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REVIEW ARTICLE

Approaches of emergency department to burns management: a systematic review

Saleh Emad Saleh Abuzaid[1*], Dahian Abdullah Dhuhayyan Aldahian[1], Abdulkarim Ibrahim Abdulkarim Algowaify[1]

ABSTRACT

Burn injuries in mass casualty incidents (MCIs) pose particular difficulties. Expert knowledge, specialized abilities, and prompt access to technical resources are all advantageous for burn management. There is a clear need to improve burn care competency, given the prevalence of burn MCIs worldwide and the considerable variations in current burn treatment practices. This study aimed to evaluate the approaches to burn management in the emergency department (ED). This was an updated systematic review that addressed research conducted between 2012 and 2023 regarding burn management strategies in emergency rooms. Studies were examined using the PubMed, Cochrane, Web of Science, and Google Scholar databases. The terms were employed in different combinations and included "approaches, guidelines, burn, management, emergency, and department." Furthermore, a review of original literature was conducted about methods to burn care in the ED. Publications in full text were used as the inclusion criterion. Out of the 85 articles that were acquired, only 9 were deemed suitable for inclusion. Every study was a retrospective study. Approximately 1,135,990 burn patients were included in the research population; 622 of these patients were children (0-15 years old) who had acute burns and were hospitalized within 24 hours of the injury. Burn patients require substantial continuous medical and psychological care. Approaches to burn management included first aid, immediate hospital management, fluid resuscitation, escharotomy, analgesia, surgery, and rehabilitation.

Introduction

Mass casualty occurrences [mass casualty incidents (MCIs)] resulting in burn injuries provide unique challenges [1]. At least 200,000 deaths are attributed to burn injuries each year, making them a major global public health problem in terms of morbidity, mortality, and disability [2]. Nonfatal burns are one of the leading causes of disability-adjusted life years loss in low- and middle-income nations [3]. Most people agreed that burn injuries are among the most excruciating ailments someone can have. In addition to the agony caused by the burn, treating a burn injury involves difficult procedures such as surgery, debridement, ongoing wound care, and physical and occupational therapy. Particularly complex, burn pain has several facets and often evolves due to the patient undergoing numerous operations and treatments that involve manipulating their excruciating burn sites [4].

Thermal or conventional burns are caused by the temperature gradient and duration of application to the skin. The bigger the temperature gradient and the longer this is applied, the greater the burn intensity or burn over a broader surface area. This type of burn is caused by exposure to steam, hot liquids, hot objects, and flames, the last two of which are sometimes referred to as scalds [5]. Chemical burns can also happen in an industrial environment when a material might accidentally leak and damage any body area because acid burns produce a coagulative necrosis rather than an alkali burn's liquefactive necrosis, which tends to penetrate deeper and damage more tissue, acid burns are typically less severe than alkali burns [6].

High voltages typically cause electrical burns, which might or might not have any apparent injuries. Since the energy would follow the path of least resistance to Earth, it might do significant injury as it passes through the body [7].

Exposure to ionizing or electromagnetic radiation can result in radiation burns. The most prevalent example of

Correspondence to: Saleh Emad Saleh Abuzaid
*Emergency Consultant, Prince Sultan Military Medical City, Riyadh, Saudi Arabia.
Email: Dr.s.abuzaid@gmail.com
Full list of author information is available at the end of this article.
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the form is "sunburn," which is often superficial while being widely distributed. Although they are less common, ionizing radiation burns can still harm those working in the nuclear sector and patients repeatedly or continuously exposed to therapeutic radiation for medical purposes [7].

The management of burn injuries necessitates specialized knowledge, expertise, and prompt access to technical resources. Inadequate early decision-making in patient management and delayed (on-scene) patient treatment can have a substantial influence on medical institutions' capacity to offer high-quality burn care as well as patient outcomes [8]. Multiple burn injury patients in MCIs have illustrated the heavy burden on local healthcare facilities and medical staff and the high rates of morbidity and mortality that follow. The need to improve burn care capability is obvious, given the prevalence of burn MCIs worldwide and the significant regional variations in current burn care capacity [9].

Several studies addressed the insufficiency of burn pain therapy even though pain management is recognized as critical to the healing process following burn injuries. Moreover, there has been ample documentation of inconsistencies in practice standards for nearly 30 years [10-12]. Thus, this systematic review aimed to evaluate the approaches to burns management in the emergency department (ED).

Subjects and Methods

Search strategy

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist standards for systematic reviews and meta-analyses are followed by this systematic review [13]. The Cochrane, PubMed, Web of Science, and Google Scholar databases were searched. The research was released in publications from 2012 to 2023. Several keywords, such as "approaches, guidelines, burn, management, emergency, and department," were included throughout the search process. Furthermore, all related articles were compiled using the related keywords. All the titles were revised as a consequence of this preliminary investigation.

Eligibility criteria

After examining the titles related to methods of burn management in the ED before 2012, only publications that concentrated on these techniques were eliminated. Following an evaluation of the abstracts of the remaining publications, the second phase entailed the selection of solely original, English-language studies detailing methods for burn management in the ED. However, case reports, editor letters, and review articles were not included. Original English-language publications analyzing and assessing strategies for burn care in emergency rooms were added in the last phase. These articles underwent

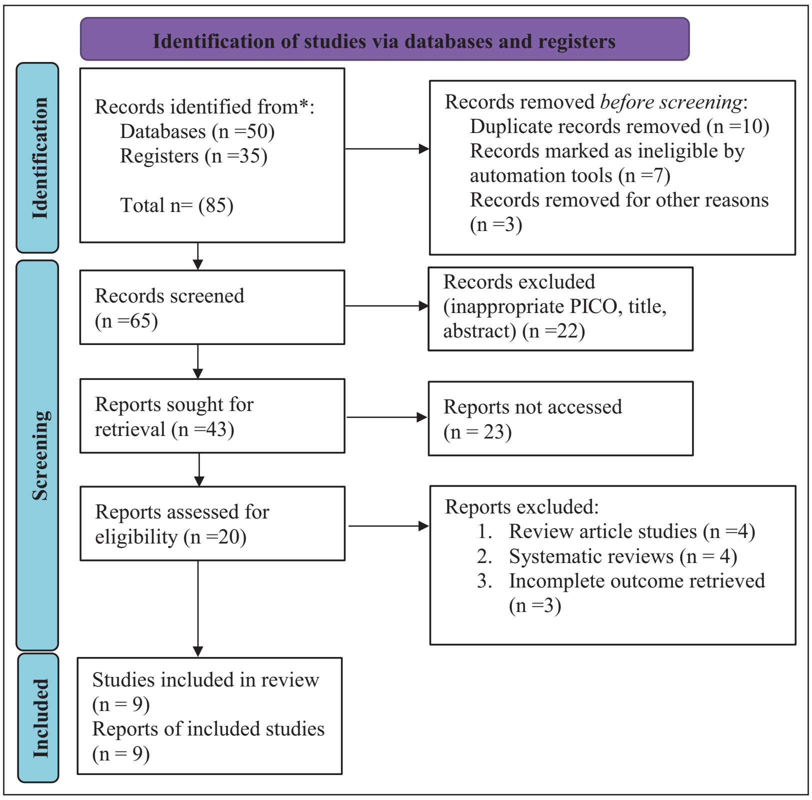

Figure 1. *Planning of eligible criteria.*

additional scrutiny to eliminate duplicates, articles without full text, and articles with inadequate material, such as data that overlapped or was partial (Figure 1).

Data reviewing and analysis

The full texts and abstracts of the papers were evaluated to extract the relevant data and transfer it to a premade Excel sheet. The selected data were then modified in the Excel document and merged to create a summary that would make data analysis easier.

Bias risk assessment

The "risk of bias" approach for Cochrane reviews was used to assess the risk of bias in randomized controlled trials. It was believed that these measurements were biased and susceptible to confounding effects even if they were not performed, as there is controversy over their appropriate application in observational research. Every reviewer assessed every study on their own. Any differences of opinion were settled by consensus or by talking to the third author (RHGM).

Measurements of treatment effect

Two distinct techniques were used to measure the impact of the intervention. For trials that assessed the effects of the myelomeningocele intervention alone, a proportional meta-analysis was carried out using StatsDirect (StatsDirect Ltd., Birkenhead, Merseyside, UK) software, version 3.0.121. Dichotomous outcome data, which were given as a proportion with matching 95% confidence intervals, were summarized using forest plots.

Results

Nine papers [14-22] met the inclusion criteria for this systematic review (Table 1).

Publications from 2012 [20], 2014 [18,19], 2015 [17], 2016 [15,16], 2019 [22], 2021 [21], and 2023 [14] were included. All the studies [14-22] were retrospective studies. The study population consisted of 1,135,990 burn patients, 622 of them were children aged 0-15 years who were hospitalized within 24 hours following the burn incident due to severe burns.

Two studies [15,19] investigated the intubations of patients transferred to burn centers by air or ground ambulance, while one study [14] sought to determine the burn etiology, demographics, clinical characteristics, and results in patients needing treatment in a regional burn unit. In addition, research [16] examined the first wound treatment, pain relief, and cooling of burn patients in youngsters. A national study [17] sought to generate estimates of the number of burns treated in EDs; another [18] described the frequency and features of difficult intubation in patients with facial and neck burns; a study [20] examined whether bronchoscopy revealed an inhalation injury in intubated patients and whether intubation was required. Furthermore, a study [21] investigated the degree to which burn patients were referred and admitted to a hospital, with or without a burn center, by the Emergency Management of Severe Burns Course (EMSB) referral criteria. A study [22] examined the results for burn patients, alterations in intensive care unit (ICU) indication, and the impact of a shifting case mix.

In terms of the types of burns, research [14] found that the majority of burns were produced by thermal causes, accounting for 94.6% of burn cases. However, according to another study [17], more than 60% of burns were caused by scalds and thermal burns. A high ABSI score, substantial full-thickness burns, burns affecting the arms, inhalation injuries, and the need for mechanical ventilation are significant risk factors for mortality. Based on the results, patients with severe burns might have a better prognosis if protein, creatine kinase, and leukocyte levels are quickly adjusted [14].

According to a study, 1,132,000 nonfatal occupational burns were treated in EDs [17]. During the 10 years, burn rates and numbers decreased by about 40%. Men and workers between 15 and 24 had the most significant rates in 2008. The industries with the highest number of burns were manufacturing, construction, lodging, and food service [17].

There was no discernible difference in ventilator days, length of stay (LOS), or percent TBSA between the groups. One patient brought for airway observation needed to be intubated, and another patient's postoperative extubation attempt failed. Before performing an intubation, patients receiving home oxygen therapy who might have suffered an inhalation injury should ideally be watched for indications of airway compromise [20].

Patients who were sent to a nonburn center frequently met the requirements. Almost 25% of those who met the requirements were not sent to a burn center. Patients with chemical and electrical burns can progress most toward their unique goals [21].

The total mortality rate decreased to 7% in one study. Burn mortality significantly decreased by 15%. In the main burn group, there was a 36% drop. There was an increase of 21% in the alert waiting group and 9% in the inhalation injury. The proportion of ventilated patients rose by 14% in the main burn group. Forty percent of patients in the careful waiting group required ventilation [22].

Both older age and a higher percentage of TBSA burn were shown to be independently correlated with intubation that lasted longer than 2 days. There were no re-intubations in patients who were intubated for 2 days or less. In the burn community, early intubation before transfer is highly recommended for patients who have face burns, inhalation injuries, or severe burns. However, this has resulted in many potentially needless intubations, putting patients at risk for consequences, while many burn patients benefit significantly from early intubation, standards should be established to identify when intubation is unnecessary [15]. Patients in air ambulances often had lower Glasgow Coma scores, were older, had

Table 1. *List of included articles.*

Author and publication year	Study design	Population, sample size, and characterization	Main points	Results and main findings
Niculae et al. (2023) [14]	Retrospective observational study of 2021	Ninety-three burned patients in our study were divided into two groups: the live patients' group (63.4%) and the deceased patients' group (36.6%).	To better understand the burn etiology, demographics, clinical traits, and outcomes in patients needing care at a local burn unit.	Most burns were caused by heat factors, accounting for 94.6% of accidents. Significant risk factors for death include extensive full-thickness burns, burns that impact the arms, inhalation injuries, the requirement for mechanical ventilation, and a high Abbreviated Burn Severity Index (ABSI) score. The prognosis of severe burn patients may be improved if protein, creatine kinase, and leukocyte levels are promptly corrected, according to the findings.
Romanowski et al. (2016) [15]	A retrospective review of all adults intubated before burn transfer and survived discharge from August 2003 to June 2013.	A total of 416 patients with acute burns.	Intubations in patients transferred to burn centers.	Intubation over 2 days was independently associated with older age and a more significant percentage of total body surface area (TBSA) burns. There were no reintubations in intubated patients for 2 days or less. In the burn community, we have stressed the importance of early intubation before transporting patients with severe burns, inhalation injuries, or facial burns. Regretfully, this has resulted in many potentially needless intubations, putting patients at risk for problems, while many burn patients benefit significantly from early intubation, standards should be established to identify when intubation is unnecessary.
Baartmans et al. (2016) [16]	Retrospective study	Sixty-two children aged between 0 and 15 who had acute burns and were formally sent to one of the three Dutch burn clinics within 24 hours of the burn occurred were eligible.	Cooling, wound care, and pain management	Are children's three early burn care strategies. Over 90% of the children had been cooled before admission. Both wound covering (from 64%) and pain therapy (from 68%) increased dramatically over time. Predominantly, paracetamol and morphine were used. Referrals from ambulance services or general practitioners were independent solid predictors for not receiving preburn center pain medication. On the other hand, flame burns and more extensive burns were independent predictors of receiving pain medication.
Reichard et al. (2015) [17]	Retrospective study	1,132,000 cases were reviewed by the National Electronic Injury Surveillance System - Occupational Supplement to produce national estimates of burns treated in EDs from 1999 to 2008	To make national estimates of burns treated in EDs	One million one hundred thirty-two thousand nonfatal occupational burns treated in EDs. Burn numbers and rates declined approximately 40% over the 10 years. In 2008, men and younger workers 15-24 years old had the highest rates. Scalds and thermal burns accounted for more than 60% of burns. Accommodation and food service, manufacturing, and construction industries had the most considerable burns.
Esnault et al. (2014) [18]	Retrospective study	We had 134 patients between January 2007 and December 2011	Describe the frequency and features of challenging intubation in face-and-neck burns (FNB) patients.	They enrolled 134 patients between January 2007 and December 2011. The rate of difficult intubation was 11.2%; however, it was higher in the burn center than in the preburn center (16.9% vs. 3.5%, $p = 0.02$).

Continued

Author and publication year	Study design	Population, sample size, and characterization	Main points	Results and main findings
Ahmed et al. (2014) [19]	Retrospective study	Two hundred fifty-nine air and 590 ground ambulance patients met the inclusion criteria.	To describe the state of intubation for patients being flown or driven by ground ambulance to a burn center in a rural	Patients receiving air ambulances tended to be older, had greater TBSA burned, shorter hospital stays, lower Glasgow Coma scores, and more frequent inhalation injuries. Of the patients who arrived by air, about 10% required intubation after being admitted to a burn center, and 49% were extubated within a day of admission. The corresponding numbers for patients transferred by ground were 2% and 40%. The chance of an intubation status change was higher in cases of advanced age and air ambulance transportation. The likelihood of intubation by burn center providers increased with age, with suspicion of inhalation injury, and for patients transported by air. The likelihood of extubation within 24 hours of burn center admission increased with age, decreased with suspected inhalation injury, and was independent of transport mode.
Amani et al. (2012) [20]	Retrospective study	Retrospective reviews of all patients (*n* = 86) who had burns while receiving home oxygen therapy were conducted between May 2000 and 2010. There were 86 patients total (mean age 64 years, mean %TBSA 2.6). Fifty-two patients (61%) were not intubated before transfer to the burn unit, while 32 patients (37%) were. Bronchoscopy confirmed inhalation damage in 12 (39%).	Of the 32 intubated patients. to ascertain whether bronchoscopy revealed inhalation damage in intubated patients and whether intubation was required.	No difference between the groupings was observed in ventilator days, LOS, or %TBSA. Intubation was necessary for one patient who was admitted for airway surveillance, while postoperative extubation failed for another. Before performing an intubation, patients receiving home oxygen therapy who may have suffered an inhalation injury should preferably be watched for indications of airway compromise.
Van Yperen et al. (2021) [21]	A retrospective, multicenter cohort study.	A total of 1,790 burn patients were included	To ascertain the degree to which burn patients were referred and admitted to a hospital, with or without a burn center, by the EMSB referral criteria.	Patients presenting to a nonburn center generally adhered to the referral criteria with reasonable consistency. Almost 25% of those who met the requirements were not sent to a burn center. Patients with chemical and electrical burns can make the most significant progress toward meeting particular requirements.
Gigengack et al. (2019) [22]	A study was conducted retrospectively on ICU patients	From 1987 to 2016. significant burns (≥15% TBSA), inhalation injury with mild injury (<15% TBSA, inhalation injury), watchful waiting (<15% TBSA, without inhalation injury), and tender loving care (patients withheld from treatment).	The study aimed to analyze burn patient outcomes; investigate variations in ICU indication; and investigate the impact of a shifting case.	Mortality overall dropped to 7%. There was a 15% reduction in significant burn mortality. The primary burn group saw a 36% decline. By 9% and 21%, respectively, the inhalation injury and the cautious waiting group grew. In the significant burn category, the proportion of ventilated patients rose by 14%. 40% of patients were circulated in the watchful waiting group.

longer stays in the hospital, had more inhalation injuries, and had more body surface area burned overall. After being admitted to a burn center, 10% patients who came by air were intubated, and 49% were extubated within 24 hours of admission. For patients moved by ground, the equivalent figures were 2% and 40%. In situations of increasing age and air ambulance transport, there was a larger likelihood of a change in the status of intubation. Patients who were older, thought to have had an inhalation injury, or were being flown were more likely to require intubation by burn center providers. Extubation occurred more frequently in elderly patients within 24 hours of admission to a burn center, less frequently in patients with suspected inhalation injuries, and was not impacted by the route of transportation [19].

More than 11.2% of fine needle biopsy patients had a high frequency of difficult intubation, indicating that intubation is more challenging at burn centers. This is likely because the procedure is carried out later, which allows for the development of cervical and laryngeal edema [18].

More than 90% of the pediatric patients had been cooled before their entrance. The percentage of patients receiving pain treatment (from 68% to 79%) and wound covering (from 64% to 89%) rose over time. Most commonly, morphine and paracetamol were utilized. One of the most reliable independent indicators that someone would not receive preburn center pain medication was a referral from an ambulance service or a general practitioner. However, more severe burns and flame burns were independent predictors of the need for painkillers [16].

Discussion

All across the world, burns are a prevalent form of trauma. According to estimates from the World Health Organization (WHO), 180,000 people globally die from burns each year, and 11 million people worldwide have burns that require medical treatment. According to the WHO, burns represent the greatest burden of morbidity, encompassing rejection, ugliness, shame, and disability [23]. Ninety percent of burns happen in low- and middle-income nations [24], where burn victims might not have easy access to specialized acute or long-term treatment. All across the world, the expense of treating burn patients is still quite high since they require several operations, critical care, long-term monitoring, and rehabilitation. To lessen the toll on society and the economy, the WHO seeks to prevent burns worldwide. The majority of burns happen in the home, and with burn education, first aid, and care programs, they might either be avoided or their effects can be controlled [23]. In the current systematic review, it was aimed to evaluate the approaches to burn management in the ED.

The current findings showed that the majority of burns were caused by thermal causes, with accidents accounting for 94.6% of burn cases. A high ABSI score, substantial full-thickness burns, burns affecting the arms, inhalation injuries, and the need for mechanical ventilation are significant risk factors for mortality. Patients sent to a nonburn center often adhered to the referral criteria. Almost 25% of those who met the requirements were not sent to a burn center. Patients with chemical and electrical burns can progress most toward their unique goals. More age and a higher percentage of TBSA burn were independently correlated with intubation lasting longer than 2 days. There were no re-intubations in intubated patients for 2 days or less, while many burn patients benefit significantly from early intubation, standards should be established to identify when intubation is unnecessary. Air ambulance patients tended to be older, have longer LOS, a higher incidence of inhalation injuries, a higher TBSA burned, and lower Glasgow Coma scores. Providers at burn centers were more likely to intubate patients if they were older, suspected of having an inhalation injury, or were being flown. More than 90% of the pediatric patients had been cooled before their entrance. The percentage of patients receiving pain treatment (from 68% to 79%) and wound covering (from 64% to 89%) rose over time. Most commonly, morphine and paracetamol were utilized for pain management.

The socioeconomic and gender contexts in which burns occur are different. Across the globe, burn injuries occur more frequently in the home among women and children than in the workplace or during outdoor leisure activities. Worldwide, only 5% of burns are caused by abuse, intentional self-burning, or malevolent actions; the majority are unintentional [25].

Burns are severe wounds that are typically brought on by heat-related incidents, although they can also happen from exposure to chemicals, electricity, or radiation. It is also crucial to remember that burns and some dermatological disorders known as "skin failure" manifest and are treated similarly. Because of the increased capillary permeability in the damaged region, large molecules such as albumin might exit circulation. This resulted in a significant loss of fluid, especially if a significant surface area was affected. Large molecule escape exacerbates this fluid loss by producing an oncotic gradient that favors the tissues, which causes additional fluid to escape the circulation. Left untreated, this leads to significant dehydration and cardiovascular collapse [26].

In more extensive burns, systemic effects are brought about by the widespread release of histamine and other inflammatory mediators. This can result in cardiac dysfunction and pulmonary edema by increasing capillary permeability throughout the body. Significant endogenous steroid and catecholamine release results in elevated cardiovascular strain and important catabolism, both harmful to the burn's continued healing. The inability of the skin to control body temperature can lead to severe hypothermia, which exacerbates the weakened immune system caused by high endogenous steroid levels and the breakdown of the pathological barrier. As a result, burn patients are more likely to develop sepsis [27].

To minimize thermal damage, stopping the burning process is the most important step. This entails using tepid water, preferably at 15°C, to cool the burn for at least 20 minutes. By doing these steps, the burn's final size and depth might be decreased. Burned regions can be wrapped while being transported to the hospital to reduce pain and stop further fluid loss. One of the greatest ways to accomplish this is with cling film, which is practically pathogen-free and easily accessible. Immediate hospital administration, the receiving hospital would have been alerted to the impending arrival of a patient with severe burns and would have had enough time to arrange a suitable team, which includes burn specialists and trained airway staff [28]. The ambient temperature of the patient's room should be increased to reduce heat loss. Upon arrival at the ED, burn patients should be assessed, bearing in mind that the burn might not have occurred in isolation, and traumatic injuries might need to be managed [29].

Breathing might be compromised by inhalational injury, low consciousness level, the presence of systemic toxins, or circumferential thoracic burns preventing adequate ventilation. It is important to note that pulse oximetry is unreliable at picking up carbon monoxide poisoning as it cannot easily distinguish between oxyhemoglobin and carboxyhemoglobin; therefore, arterial blood gas analysis with co-oximetry and CO measurement should be undertaken [30].

While assessing circulation, remember that hypovolemia and shock are unlikely to be caused by the burn itself in the early stages. Instead, look for any concomitant traumatic hemorrhage. access should be secured (this can be through burnt tissue if no other appropriate sites are available), and fluid resuscitation should be started. Limbs should be assessed for circumferential burns causing ischemia [31].

The Glasgow Coma Scale score and pupillary size and response should be assessed as part of the overall trauma assessment. A burn history should be sought, and its size and depth should be evaluated. Any jewelry should be removed as it might cause limb compromise when swelling occurs. To avoid hypothermia, the patient has to be covered with a warming blanket when the assessment is complete [32].

The significant fluid shifts and loss following a burn lead to reduced intravascular volume, requiring fluid resuscitation. An ideal fluid has yet to be found for this. Still, Hartmann's solution or Ringer's lactate is most commonly used as it is the most physiological and avoids the complication of hyperchloraemia acidosis found with large volume infusion of 0.9% saline solutions. There are several formulae describing the amount of fluid to use, the most common of which is the Parkland formula, which states that 4 ml of fluid resuscitation fluid should be used per % burn per kilogram of body weight. Half of this volume is administered in the first 8 hours following the burn and the other half in the subsequent 16 hours [33].

It can be necessary to perform an escharotomy in the thoracic region to enable respiration or in the limbs if a tight burn eschar impairs the vascular supply. In either case, the burn eschar needs to be incised down to the level of healthy tissue. There is a significant risk of large blood loss through the burnt tissue, which might also be painful. It is advised to provide a general anesthetic before this procedure, except in emergencies [34].

Anyone who had a significant burn or is at risk for an airway burn must be urgently assessed by an anesthetist or an intensive care doctor. If the airway needs to be secured, then this should be done as soon as is safely possible by the most experienced person available. Ideally, the patient should be nasally intubated with the largest diameter endotracheal tube, which would pass. The nasal route is preferred as it provides some stability for the tube in the event of facial swelling. If it is only possible to intubate orally, then the tube is commonly secured to the jaw with wires [35].

Suxamethonium might be used within the first few hours of burn but is then contraindicated as its use would cause a significant rise in plasma potassium levels. A high index of suspicion is needed for subglottic injury and systemic toxicity. Careful ventilator management is necessary for the former to avoid further lung injury. In contrast, hyperbaric oxygen high inspired oxygen concentrations or cyanide antidotes are needed for the latter to treat severe carbon monoxide intoxication [36].

Partial-thickness burns can be excruciating, and analgesia is essential in initial burn management. This might include the induction of general anesthesia if there are most severe or extensive burns. A multimodal approach is advocated, and it should be noted that large amounts of opioid analgesia might be required. Longer-term burn patients are at risk of chronic pain and complex regional pain syndromes. They should be referred early to specialists in pain management [37].

In the UK, surgery is a specialism of plastic surgery. The early debridement and covering of burned tissue is the cornerstone of surgical intervention. The amount of the burn and the patient's stability would determine when this is accomplished, but it usually happens in the first 24-72 hours. There would probably be more excruciatingly painful journeys back to the operating room for dressing changes and the reconstruction of more intricate burns [38].

Following a significant burn, recovery is a drawn-out process that needs the assistance of numerous medical specialists, such as occupational therapists, dieticians, physiotherapists, and psychiatrists. Late problems such as infection, graft failure, or contractures might arise and necessitate early treatment. Long-term physical and psychological repercussions might also occur, including scarring and impairment [39].

Conclusion

Severe burns are a significant source of worldwide morbidity and mortality, the impact of which can be lessened by education, burn prevention programs, initial simple first aid, and specialist burns services. Thorough assessment to rule out other injuries and to ascertain the extent and depth of the burn is paramount and would guide therapy. Burns has a significant ongoing physical and psychological care need. Approaches to burn management included first aid, immediate hospital management, fluid resuscitation, escharotomy, analgesia, surgery, and rehabilitation.

List of Abbreviations

EMSB Emergency Management of Severe Burns Course
ICU Intensive care unit
LOS Length of stay

Conflict of interests

The authors declare that there is no conflict of interest regarding the publication of this article.

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Author details

Saleh Emad Saleh Abuzaid[1], Dahian Abdullah Dhuhayyan Aldahian[1], Abdulkarim Ibrahim Abdulkarim Algowaify[1]

1. Emergency Consultant, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

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