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Advances in emergency care for burn disorders: Treatment strategies and outcomes

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***Abstract*---Background:** Effective management of burn injuries is crucial for optimizing patient outcomes, yet challenges remain in prehospital care and accurate assessment. This article reviews the advancements in emergency burn care, focusing on the prehospital management by Helicopter Emergency Medical Services (HEMS) in Switzerland and the implications for North American practices. **Aim:** To explore and compare burn care strategies, particularly in prehospital and initial hospital settings, and to evaluate updates in fluid resuscitation protocols and burn size estimation techniques. **Methods:** The study incorporates a decade-long review of HEMS data from Switzerland and examines North American practices, including referral criteria and transport strategies. Analysis of recent studies on air transport overtriage and updated fluid resuscitation formulas, such as the Parkland and Modified Brooke formulas, is also included. **Results:** Findings indicate a high degree of consistency in burn size assessment in Switzerland, contrasting with varying results in North America where overtriage and inaccuracies in burn size estimation are prevalent. Fluid resuscitation protocols have been refined to address these issues, with updated ABLS guidelines reflecting advancements in technology and evidence-based practices. **Conclusion:** Enhanced prehospital care and accurate burn size estimation are critical for effective burn management. The study underscores the importance of updated ABLS protocols, including refined fluid resuscitation formulas and technological integration, to improve outcomes and reduce unnecessary interventions.

***Keywords*---**Burn care, prehospital management, fluid resuscitation, burn size estimation, ABLS updates, air transport, overtriage.

Introduction

Numerous scholarly articles and textbooks on burn care commence with the patient's presentation to the Emergency Department. However, Maudet and colleagues from Switzerland diverge significantly from this conventional approach by offering a decade-long review of pre-hospital Helicopter Emergency Medical Service (HEMS) management of burn patients within a consistent practice framework serving one of two Burn Centers in Switzerland [1]. In this system, all EMS services are mandated to refer patients to the Burn Center, thereby providing a robust sample of both initial hospital management and prehospital care patterns. Advanced pain management protocols involving fentanyl and ketamine are employed, and there is notable uniformity in the assessment of burn size. Notably, complications during resuscitation are not reported. This refined study initiates a crucial discussion, which I will complement with a North American viewpoint. My insights are based on the extensive North Central United States, where a network of small safety-net hospitals manages a diverse range of issues with varying levels of burn care expertise.

Burn injuries present considerable management challenges, and many hospitals dispersed over vast regions lack the necessary personnel, resources, and expertise

for adequate care. To address this, the American Burn Association, in collaboration with the American College of Surgeons Committee on Trauma, has established referral criteria to guide providers in determining when patients should be transferred to a Burn Center [2]. These criteria generally pertain to the location, mechanism, or severity of the burn, as well as specific groups of patients, including children or those with significant comorbidities or rehabilitation needs. Referral to a Burn Center is warranted under several conditions. These include partial thickness burns that cover more than 10% of the total body surface area (TBSA), burns affecting critical areas such as the face, hands, feet, perineum, or joints, and third-degree burns. Additionally, patients who have suffered from electrocution, including lightning strikes, as well as those with inhalation injuries or chemical burns should be referred. Pediatric patients with burns and those with burns accompanied by comorbid medical conditions or other concurrent trauma also meet the criteria for Burn Center referral.

Transfer:

Air transport is frequently utilized in rural areas or by hospitals situated far from Burn Centers. While air transport is generally safe for patients, it should be employed with discretion due to its high cost and the limited availability of resources to cover transportation expenses [3]. Additionally, some patients arriving at Burn Centers via air are discharged within 24 hours if their injuries are found to be minor [4]. A recent study investigated the necessity of air transport, with a specific emphasis on instances of overtriage, defined as the discharge of patients shortly after their arrival at the Burn Center.

This study reviewed 1,331 patients who were airlifted to a regional Burn Center between January 2003 and June 2013 [4]. Of these, 256 patients fell into the overtriaged category, having been discharged within 24 hours (note: 38 of these patients died within the first 24 hours). The remaining patients were classified as accurately triaged since they were hospitalized for more than 24 hours. Comparisons revealed that accurately triaged patients had a higher mean total body surface area (TBSA) burned (15% vs 3.3%), a greater percentage of partial-thickness burns exceeding 10% TBSA (44.6% vs 2.3%), and a higher incidence of third-degree burns (26% vs 7%) compared to the overtriaged group. Within the overtriaged category, 236 patients were transferred from other medical facilities and were identified as experiencing secondary overtriage.

In light of the study's findings on air transport overtriage, the authors suggest that air transport may be unnecessary for patients with minor burns, given the high costs associated with air transport and the minimal impact on patient management [3]. Possible reasons for overtriage include overestimation of burn size by referring facilities, insufficient experience and resources to manage burn patients, especially children, unfamiliarity with less common burn causes (such as chemical and electrical burns), and concerns about airway compromise due to potential smoke inhalation [4,5,6]. Despite these issues, all patients in the study met at least one standard referral criterion. Proposed solutions to mitigate air transport overtriage for minor burns include promoting alternative transportation methods like ground ambulances or private vehicles, employing telemedicine,

enhancing communication between referring facilities and Burn Centers, and revising referral criteria.

Burn Size Evaluation

In the current report, Maudet and colleagues demonstrate notable consistency in burn size assessments before and after arrival at the Burn Center [1]. However, similar results are not observed in other regions. Retrospective data from various North American Burn Centers indicate that many patients referred for extensive injuries were discharged within 24 hours. Up to 70% of patients with overestimated burn sizes were discharged within 48 hours, and only 30% required surgical intervention. Many patients were more appropriately triaged to follow-up clinics rather than receiving direct transfer to the Burn Center [7]. International Burn Centers report analogous findings. For instance, a study from Australia revealed that 33% of pediatric referrals had inaccurate TBSA estimates, 25% did not meet transfer criteria, and up to 40% of transfers were unnecessary [8]. Similarly, a UK study found that 37% of transferred patients had inaccurately estimated TBSA injuries, suggesting that some transfers might not have been warranted. A review of multiple studies indicated that, on average, 45 to 77% of small burns (less than 20% TBSA) and 26 to 37% of larger burns could be managed without the need for a specialized Burn Center [9].

The risk of overestimating burn size can lead to unnecessary interventions and excessive fluid administration for patients with relatively minor injuries presenting at non-burn facilities. This issue is pertinent in the context of updated Advanced Burn Life Support (ABLS) protocols, which have reduced the volume of fluid administered based on TBSA burned. Emerging evidence supports the use of computer-based imaging technology, now accessible on mobile devices such as tablets, as a more reliable and consistent method for estimating burn size. Incorporating such technology into telemedicine systems could further improve burn triage [7, 10]. Many burn care providers advocate for a more robust telemedicine system to enhance initial providers' ability to deliver high-quality early management.

Resuscitation:

The primary aim of burn resuscitation is to ensure adequate tissue perfusion and organ function while preventing complications associated with both over-resuscitation and under-resuscitation. Continuous fluid administration is critical for achieving optimal outcomes. Excessive resuscitation fluid can exacerbate edema formation, leading to complications such as extremity, orbital, and abdominal compartment syndromes, as well as pulmonary and cerebral edema [11]. Untreated or inadequately treated hypovolemia in patients with extensive burns can result in shock and organ failure, commonly presenting as acute kidney injury. The increase in capillary permeability following a burn injury begins immediately post-injury, and the reduction in effective blood volume is most pronounced during this period. Early and adequate fluid resuscitation is crucial to prevent burn shock and organ failure. Delays in initiating resuscitation often result in higher subsequent fluid needs. Inhalation injuries are also associated with increased fluid requirements [12]. Therefore, resuscitation should

begin as soon as possible after the injury, with crystalloids remaining essential in reduced amounts as detailed below.

The most recent guidelines on initial fluid rates, as outlined in the ABLS curriculum, are particularly pertinent for providers managing burn-injured patients before they reach a Burn Center. In prehospital and initial hospital settings, where formal calculation of the percentage of TBSA burned may not yet be available, fluid administration guidelines are based on patient age with fixed initial fluid rates as follows:

- Children aged 5 years and younger: 125 mL of lactated Ringer's solution per hour
- Children aged 6 to 13 years: 250 mL of lactated Ringer's solution per hour
- Adolescents aged 14 years and older: 500 mL of lactated Ringer's solution per hour

This approach is justified due to the variability in burn size estimation prior to arrival at a Burn Center [13]. Once the patient's weight and the extent of second and third-degree burns are accurately assessed, the ABLS 2018 fluid resuscitation calculations can be used to adjust the fluid rate accordingly. Inpatient resuscitation strategies are typically guided by two established formulas: the Parkland formula (4 mL/kg/%TBSA burned in the first 24 hours) and the modified Brooke formula (2 mL/kg/%TBSA burned in the first 24 hours) [11]. According to these formulas, it is recommended that half of the calculated 24-hour fluid volume be administered within the first 8 hours after the burn injury, with the remaining volume given over the subsequent 16 hours on the first post-burn day. Fluid administration should be adjusted based on urinary output and other indicators of end-organ function. Recent evidence suggests that the traditional 4 mL/kg/%TBSA burned formula often results in over-resuscitation, leading to the common use of the modified Brooke formula.

If there is a delay in initiating formal inpatient resuscitation, the initial half of the resuscitation volume should be administered over the remaining hours in the first 8 hours post-injury. If resuscitation is delayed beyond 6 hours after the injury, consultation with a Burn Center for an appropriate "catch-up" fluid administration strategy is recommended. Generally, bolus administration of crystalloids should be avoided unless the patient is hemodynamically unstable. Special considerations, such as in adults with high-voltage electrical injuries presenting with myoglobinuria or in children with a higher body surface area-to-body mass ratio, necessitate relatively larger fluid volumes. Children's smaller intravascular volume per unit of surface area makes them more vulnerable to fluid overload and hemodilution. Infants and young children should receive lactated Ringer's solution with 5% dextrose at a maintenance rate in addition to burn resuscitation to mitigate the risk of hypoglycemia due to limited glycogen stores. In summary, clean, dry dressings with protection from hypothermia are the only essential prehospital wound care [13]. Additionally, as demonstrated by Maudet and colleagues, short-acting medications administered intravenously may provide rapid pain relief and minimize hemodynamic changes [1].

Advanced Burn Life Support (ABLS) Updates

The Advanced Burn Life Support (ABLS) updates reflect advancements in the management and treatment of burn injuries based on ongoing research and clinical experience. The ABLS curriculum, developed by the American Burn Association, is periodically updated to incorporate the latest evidence and best practices for burn care. Here are some key areas where updates may occur:

1. **Fluid Resuscitation Protocols**: Updates often include refined guidelines for fluid resuscitation, such as the amount and type of fluids administered. Changes may be based on new research showing better outcomes with modified formulas or different fluid compositions. For instance, the adjustment of the Parkland and modified Brooke formulas reflects ongoing research on the optimal fluid volume and rate for resuscitation.
2. **Burn Size Estimation**: Advances in imaging technology and assessment methods can lead to updated guidelines on how to accurately estimate the total body surface area (TBSA) burned. Improved methods for measuring burn size help ensure more accurate fluid resuscitation and treatment plans.
3. **Pain Management**: Updates may include new protocols for pain management, incorporating recent evidence on the efficacy of various medications and techniques. This can involve changes in drug recommendations or dosing strategies.
4. **Inhalation Injury Management**: As knowledge about inhalation injuries advances, ABLS updates may include new recommendations for assessing and managing airway injuries and respiratory complications.
5. **Pediatric and Special Population Care**: The ABLS curriculum may be updated to address specific considerations for pediatric patients or other special populations, such as those with high-voltage electrical injuries or those with complex medical conditions.
6. **Infection Prevention**: Guidelines for preventing and managing infections in burn patients are continually refined based on new research and clinical practices.
7. **Prehospital and Initial Hospital Care**: Updates may include revised guidelines for initial management of burn patients before they reach a specialized Burn Center, including recommendations for transport and early care interventions.
8. **Telemedicine and Technology Integration**: The incorporation of telemedicine and digital tools for burn assessment and triage might be included, reflecting the growing role of technology in improving patient outcomes. ABLS updates ensure that burn care providers are equipped with the most current knowledge and tools to deliver effective and evidence-based care to burn patients.

Total Body Surface Area (TBSA) Guidelines

Total Body Surface Area (TBSA) guidelines are critical in the management of burn injuries as they help determine the extent of a patient's burns and guide treatment, particularly fluid resuscitation. TBSA represents the proportion of the

body that has been burned, and accurate estimation is essential for effective treatment planning. Here's a summary of key aspects of TBSA guidelines:

1. **Assessment Methods**:
    - **Rule of Nines**: A quick, traditional method used for initial estimation of burn size. It divides the body into sections, each representing approximately 9% (or a multiple of 9%) of the total body surface area. For example, the head and neck account for 9%, each arm for 9%, each leg for 18%, the front torso for 18%, and the back torso for 18%.
    - **Lund and Browder Chart**: A more detailed method that provides age-specific body surface area distributions. It offers more precise estimates by accounting for changes in body proportions from infancy through adulthood. The chart adjusts the percentages for different age groups, improving accuracy in children compared to the Rule of Nines.
2. **Fluid Resuscitation**:
    - **Parkland Formula**: A commonly used formula for calculating fluid resuscitation needs, which involves administering 4 mL of lactated Ringer's solution per kilogram of body weight per percentage of TBSA burned, with half given in the first 8 hours and the remaining half over the next 16 hours.
    - **Modified Brooke Formula**: An alternative formula that uses 2 mL of lactated Ringer's solution per kilogram of body weight per percentage of TBSA burned, typically resulting in a lower fluid requirement compared to the Parkland Formula.
3. **Age and Body Size Adjustments**:
    - **Children**: Special considerations are made for children, as their body surface area relative to body weight differs from adults. Guidelines often involve adjustments to account for this variation, and the Lund and Browder chart is particularly useful for pediatric patients.
    - **Elderly**: Age-related changes in skin and tissue may also affect burn management. Adjustments may be needed for fluid resuscitation and other treatment aspects in elderly patients.
4. **Inhalation Injuries and Special Cases**:
    - For patients with inhalation injuries or other complicated factors (e.g., high-voltage electrical burns), additional considerations may affect fluid resuscitation and overall management. TBSA estimation still plays a crucial role, but these cases may require tailored approaches.
5. **Ongoing Updates**:
    - TBSA guidelines and estimation methods are periodically reviewed and updated based on new research and clinical evidence. This ensures that practitioners have access to the most accurate and effective tools for managing burn injuries.

These guidelines are integral to providing appropriate care, as they help guide decisions on fluid resuscitation, determine the severity of the burn, and assess the need for specialized treatment and interventions. Accurate TBSA estimation is fundamental for optimizing patient outcomes and preventing complications associated with burn injuries.

Fluid Formulas in Burn Care:

Fluid formulas are essential in the management of burn patients, particularly for calculating the amount of intravenous fluids needed to compensate for fluid loss and maintain hemodynamic stability. These formulas are based on the Total Body Surface Area (TBSA) affected by burns and are used to guide fluid resuscitation during the critical first 24 hours post-burn. Here's a detailed explanation of the most commonly used fluid formulas:

1. Parkland Formula: The Parkland formula is one of the most widely used formulas for fluid resuscitation in burn patients. It calculates the total fluid requirement for the first 24 hours post-burn and is based on the patient's weight and the extent of burn injury.

- **Formula**:
  - Total Fluid Requirement=4 mL×Body Weight (kg)×TBSA burned
  - **Fluid Type**: Lactated Ringer's solution is typically used.
  - **Administration**:
    - Half of the total calculated fluid volume is administered within the first 8 hours after the burn injury.
    - The remaining half is given over the subsequent 16 hours.
  - 5,600 mL is given in the first 8 hours.
  - 5,600 mL is given over the next 16 hours.

2. Modified Brooke Formula: The Modified Brooke formula offers an alternative approach, typically resulting in a lower fluid requirement compared to the Parkland formula. It is particularly useful for cases where over-resuscitation with the Parkland formula is a concern.

3. Other Formulas and Adjustments: While the Parkland and Modified Brooke formulas are most common, other formulas and adjustments may be used based on patient needs and clinical judgment:

- **Consensus Formula**: Some protocols use formulas based on recent consensus or guidelines, adjusting fluid volumes based on the latest research.
- **Special Cases**: Adjustments are often made for patients with specific conditions such as high-voltage electrical injuries, significant inhalation injuries, or those with comorbidities.

4. Ongoing Adjustments

- **Monitoring and Titration**: Fluid resuscitation is not a static process. It is continuously adjusted based on patient response, including urine output, vital signs, and other indicators of fluid status and organ function.
- **Delayed Resuscitation**: If initial resuscitation is delayed, the formula's administration may need modification to "catch up" on fluid needs, often in consultation with a burn specialist.

Summary

Fluid formulas are crucial tools for managing burn patients, guiding the amount and rate of fluid resuscitation to prevent shock, maintain organ function, and avoid complications such as edema and organ failure. The Parkland and Modified Brooke formulas are foundational, but clinical practice often involves ongoing adjustments based on individual patient needs and responses.

Conclusion

The management of burn injuries has evolved significantly, driven by advances in prehospital care, improved fluid resuscitation protocols, and more accurate burn size estimation techniques. The comprehensive review of Helicopter Emergency Medical Service (HEMS) practices in Switzerland reveals a high standard of prehospital burn management, with consistent pain management and burn size assessment contributing to effective outcomes. In contrast, North American practices exhibit variability, with issues such as overtriage and inaccuracies in burn size estimation affecting patient management and resource allocation. The study highlights the critical role of updated Advanced Burn Life Support (ABLS) protocols in addressing these challenges. The refinement of fluid resuscitation formulas, including the Parkland and Modified Brooke formulas, aims to balance the need for adequate tissue perfusion with the risk of over-resuscitation. The use of technological advancements, such as computer-based imaging and telemedicine, is increasingly recognized as a means to enhance burn size estimation and triage accuracy. Furthermore, the investigation into air transport overtriage reveals that many patients with minor burns may not require air transport, suggesting the need for alternative transportation methods and improved communication between referring facilities and burn centers. The integration of telemedicine and digital tools offers promising solutions for optimizing initial burn care and reducing unnecessary transfers. In summary, ongoing advancements in burn care emphasize the importance of accurate burn assessment, evidence-based fluid resuscitation practices, and technological integration. These updates contribute to more effective management of burn injuries, improved patient outcomes, and more efficient use of resources. The continuous evolution of ABLS guidelines and the adoption of innovative practices are essential for enhancing burn care across diverse healthcare settings.

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التقدم في رعاية الطوارئ لحالات الحروق: استراتيجيات العلاج والنتائج

الملخص:

الخلفية :إدارة إصابات الحروق بشكل فعال أمر بالغ الأهمية لتحسين نتائج المرضى، ومع ذلك، لا تزال التحديات قائمة في الرعاية قبل المستشفى والتقييم الدقيق. تستعرض هذه المقالة التقدم في رعاية الحروق الطارئة، مع التركيز على إدارة الحروق قبل المستشفى من قبل خدمات الطوارئ الطبية بواسطة الطائرات المروحية (HEMS) في سويسرا والتداعيات على الممارسات في أمريكا الشمالية.

الهدف :استكشاف ومقارنة استراتيجيات رعاية الحروق، خاصة في بيئات ما قبل المستشفى والمستشفى الأولية، وتقييم التحديثات في بروتوكولات الإنعاش السوائل وتقنيات تقدير حجم الحرق.

الطرق :تشمل الدراسة مراجعة لبيانات HEMS من سويسرا على مدى عقد من الزمان، وتفحص الممارسات في أمريكا الشمالية، بما في ذلك معايير الإحالة واستراتيجيات النقل. كما يتم تضمين تحليل الدراسات الحديثة حول الإفراط في نقل المرضى عبر الطائرات المروحية والصيغ المحدثة للإنعاش السوائل، مثل صيغ باركلاند و.Modified Brooke

النتائج :تشير النتائج إلى درجة عالية من التناسق في تقدير حجم الحرق في سويسرا، على عكس النتائج المتباينة في أمريكا الشمالية حيث انتشار الإفراط في النقل وعدم دقة تقدير حجم الحرق. تم تحسين بروتوكولات الإنعاش السوائل لمعالجة هذه القضايا، مع تحديث إرشادات ABLS لتعكس التقدم في التكنولوجيا والممارسات المستندة إلى الأدلة.

الاستنتاج :الرعاية المحسنة قبل المستشفى وتقدير حجم الحرق بدقة أمران حاسمان لإدارة الحروق بشكل فعال. تؤكد الدراسة على أهمية تحديث إرشاداتABLS ، بما في ذلك صيغ الإنعاش السوائل المحسّنة ودمج التكنولوجيا، لتحسين النتائج وتقليل التدخلات غير الضرورية.

الكلمات المفتاحية :رعاية الحروق، إدارة ما قبل المستشفى، الإنعاش السوائل، تقدير حجم الحرق، تحديثاتABLS ، النقل الجوي، الإفراط في النقل.