effective communication between the transferring unit and the receiving center.

Once the need to transfer the patient is identified, the transferring process begins. The doctor-to-doctor referral process starts with the initial care facility. Available phone numbers and doctor information should be available to centers that should promptly call and ask for all the information needed for the transfer.

The referring physician should give a brief and concise history of the event that includes the time of injury and all resuscitation efforts prior to the call. The ABCs of trauma resuscitation should be discussed and the most current vital signs and physical examination findings should be presented. The accepting facility should then fill out an intake form that details all the information. Understanding of the patient’s current status is needed for a successful and uneventful transfer. It is imperative that physicians participate in the process adding to the already available information gathered by other personnel.

Decompression of the stomach is usually necessary because an anxious, apprehensive patient will swallow considerable amounts of air and distend the stomach. Narcotics also diminish peristalsis of the gastrointestinal tract and result in distension.

A patient must be kept warm and dry

Hypothermia is detrimental to traumatized patients and can be avoided or at least minimized by the use of sheet and blankets. Wet dressings should be avoided.

Pain

The degree of pain experienced initially by the burn victim is inversely proportional to the severity of the injury. No medication for pain relief should be given intramuscularly or subcutaneously. For mild pain, acetaminophen 650 mg orally every 4–6 h may be given. For severe pain, morphine, 1–4 mg intravenously every 2–4 h, is the drug of choice, although meperidine (Demerol) 10–40 mg by IV push every 2–4 h may be used. Recommendations for tetanus prophylaxis are based on the patient’s immunization history. All patients with burns should receive 0.5 mL of tetanus toxoid. If prior immunization is absent or unclear, or if the last booster was more than 10 years ago, 250 units of tetanus immunoglobulin is also given.

### Table: Estimation of burn size using the Lund and Browder method

<table>
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<tr>
<th>Age</th>
<th>0–1</th>
<th>1–4</th>
<th>5–9</th>
<th>10–14</th>
<th>15</th>
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<tr>
<td>A – ½ of head</td>
<td>9½%</td>
<td>8½%</td>
<td>6½%</td>
<td>5½%</td>
<td>4½%</td>
</tr>
<tr>
<td>B – ½ of one thigh</td>
<td>9½%</td>
<td>8½%</td>
<td>6½%</td>
<td>5½%</td>
<td>4½%</td>
</tr>
<tr>
<td>C – ½ of one leg</td>
<td>9½%</td>
<td>8½%</td>
<td>6½%</td>
<td>5½%</td>
<td>4½%</td>
</tr>
</tbody>
</table>

**Figure 7.3** Estimation of burn size using the Lund and Browder method.
Transferring a patient without the needed information can potentially lead to bad outcomes and or unnecessary expense. For example, a burn patient with an underlying anoxic brain injury could be transferred to a burn center, when instead the diagnosis of brain death could have been done at the initial care facility.

Physicians have the availability of accessing patient information utilizing different technologies. Although a doctor-to-doctor phone call is preferred by many, today’s technology allows patient data including pictures, laboratory results as well as any other clinical information needed to further assess the patient’s needs.15 While some physicians still prefer the immediacy of the telephone, secure electronic messaging tools are beginning to supplement phone calls and beepers to facilitate communication among physicians.15,16

Privacy and security issues

Perhaps the most fundamental choice physicians must make when selecting tools to communicate electronically with each other and with patients is how they will manage the privacy and security of the information exchanged.

The HIPAA (Health Insurance Portability and Accountability Act) is ‘technology-neutral,’ in that it does not require any set form of encryption or information safeguarding, and is ‘scalable,’ in that it allows small practices to do what they can afford to do without requiring them to purchase expensive communication security systems.15–17

For electronic communication, the physician should have an informed consent form signed by each patient specific to the form of communication being used, such as e-mail. The form should verify the patient’s e-mail address; should discuss the security risks involved, e.g. that other parties on the patient’s end might have access to their e-mail accounts, and that standard (unencrypted, non-secure) e-mail can be intercepted by unintended parties; should discuss allowable content of the communication; and should include a provision to hold the physician harmless if security is breached.

While there is no private right of action under the HIPAA, i.e. a patient cannot sue physicians for breach of HIPAA’s privacy or security provisions, the federal agencies that oversee the HIPAA have recently announced plans to step-up their audits, and they could conduct an inquiry if a patient filed a complaint. Federal investigations seem more likely to focus on hospitals than physician offices. Carelessness could also have legal repercussions. For example, information could be sent to the wrong recipient because of failure to verify the address field before sending the message. Physicians using standard e-mail should take as many practical safeguards as possible to minimize liability exposure. This could include a privacy and security disclaimer footer on each e-mail; requesting the patient’s permission before continuing to respond to certain issues by e-mail; limiting the amount of medical detail in the messages, password-protecting e-mail access on office and home workstations, as well as on portable devices, such as PDAs and Blackberries, in case they are lost.

Another way to alleviate security or HIPAA compliance concerns is to leave out ‘protected health information’ (PHI) in standard e-mail: that both personally identifies a patient and reveals a specific diagnosis or condition. While standard e-mail works and is offered free of charge by service providers such as Yahoo, Gmail, Comcast and many others, vendors of secure messaging networks are quick to point out multiple deficiencies (Box 7.3).

Whether or not electronic communication is encrypted or secure, physicians should guard against getting lulled by the casual nature of e-mail which, unlike a conversation or phone call, is not erased from a computer’s hard drive when deleted and is potentially discoverable in litigation.

Transportation guidelines

The primary purpose of any transport teams is not to bring a patient to an intensive care unit but to bring that level of care to the patient as soon as possible. Therefore, the critical time involved in a transport scenario is the time it takes to get the team to the patient. The time involved in transporting a patient back to a burn center becomes secondary. Communication and teamwork are the keystones to an effective transport system.

When transportation is required from a referring facility to a specialized burn center, a patient can be fairly well stabilized before being moved. Initially, the referring facility should be informed that all patient referrals require physician-to-physician discussion. Pertinent information needed include: patient demographic data; time; date; cause and extent of burn injury; weight and height; baseline vital signs; neurological status; laboratory data; respiratory status; previous medical and surgical history, and allergies.

A referring hospital is informed of specific treatment protocols regarding patient management prior to transfer. To ensure patient stability, the following guidelines are offered:

- Establish two IV sites, preferably in an unburned upper extremity, and secure IV tubes with sutures.
- Insert a Foley catheter and monitor for acceptable urine output (30 mL/h adult; 1 mL/kg/h child).
- Insert a nasogastric tube and ensure that the patient remains NPO.
- Maintain body temperature between 38 and 39.0°C rectally.
- Stop all narcotics.

Box 7.3 Deficiencies of electronic mail services for the transmission of medical information

- Lack of encryption or authentication
- Can be used by anyone to access a physician if they simply know the physician’s e-mail address
- Have no ‘terms of service’ or legal disclaimers to protect physicians
- Can easily expose patient e-mail addresses and identities to unintended third parties
- Can breach patient privacy by using employer e-mail networks
- Offer no charge capture function
- Have no template or medical records features
- Lack of consistency with HIPAA or medical liability insurance company standards.
• For burns less than 24 h old, only use lactated Ringer’s solution. The staff physician will advise on the infusion rate, which is calculated based on the percentage of total body surface area burned.

Following physician-to-physician contact and collection of all pertinent information, the physicians will make recommendations regarding an appropriate mode of transportation. The options are based on distance to a referring unit, patient complexity, and comprehensiveness of medical care required. Options include:

- Full medical intensive care unit transport with a complete team, consisting of a physician, a nurse, and a respiratory therapist from the burn facility
- Medical intensive care transport via fixed wing or helicopter with a team from a referring facility
- Private plane with medical personnel to attend patient
- Commercial airline
- Private ground ambulance
- Transport van with appropriate personnel.

Transport team composition

Because stabilization and care for a burned patient is so specialized, team selection is of the utmost importance. Traditionally, these patients were placed in an ambulance with an emergency medical technician and transported with few efforts made to stabilize the patient prior to transfer. As levels of care and technology have evolved, the need for specialized transport personnel has been increasingly observed. Today most transport teams are made up of one or more of the following healthcare members: a registered nurse, a respiratory therapist, and/or a staff physician or house resident. Because a large number of burned patients require some type of respiratory support due to inhalation injury or carbon monoxide intoxication, the respiratory therapist and nurse team has proven to be an effective combination. The background and training of nurses and therapists differ in many ways, so such a team provides a larger scope of knowledge and experience when both are utilized. Team members ideally should be cross-trained so that each member can function at the other’s level of expertise.

Training and selection

Since the transport team will work in a high-stress environment, often with life or death consequences, these individuals must be carefully selected. The selection process should involve interviews with a nursing administrator, a director of respiratory therapy, and a medical director of a transport program.

Minimum requirements for transport team members should include:

- Transport nurse qualifications:
  - a registered nurse;
  - minimum of 6 months burn care experience;
  - current cardiopulmonary resuscitation (CPR) certification;
  - advanced cardiac life support (ACLS) or pediatric advanced life support (PALS) certification;
  - ability to demonstrate clinical competency;

- observe two transports;
- a valid passport for international response.

- Transport respiratory therapist qualifications:
  - registered respiratory therapist with 6 months burn care experience;
  - licensed by appropriate regulatory agency as a respiratory care practitioner;
  - have current BLS;
  - ACLS or PALS certification;
  - ability to demonstrate clinical competency;
  - observe two transports;
  - demonstrate a working knowledge of transport equipment;
  - a valid passport for international response.

Because all of the care rendered by a transport team outside a hospital is given as an extension of care from a transporting/receiving facility, specific steps must be taken to protect staff and physicians from medical liability and to provide consistent care for all patients. Strict protocols are used to guide all patient care; team members should be in constant communications with an attending physician regarding a patient’s condition and the interventions to be considered. Team members must be proficient at a number of procedures, which may be needed during transport or while stabilizing a patient prior to transport. To keep up with current technology and changes, team members should be included in discussions of recent transports and current management techniques, so that they can discuss patient care issues, receive ongoing in-service education, and participate in a review of the quality of transports.

Modes of transportation

Once the need for transport of a burned patient is established, the decision must be rendered concerning what type of transportation vehicle is to be used (Table 7.1). There are two models of transport commonly used: ground (ambulance/transport vehicle); air (helicopter, fixed wing), or a combination of both. Factors to be considered when selecting a mode of transportation are the condition of the patient and the distance involved. The level of the severity of the burn mandates the speed with which the team must arrive in order to stabilize and transport a patient.

Ground transport

Ground transport should be considered to cover distances of 70 miles or less; however, sometimes a patient’s condition may require air transport, particularly helicopter transport, even though the distance is within the 70-mile range. The ground transport vehicle should be modified with special equipment needed for intensive care transport, and there must be enough room to comfortably seat team members and equipment.

Air transport

Air transport is used primarily when long distances or the critical nature of an injury separate a team from a patient. Air transport, however, does present its own unique set of problems. Aviation physiology is a specialty unto itself, and...
the gas laws play an important role in air transport and must be taken into consideration.

Dalton’s law states that in a mixture of gases, the total pressure exerted by the mixture is equal to the sum of the pressures each would exert alone. This is important when changing a patient’s altitude because as altitude increases, barometric pressure decreases. The percentage of nitrogen, oxygen, and carbon dioxide remain the same, but the partial pressures exert change.

Altitude is an important factor in the oxygenation of a transported patient and constant monitoring by a team is required under such circumstances. Boyle’s law states that the volume of gas is inversely proportional to the pressure to which it is subject at a constant temperature. This gas law significantly affects patients with air leaks and free air in the abdomen, because as altitude increases, the volume of air in closed cavities also increases. For this reason, all air that can be reached should be evacuated prior to an increase in altitude. Intrathoracic air and gastric air must be removed via functional chest tubes or nasogastric tubes and periodically checked during transport. Other factors that should be considered during air transport are reduced cabin pressure, turbulence, noise and vibration, changes in barometric pressure, and acceleration/deceleration forces. Physiologic changes which affect a patient and team members include middle ear dysfunction, pressure-related problems with sinuses, air expansion in a gastrointestinal tract, and motion sickness. Utilizing transport vehicles that have pressurized cabins can reduce or eliminate most of these problems.

### Helicopters and fixed wing aircraft

Helicopters and fixed wing aircraft both have advantages and disadvantages related to patient care. Helicopters are widely used for short-distance medical air transport. Medical helicopters, because they are usually based on hospital premises, have no need to use airport facilities or ambulance services and, thereby, reduce team response time. Helicopters are able to land close to a referring hospital. Additionally, helicopters provide ease in loading and unloading patients and equipment. The disadvantages of helicopter transport include its limited range, usually less than 150 miles and its non-pressurized cabin which limits the altitude at which patients can be safely carried. The low-altitude capabilities also subject the aircraft to variability in weather (i.e. fog, rain, and reduced visibility); therefore, helicopter flights experience much more interference due to the weather. Other disadvantages include noise, vibrations, reduced air speed, small working space, lower weight accommodation, and high maintenance requirements.

When long distances must be traveled (more than 150 miles) or when increased altitude is necessary, fixed wing aircraft are considered as a viable mode of transport for patients. The advantages of using fixed wing aircraft include: long range capabilities, increased speed, ability to fly in most weather conditions, control of cabin pressure and temperature, larger cabin space, and more liberal weight restrictions. Disadvantages of fixed wing aircraft include the need for an airport with adequate runway length, difficulty in loading and unloading patients and equipment, and the pressure of air turbulence and noise.

<table>
<thead>
<tr>
<th>Weight (kg)</th>
<th>Distance (miles)</th>
<th>Team*</th>
<th>Transport mode</th>
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<tr>
<td>≤3</td>
<td>Any</td>
<td>C</td>
<td>Van, helicopter</td>
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<tr>
<td></td>
<td>76–250</td>
<td>C</td>
<td>Turboprop plane</td>
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<td>&gt;251</td>
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</table>

*Complete team (doctor, nurse, respiratory therapist); N, nurse; RT, respiratory therapist.

If any of the following criteria exist, the transport shall be changed to the fastest mode with a complete team:

- Depressed mental status
- Drug depression
- Respiratory support
- Unstable cardiovascular system
- Presence of associated diseases
- Decreased urine output/ureteral insensitivity to appropriate fluid administration
- Absent or marginal venous access
- Hypothermia unresponsive to corrective measures

### Equipment

Because medical equipment used in intensive care units has evolved tremendously in the last 10 years, there is no reason that these advances should not be extended to the equipment which is used in a transport program. The transport team must be able to provide ICU level care whenever needed. Most hospitals are well stocked and able to provide necessary supplies for initial patient stabilization and resuscitation; however, specialty items relating to the care of burn patients may not be present or adequate to meet the needs of burn victims. It is imperative that adequate equipment be available to handle any situation, which may arise during a transport process (Fig. 7.4).
Portable monitor
A portable ECG monitor capable of monitoring two pressure channels should accompany all patients in transport. This allows for continuous monitoring of heart rate, rhythm, and arterial blood pressure. The second pressure channel may be used for patients with a pulmonary artery catheter or those who need intracranial pressure monitoring. This monitor should be small and lightweight but able to provide a display bright enough to be seen from several feet away. The monitor should have its own rechargeable power supply which continuously charges while connected to an alternating current (AC) power supply. One suitable unit is the Protocol Systems Propaq 106 portable monitor. This monitor has two pressure channels; it provides a continuous display of ECG, heart rate, systolic, diastolic, and mean blood pressure; it can display temperature and oxygen saturation; and it is also capable of operating a non-invasive blood pressure cuff. High and low alarms for each monitored parameter can be set, silenced, or disabled by a trained operator.

Infusion pump
Continuous delivery of fluids and pharmacological agents must not be interrupted during transport. Infusion pumps can be easily attached to stretchers and are usually capable of operating for several hours on internal batteries. These devices should have alarms to warn of infusion problems and should be as small and lightweight as possible.

Ventilator
Size, weight, and oxygen consumption are the primary concerns in selecting transport ventilators. A weight under 5 pounds (2.2 kg) is desirable, and a ventilator’s dimensions should make it easy to mount or to place on a bed. Orientation of controls should be along a single plane, and inadvertent movement of dials should be difficult. The ventilator breathing circuit and exhalation valve should be kept simple, and incorrect assembly should be impossible. One type of transport ventilator that has become popular is the TXP transport ventilator. The TXP transport ventilator (Percussionaire Corporation, Sand Point, ID) is a portable pressure-limited time-cycled ventilator and is approved for in-flight use by the US Air Force. The transport ventilator weighs 1.5 pounds (0.68 kg), can be set to provide respiratory rates of between 6 and 250 breaths per minute, and provides tidal volumes of between 5 and 1500 cc. This ventilator is powered entirely by oxygen and requires no electrical power. All timing circuit gases are delivered to the patient so that operation of the ventilator does not consume additional oxygen. The I:E ratios are preset at the factory from 1:1 at frequencies of 250 cycles per minute to 1:5 at a rate of 6 cycles per minute. As a result, breath stacking and undesired over inflation due to air trapping may be avoided.

Stabilization
One of the primary reasons for a specialized transport team is to be able to transport a patient in as stable condition as possible. Current practice has evolved to embrace the concept that events during the first few hours following burn injury may affect the eventual outcome of the patient; this is especially true with regard to fluid management and inhalation injury. Stabilization techniques performed by the transport team have been expanded to include procedures that are usually not performed by nursing or respiratory personnel. Such techniques include interpreting radiographs and laboratory results and then conferring with fellow team members, referring physicians, and the team’s own medical staff in order to arrive at a diagnosis and plan for stabilization. The transport team may perform such procedures as venous cannulation, endotracheal intubation, arterial blood gas interpretation, and management of mechanical ventilators. Team members may request new radiographs, in order to assess catheter or endotracheal tube placement or to assess the pulmonary system’s condition. Team members may aid in the diagnosis of air leaks (pneumothorax) and evacuate the pleural space of the lung by needle aspiration as indicated. All of these procedures may be immediately necessary and life-saving. Cross-training of all team members to be able to perform the others’ jobs is recommended in order to safeguard patients in the event that any team member becomes incapacitated during transport. All these skills can be learned via experience in a burn intensive care unit, through formal training seminars, and via a thorough orientation program. Mature judgment, excellent clinical skills, and the ability to function under stress are characteristics needed when selecting candidates for a transport program.

Patient assessment prior to transport to a specialized burn care unit from a referring hospital
Initial assessment upon arrival of a flight team should include a list of standard procedures for determining a burned patient’s current condition. First, a thorough review of the patient’s history concerning the accident and past medical history must be done. This process provides the transport team with an excellent base from which to begin to formulate a plan of action. The patient will certainly have problems overlooked in initial evaluations. Stabilization care is a specialized field, modes of treatment...
may vary greatly outside the burn treatment community. Frequently, a referring hospital is not well versed in the treatment of burn victims and should not be expected to display the expertise found among clinicians who work with such patients’ everyday. Thus, the next step in stabilizing a burn patient is a physical assessment done by a transport team. These procedures should always be performed in the same order and in a structured fashion. Assessment of a burn patient begins with the ABCs of a primary survey, including airway, breathing, circulation, cervical spine immobilization, and a brief baseline neurological examination. All patients should be placed on supplemental oxygen prior to transport in order to minimize the effects of altitude changes on oxygenation. Two IV lines should be started peripherally with a 16-gauge catheter or larger. Ideally, IV lines should be placed in non-burned areas but may be placed through a burn if they are the only sites available for cannulation. Intravenous lines should be sutured in place because venous access may not be available after the onset of generalized edema. The fluid of choice for initial resuscitation is lactated Ringer’s solution.

In addition to initial stabilization procedures, blood should be obtained for initial laboratory studies if not already done. Initial diagnostic studies include hematocrit, electrolytes, urinalysis, chest X-ray, arterial blood gas, and carboxyhemoglobin levels. Any correction of laboratory values must be done prior to transfer and verified with repeat studies. Electrocardiographic monitoring should be instituted on any patient prior to transfer. Electrode patches may be a problem to place because the adhesive will not stick to burned skin. If alternative sites for placement cannot be found, an option for monitoring is to insert skin staples and attach the monitor leads to them with alligator clips. This provides a stable monitoring system, particularly for the agitated or restless patient who may displace needle electrodes. A Foley catheter with an urometer should be placed to accurately monitor urine output. Acceptable hydration is indicated by a urine output of more than 30 mL/kg/h in an adult (5 mL/kg/h) and at least 1 mL/kg/h in a child.

With the exception of escharotomies, open chest wounds, and actively bleeding wounds, management during transport consists of simply covering wounds with a topical antimicrobial agent or a biological dressing. Wet dressings are contraindicated because of the decreased thermoregulatory capacity of patients sustaining large burns and the possibility of hypothermia. To combat the problem of a gastric ileus, a nasogastric tube should be inserted in all burn patients in order to decompress the stomach. This is especially important for patients being transferred at high altitudes. Hypothermia can be avoided or minimized by the use of heated blankets and/or aluminized Mylar space blankets. The patient’s rectal temperature must be kept between 37.5 and 39.0°C.

A clear, concise, chronological record of the mechanism of injury and assessment of airway, breathing, and circulation should be kept in the field and en route to the hospital. This information is vital for a referring facility to better understand and anticipate the condition of the patient. Additionally, all treatments, including invasive procedures, must be recorded, along with a patient’s response to these interventions.

Summary

Burn injuries present a major challenge to a healthcare team, but an orderly, systematic approach can simplify stabilization and management. A clear understanding of the pathophysiology of burn injuries is essential for providing quality burn care in the pre-hospital setting, at the receiving healthcare facility, and at the referring hospital prior to transport. After a patient has been rescued from an injury-causing agent, assessment of the burn victim begins with a primary survey. Life-threatening injuries must be treated first, followed by a secondary survey, which documents and treats other injuries or problems. Intravenous access may be established in concert with logical/regional medical control and appropriate fluid resuscitation begun. Burn wounds should be covered with clean, dry sheets; and the patient should be kept warm with blankets to prevent hypothermia. The patient should be transported to an emergency room in the most appropriate mode available.

At the local hospital, it should be determined if a burn patient needs burn center care according to the American Burn Association Guidelines. In preparing for organizing a transfer of a burn victim, consideration must be given to the continued monitoring and management of the patient during transport. In transferring burn patients, the same priorities developed for pre-hospital management remain valid. During initial assessment and treatment and throughout transport, the transport team must ensure that the patient has an adequate airway, breathing, circulation, fluid resuscitation, urine output, and pain control. Ideally, transport of burn victims will occur through an organized, protocol-driven plan, which includes specialized transport mechanisms and personnel. Successful transport of burn victims, whether in the pre-hospital phase or during inter-hospital transfer, requires careful attention to treatment priorities, protocols, and details.

Further reading


References

FIGURE 1-14. (A) Escharotomy of the thorax extending from the clavicle to the subcostal margin in the anterior axillary line. The two incisions are connected if, after having been made, expansion continues to be limited. (B) Escharotomies should be tailored to fit the burn as illustrated in this injury where thoracic expansion was limited by a left sided full thickness injury and relieved after a single incision.