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Critical Care Update

Burn Care: Transfers and Toxins

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Air medical providers are frequently called on to transfer burned patients, particularly children. Recent literature calls standard transfer criteria into question and reveals that children presenting in the emergency department who may meet transfer criteria are often discharged. Furthermore, although concern for carbon monoxide and cyanide exposure is not new in the setting of burn care, recent literature suggests a lack of consensus regarding the use of available therapies. Here are some recent comments on these subjects.

American College of Surgeons Committee on Trauma. Guidelines for trauma centers caring for burn patients. In: Rotondo MF, Cribari C, Smith RS (eds). *Resources for Optimal Care of the Injured Patient.* Chicago, IL: American College of Surgeons; 2014:100-106.

Johnson SA, Shi J, Groner JI, et al. Interfacility transfer of pediatric burn patients from U.S. emergency departments. *Burns.* 2016;42:1413-1422.

Warner P, Bailey JK, Bowers L, et al. Aeromedical pediatric burn transportation: a six-year review. *J Burn Care Res.* 2016;37:e181-e187.

Kashefi N, Dissanaike S. Use of air transport for minor burns: is there room for improvement? *J Burn Care Res.* 2016;37:e453-e460.

Burn injuries can be challenging to manage, and many hospitals do not have the personnel, resources, and expertise to care for these patients. Consequently, the American Burn Association, in conjunction with the American College of Surgeons Committee on Trauma, has developed referral criteria to help providers determine that patients should be transferred to a burn center (Table 1). Many of these criteria relate to the location, mechanism, or severity of the burn. In addition, there are also criteria that recommend the transfer of specific groups of patients, such as children or patients with significant comorbidities or rehabilitation needs. For patients who require transfer, emergency medical service (EMS) providers will often be needed to transport these patients. This is particularly important with children because of the unique equipment, expertise, and personnel needed to care for these patients.

The study by Johnson et al examined pediatric burn patients presenting to an emergency department (ED) and identified factors associated with transfer to another medical facility. The study identified pediatric burn patients in the 2012 Nationwide Emergency Department Sample, which is a database of discharge data from EDs of several hundred hospitals in the United States. Using weighting variables associated with this database, national estimates for ED data were obtained. In 2012, a total of 28,363 pediatric burn patients were identified in the Nationwide Emergency Department Sample, which produced a national estimate of 126,742 patients. Of this overall estimate, 69,003 (54.4%) patients met at least 1 of the burn referral criteria, and most of these patients, 57,382 (83.2%), were initially treated at low-volume hospitals, which were defined as hospitals that admitted less than 50 burn patients per year. Interestingly, only a small percentage of the patients who met at least 1 referral criteria and were initially treated at low-volume hospitals were transferred (8.2%), but the majority of patients (90.1%) were treated and discharged from the ED. Some of the factors associated with transfer in the patients meeting referral criteria at low-volume hospitals were age < 5 years, partial thickness burns > 10% total body surface area (TBSA), partial thickness burns of the face/head/neck or genitalia, and full-thickness burns. Although the destinations of these transferred patients were not provided in this study, presumably these patients were transferred to regional burn centers because the patients treated at low-volume hospitals in this study were used as surrogates for patients treated at hospitals without

Table 1
Burn Center Referral Criteria

Burn Center Referral Criteria
Partial-thickness burns of > 10% TBSA
Burns involving face, hands, feet, genitalia, perineum, and major joints
Third-degree burns in any age group
Electrical burns, including lightning
Chemical burns
Inhalation injury
Burn injury with medical disorders that could complicate management
Burns and concomitant trauma
Burns in children
Burn injury in patients who require special social, emotional, and rehabilitation considerations

TBSA = total body surface area.
Modified from Committee on Trauma American College of Surgeons. *Resources for Optimal Care of the Injured Patient*. Chicago, IL: American College of Surgeons; 2014:101.

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significant experience caring for burn injuries. Consequently, the authors pose the question of whether more of the pediatric burn patients treated at low-volume hospitals should be transferred and suggest that this may lead to improved outcomes in these patients. Finally, the authors provide potential solutions to increase the transfer rate, which include improved communication between burn centers and transferring hospitals along with more detailed referral criteria.

Unfortunately, the number of active burn centers in the United States has declined over recent decades, which implies that the nearest burn center may be a great distance from the transferring hospital. In this situation, air transport is often necessary. Air transport has been used for decades with burn patients, and burn flight teams, teams of medical providers that specialize in the air transport of burn patients, are often tasked with transporting these patients. However, more rapid transport of these patients is frequently possible with nonburn flight teams. Consequently, it is important for air medical EMS providers to have some experience with transporting burn patients. The challenges of transporting "standard" critically ill and injured patients by air are well-known, but there are some unique aspects of transporting burn patients that all air medical EMS providers should consider.

The recent study by Warner et al examined the outcomes of pediatric burn patients transported to a single burn center by either a nonburn flight team or a dedicated burn flight team between January 2007 and January 2013. Several outcomes were examined, and there were some differences between the 2 groups. Patients transported by nonburn flight teams were more hypotensive and hypothermic on admission to the burn center than the patients transported by burn flight teams ($P < .008$ and $P < .001$, respectively). In addition, there was lower hourly urine output and more variability in urine output in patients transported by nonburn flight teams compared with burn flight teams. Despite these differences, both groups had similar complication rates, and neither group had any in-flight deaths. The authors concluded that transporting pediatric burn patients by air is safe, but nonburn flight teams that do not have any experience transporting burned children should consider burn physiology in the child before transport. Burned children are at an increased risk for hypoxia, hypothermia, and fluctuations in blood pressure with transport conditions. Therefore, communication between the burn center and flight teams is imperative to ensure that burn patients are stable for transport and to minimize complications. Moreover, given the specific findings of this study, nonburn flight team providers should pay particular attention to resuscitation and temperature control when transporting burn patients.

Air transport is heavily used in rural areas or by hospitals that are far from burn centers. Although this mode of transport is safe for patients, it should be used judiciously. Air transport is expensive, and insurance companies may only reimburse some of the transport costs. This puts the patients at risk of having to pay for the transport bill out of pocket. Moreover, some patients who are brought to the burn center by air are discharged within 24 hours if their injuries are minor. This raises the question of whether air transport was necessary. Kashefi and Dissanaike examined this and other questions in a recent study. A particular focus of this study was air transport resulting from overtriage, which was defined as discharge shortly after being brought to the burn center. This can be further defined as primary overtriage, which is discharge shortly after transport from the point of injury, or secondary overtriage, which is discharge shortly after transfer from another hospital. Both of these phenomena have been observed in patients with minor burns who are discharged from a burn center in less than 24 hours.

The study population in this triage review consisted of 1,331 patients transported by air and admitted to a single regional burn center between January 2003 and June 2013. There were 256 (19%) patients in the "overtriaged" group because they were discharged within 24 hours (in the first 24 hours, 38 patients died). The rest of the 1,037 (77.9%) patients were assigned to the "accurately triaged" group because they were hospitalized for more than 24 hours. Comparing the groups, the accurately triaged patients had a higher mean TBSA burned (15% vs. 3.3%, $P < .0001$), a higher percentage of patients with partial-thickness burns > 10% TBSA (44.6% vs. 2.3%, $P < .0001$), and a higher percentage of patients with third-degree burns (26% vs. 7%, $P < .0001$) than the overtriaged patients. Moreover, in the overtriaged group, 236 (92.2%, 17.7% overall) patients were transferred from other medical facilities, and these patients were classified as "secondary overtriaged."

Given the frequency of air transport overtriage in this study, the authors conclude that for patients with minor burns, in whom the injury severity and urgency for treatment is low, air transport may not be necessary because the high costs associated with this mode of transport may outweigh the benefits and not change the management of these patients. Several possible reasons for the overtriage rate were described, including overestimation of burn size by referring facilities, lack of experience and resources to care for pediatric burn patients, unfamiliarity with managing less common etiologies of burns (eg, chemical and electrical), and concern for airway compromise and possible inhalation injury. The authors conceded that all of the patients in the study population met at least 1 of the standard referral criteria. Proposed solutions to reduce the rate of air transport overtriage for minor burn patients include other modes of transportation (eg, ground ambulance and private vehicles), telemedicine, improved communication between referring facilities and burn centers, and revised referral criteria.

Sheridan RL. Fire-related inhalation injury. *N Engl J Med*. 2016;375:464-469.

Dries DJ, Endorf FW. Inhalation injury: epidemiology, pathology, treatment strategies. *Scand J Trauma Resusc Emerg Med*. 2013;21:31.

Rose JJ, Wang L, Xu Q, et al. Carbon monoxide poisoning: pathogenesis, management, and future directions of therapy. *Am J Respir Crit Care Med*. 2017;195:596-606.

Dumestre D, Nickerson D. Use of cyanide antidotes in burn patients with suspected inhalation injuries in North America: a cross-sectional survey. *J Burn Care Res*. 2014;35:e112-e117.

Inhalation injury results from direct thermal and chemical exposure. The immune response to this exposure is combined with systemic effects of inhaled toxins, accrual of endobronchial debris, and secondary infection. Structure fires generate smoke containing a variety of chemicals, products of incomplete combustion, and aerosolized debris particles of varying sizes. Air temperature during fires varies enormously. Typically, at floor level, air temperature can be hundreds of degrees Fahrenheit. The effect on individuals is complex and unpredictable.

Direct thermal damage is generally confined to the supraglottic airway except in rare cases of steam inhalation, such as those involving inhalation of pressurized steam in engineering spaces. Most injuries below the glottis are caused by aerosolized chemicals and incomplete products of combustion. The type and severity of these injuries are highly unpredictable depending on the agents released and the particle size inhaled. Smaller particles travel to a more distal location in the airways before deposition. The local effects of these particles include irritation, mucosal slough, bronchospasm,