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Management of burns of over 80% of total body surface area: A comparative study

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ABSTRACT

The aim of this retrospective, comparative study was to analyse the management of extensive burns so as to decrease morbidity and mortality. Over 1987–1996, 24 people with burns >80% of total body surface area and >50% full-thickness burn were admitted to the burn unit of Anhui Medical University Hospital (group A); 30 similar admissions over 1997–2006 formed group B. No significant difference was found in age, male:female ratio, % total body surface or full-thickness burn area between the two groups. Severe shock developed in 19/24 cases in group A and 23/30 cases in group B, following inadequate fluid resuscitation, although group B received a higher mean resuscitation fluid volume during the first 24 h after burn. Early excision and grafting was performed for 8/24 people in group A and 23/30 in group B. Inhalation injury was seen in 18/24 cases in group A and 28/30 cases in group B. Prophylactic tracheotomy was undergone by 8/24 casualties in group A and 22/30 in group B. Mortality in group A was significantly higher than in group B (95.8% vs. 63.3%, $p < 0.05$) and survival was longer in group B. These results showed that refinements in burn shock resuscitation, and advances in early wound excision, skin grafting and respiratory management were associated with decreased morbidity and mortality after severe burn.

1. Introduction

It is well known that burn size and depth are the two most important risk factors influencing the survival and clinical outcome of a burned person. Burn size >80% of the total body surface area (TBSA) and full-thickness (FT) burn >50% are formidable surgical challenges because donor sites are inadequate for the required grafting procedures.

Hefei city is the capital of Anhui province in east China. The department of burns of the First Affiliated Hospital of Anhui Medical University, located in Hefei city and established in 1968, is the largest burn centre in the province. The centre has 44 beds for acute burns, including 7 burn intensive care unit beds for major burns, and serves a population of more than six million registered residents. The centre admits an estimated 700 burn victims per year and the number of cases of >30% TBSA burn is >100 per year. It has been well demonstrated that sepsis, inhalation injury and burn shock are the three leading causes of death in major burn [1,2]. Accordingly, the management of burn shock, wound and inhalation injury is of great significance for extensively burned people [3].

In our burn unit, 54 victims sustaining burns >80% TBSA and FT burn area >50% were admitted from January 1987 to December 2006. The mortality rate among severely burned people at our centre has decreased year by year since 1997, from 95.8% to 80% in 2001 and 45% in 2006. This has been associated with improvement of fluid resuscitation, introduction of early excision and microskin autograft, and the application of early prophylactic tracheotomy and mechanical ventilation. This study was undertaken to analyse management, morbidity and

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mortality in these cases of extensive burn, in order to refine the protocols for systemic treatment and wound care.

2. Materials and methods

2.1. Patients

In our unit, 54 people with burn size >80% TBSA and FT burn area >50% were admitted over the 20-year period from 1 January 1987 to 31 December 2006. These patients were divided into two groups on the basis of admission time; Group A comprised those admitted during 1987–1996, and Group B included those admitted during 1997–2006. Data on age, gender, cause of burn, admission time, area and depth of burn, burn indices (BI = 1/2 × %TBSA of second-degree burns + %TBSA of third-degree burns), fluid resuscitation, inhalation injury, burn-related surgery, cause of death and mortality rate were collected and compared.

2.2. Statistical analysis

Data were expressed as mean ± standard deviation. Chi-squared testing or Fisher's exact test compared qualitative variables and Student's *t*-test compared quantitative variables. Statistical significance was established as $p < 0.05$.

3. Results

3.1. Demographics in the two groups

In group A the average age was 32.83 ± 13.54 (range 16–54) years, and the male:female ratio was 1:0.09. The mean %TBSA burned and %FT burn area in group A were 91.73 ± 5.76% and 70.17 ± 13.93%, respectively. In group B the average age was 32.13 ± 6.95 (range 17–48) years, and the male:female ratio was 1:0.43. The mean %TBSA burned and %FT burn area in group B were 92.50 ± 4.24% and 75.63 ± 13.58%, respectively. The BIs in groups A and B were 80.98 ± 8.78 and 84.03 ± 8.47, respectively. No significant difference was found in age, male:female ratio, TBSA burned, FT burn area or BI between the two groups ($p > 0.05$), as shown in Table 1.

3.2. Causes of burn

In both groups flame was the most common cause of burn (61.1%), followed by explosion (24.1%) and scald (11.1%). When they were stratified by admission time, causes of burn hardly differed between the two groups (Table 2).

Table 2 – Causes of burn in the two groups

Group	Flame	Explosion	Scald	Chemical
A	14	6	3	1
B	19	7	3	1

3.3. Fluid resuscitation

The mean interval between burn and start of resuscitation in groups A and B was 4.57 ± 3.76 h and 2.78 ± 2.06 h, respectively. The difference was not statistically significant ($p = 0.054$). Because of delayed resuscitation, these severely burned people were prone to shock; 19 people (78.9%) in group A and 23 (83.3%) in group B received inadequate fluid resuscitation and developed hypotension and severe shock. Of these 42 only 8 survived, whereas 4 of the 12 casualties who did not have severe shock survived. The mortality rates with and without severe shock were 81.0% (34/42) and 66.7% (8/12), respectively; the difference was not significant ($p = 0.26$). Group B, in comparison with group A, had a significantly higher mean resuscitation fluid volume during the first 24 h after burn (2.16 ± 0.41 vs. 1.71 ± 0.42 ml/(kg %TBSA burned); $p < 0.05$) and a significantly higher mean urine output (82.68 ± 23.36 vs. 52.55 ± 27.12 ml/h; $p < 0.05$), as shown in Table 3.

3.4. Wound management

Early excision (within 1 week of injury) and grafting was undergone in 8 people in group A and 23 in group B. The early excision rate in group B was significantly higher than that in group A ($p < 0.01$). After 1994, excised large and deep wounds were covered with microskin autograft (the expansion ratio of the recipient site to the donor area can reach 15:1). The mean time from burn to first surgical management in group B was 3.82 ± 1.72 days, significantly less than that in group A (5.87 ± 1.46 days; $p < 0.01$). The total numbers of excisions with grafting in groups A and B were 14 and 24, respectively. In group A, six people underwent a second excision and grafting at a mean 4.8 days after the first excision; only one case in group B required second excision and grafting, 3 days after the first excision. In no case was a third excision necessary.

Table 1 – Demographics of the two groups

Group and *p*-value	Number of patients	Date	Males: females	Age (years) Range	Age (years) Mean ± S.D.	%TBSA burned	FT burn (%)	BI
A	24	1987–1996	22:2	16–54	32.83 ± 13.54	91.73 ± 5.76	70.17 ± 13.93	80.98 ± 8.78
B	30	1997–2006	21:9	17–48	32.13 ± 6.95	92.50 ± 4.24	75.63 ± 13.58	84.03 ± 8.47
p	N/A	N/A	0.087	N/A	0.807	0.574	0.152	0.201

S.D., standard deviation; TBSA, total body surface area; FT, full-thickness; BI, burn index.

Table 3 – Fluid resuscitation in the two groups

Group and p-value	Severe shock		Volume during first 24 h after burn (ml/(kg %TBSA burned))	Urine output during first 24 h after burn (ml/h)
	Numbers	%		
A	19	78.9	1.71 ± 0.42	52.55 ± 27.12
B	23	83.3	2.16 ± 0.41	82.68 ± 23.36
p	N/A	0.77	0.01	0.01

TBSA, total body surface area.

3.5. *Inhalation injury and management*

In all cases, inhalation injury was confirmed by clinical signs such as early hypoxia (PaO_2 <60 mmHg on room air), tachypnoea (respiratory rate >30 min^{-1}) and hypercapnoea ($PaCO_2$ >45 mmHg), etc., and/or findings of fibre-optic bronchoscopy including airway oedema, mucosal inflammation and necrosis, ulceration of the infraglottic airway and soot and charring in the airway. Groups A and B included 18 (70.83%) and 28 (93.33%) people with inhalation injury, respectively. Tracheotomies were classified according to time of operation as prophylactic (undertaken before the development of dyspnoea) or emergent (undertaken on the development of dyspnoea or later). In our study, emergency tracheotomy was performed immediately on the following indications: upper-airway stridor, hoarseness and irritation, dyspnoea, tachypnoea (respiratory rate >30 min^{-1}), PaO_2 <70 mmHg under oxygen and SaO_2 <95%. Prophylactic tracheotomy was adopted if a potential threat to the respiratory tract was present and dyspnoea appeared likely. In group A, tracheotomy was performed in 16 cases (8 prophylactically and 8 emergent). In group B, tracheotomy was performed in 27 cases (22 prophylactically and 5 emergent). There was a significantly higher rate of emergency tracheotomy in group A; the ratios of prophylactic:emergency tracheotomy in groups A and B were 1:1 and 4.4:1, respectively ($p < 0.05$) as shown in Table 4.

3.6. *Mortality rate, survival time and causes of death*

One person in group A and two in group B were not actively treated because of poverty and lack of insurance. They were discharged 3–4 days after burn and all died. Overall, 23 victims in group A and 19 in group B died as a result of their injuries, translating into a mortality rate of 95.8% and 63.3%, respectively ($p < 0.05$). Among these, the mean survival time in group B was significantly longer than in group A (17.32 ± 13.18 days vs. 9.35 ± 11.59 days; $p < 0.05$). Sepsis, diagnosed by positive blood culture, was the most common cause of death, accounting for 52% of deaths in group A and 40% of deaths in group B. The next most causes were multiple-organ dysfunction syndrome (MODS; 30% in group A and 35% in group B) and shock (9% in group A and 10% in group B), as illustrated in Fig. 1. Two people in each group died of renal failure; because of the lack of a continuous veno-venous haemofiltration machine at our centre, none received dialysis.

4. Discussion

Major burn is a serious public health problem, and the treatment of people with severe burns exceeding 80% TBSA remains a big challenge. The problem is even more serious in developing countries such as China, because of poverty; Anhui province, where this study was conducted, is relatively poor area in China. Nevertheless, advances in the care of people with major burns have led to improved survival.

If left untreated, cutaneous thermal injury >33% TBSA invariably results in severe and unique derangement of cardiovascular function called burn shock [4]. Hypotension is a feature of severe shock [5] but, in China, most such cases are not treated with acute full fluid replacement before admission. This is usually because few people know first aid for burns and also transport and traffic conditions are difficult in poor areas such as Anhui province. In our study, 42 burn victims were in severe shock on admission because of long-distance transfer and inadequate fluid resuscitation. However, the mean time from burn to fluid resuscitation was less in group B than group A, which might be attributed to increasing economic development and traffic improvement in China. Burn shock can be rapidly fatal or, if the casualty survives the shock period, can lead to increased incidence of MODS and sepsis due to ischaemic and hypoxic changes in vital organs [6]. Therefore, early, rapid and sufficient fluid resuscitation in the first 24 h after burn is needed to correct burn shock and maintain stable blood circulation. Because our sample size

Table 4 – Inhalation injury and tracheotomies in the two groups

Group and p-value	Inhalation injury		Tracheotomies			
	Patient numbers	%	Patient numbers	Prophylactic	Emergency	Prophylactic: emergent
A	18	70.83	16	8	8	1:1
B	28	90.33	27	22	5	4.4:1
p	N/A	0.12	N/A	N/A	N/A	0.043

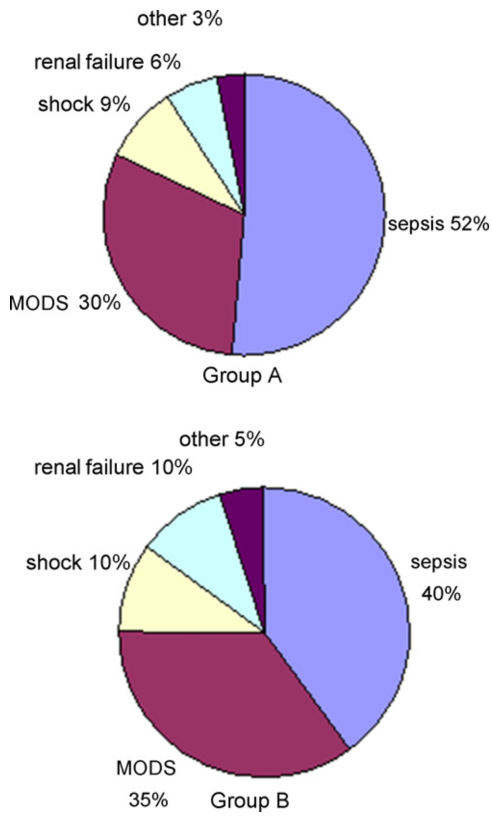

Fig. 1 – Causes of death in the two groups. MODS, multiorgan dysfunction syndrome.

was limited, the difference in mortality rate between burn victims with severe shock and those without was not statistically significant.

All patients were resuscitated with Ringer's lactated fluid and plasma according to the Chinese formula, that is 1.5 ml/(kg %TBSA burn) of crystalloids and colloids plus 2500 ml water during the first 24 h after burn, modified according to the response of the individual patient. In our hospital, before 1997 fluid replacement rates were adjusted according to physiological end points, such as urine output, heart and respiratory rates and so on. However, non-invasive indices only assessed the adequacy of fluid resuscitation and could not reflect the haemodynamic parameters when large volumes of resuscitation fluid were infused in these severe cases. After 1997 invasive monitoring, e.g. of central venous pressure, was introduced to monitor fluid resuscitation, and group B achieved a higher mean resuscitation fluid volume and a higher mean urine output than group A during the first 24 h after burn. There are many other factors such as burn depth, presence of inhalation injury, associated injuries, age, delay in resuscitation and use of drugs that can influence fluid requirements during resuscitation [7], and any fluid resuscitation formula is only a guideline and not a guarantee of adequate resuscitation [8]. We believe that haemodynamic data derived from invasive techniques are helpful both in ascertaining cardiovascular performance and end points of resuscitation, and in therapy when non-invasive monitoring seems inadequate.

Sepsis and MODS were two leading causes of death in our series. The management of wounds, from which infections always originate, is most important. Early excision with grafting is another key step in survival, involving removal of necrotic burned tissue and preservation of as much underlying viable tissue as possible. This treatment not only decreases release of inflammatory mediators but also reduces bacterial colonisation of wounds, alleviating the systemic inflammatory response syndrome (SIRS) and reducing the occurrence of sepsis and MODS [4]. The problem of how limited donor-site skin can be used to cover large surface wounds in cases with burn size over 80% TBSA and FT burn over 50% is a big challenge. In developing countries such as China, cultured epidermal autograft or Integra™ is unavailable. In our hospital, microskin autograft was introduced in 1997. In this method, donor autogenous skin for grafting is minced into tiny particles and covered with large sheet of cryopreserved allograft. The expansion ratio of the recipient site to the donor area can reach 15:1 and the wound can be completely resurfaced in 45 days, even in major burns [9,10]. In this way, the initial excision of large, deep wounds can be performed within 1 week of injury and the area of first excision can reach 60%. Microskin grafting has become one of the most important methods used in China for the treatment of extensive burns with limited areas of healthyskin [11].

Inhalation injury is a major source of morbidity and mortality in burn cases despite recent advances in critical care and wound management [12]; proper initial treatment of inhalation injury can favourably influence outcome [13]. In this study, 70.83% of burn victims in group A and 93.33% in group B had inhalation injury. We prefer tracheotomy to endotracheal intubation to maintain the airway. Clearance of airway secretions and necrotic mucosa is also of great significance in preventing pulmonary infection [14] and is easier after tracheotomy than endotracheal intubation. Furthermore, these severely burned people need long-term management and prolonged respiratory support, for which endotracheal intubation is unsuitable. Another problem is the timing of tracheotomy for inhalation injury.Our approach strongly favoured prophylactic tracheotomy, which was performed when evidence of upper airway oedema was present or airway patency was threatened.

The rate of emergency tracheotomy was significantly higher in group A than in group B. If tracheotomy is performed when or after dyspnoea develops, hypoxia is severe and can lead to respiratory failure and subsequent MODS [14]. This was confirmed by the fact that the mortality rate was much higher among burn victims who had undergone emergency tracheotomy than among those who had had prophylactic tracheotomy [14]. People who required tracheotomy because of airway oedema or pulmonary dysfunction generally received positive pressure ventilation from a mechanical ventilator, which not only improves oxygen supply promptly and adequately but also increases the humidity of airway, which is of benefit in the prevention and management of pulmonary infection [14]. There was no ventilator in our centre before 1997, so this study lacks data on mechanical ventilation in the group A; how mechanical ventilation influences mortality remains to be studied.

Generally it is not difficult to diagnose inhalation injury, but the extent of the damage is often difficult to judge. Bronchoscopy is widely accepted as the investigation of choice as it has high sensitivity [15]. Fibre-optic bronchoscopy is very helpful in the diagnosis of inhalation injury, but there is no consensus on the indications for this procedure, which is invasive and time consuming and can lead to cardiac arrhythmia or arrest [16]. In our centre, bronchoscopy was only performed when oxygen saturation remained <95% after tracheotomy and oxygen inhalation. In such cases, fibre-optic bronchoscopy is very useful for detailed examination of the airway and to clear inspissated secretions or/and exudative membrane mucosa.

In conclusion, these results showed that the following methods were associated with decreasing morbidity and mortality among people with burn size >80% TBSA and FT burn >50%: prompt, rapid and adequate fluid resuscitation; early excision and grafting, using microskin autograft for larger deep wounds; and prophylactic tracheotomy with mechanical ventilation in cases with upper airway oedema or compromised airway patency.

Conflict of interest

None declared.

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