Differences in the Outcomes and Treatments of Extensively Burned Patients between a Chinese Hospital and a Japanese Hospital

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To know the therapeutic level at one’s own institute is important and contributes to improving the treatment of patients. We compared the outcomes of extensively burned patients between a Chinese hospital and a Japanese hospital in order to identify the differences in the clinical treatment of severe burn patients. Thirty-four burn patients who were admitted to the National Defense Medical College Hospital (NDMC) in Japan and 95 burn patients who were admitted to the Shanghai Hospital of the Second Military Medical University (SMMU) in China from January 1999 to December 2003 were studied. All patients were transported to the respective hospitals within 3 days after suffering burns and their total body surface area of burns was greater than 20%. Fourteen of the 34 patients (41.2%) at NDMC hospital and 1 of the 95 patients (1.1%) at SMMU hospital were injured by attempted suicide; namely, the suicide rate was significantly higher in the patients at NDMC hospital (p < 0.001). Moreover, the age (p = 0.005) and inhalation rate (p = 0.013) were significantly higher at NDMC hospital than those at SMMU hospital. Consequently, the survival rate at SMMU was higher than at NDMC in the patients with a burn surface area of greater than 80% or with a burn index of greater than 60. The excellent outcomes of the extensively burned patients at SMMU were in part due to the fact that Chinese doctors tend to perform an immediate tracheostomy and a traditional Chinese operation with alloskin, called microskin grafting or intermingled skin grafting.

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world and then compare their results with those at leading burn centers. However, articles describing the mortality of extensively burned patients at local hospitals have seldom been reported. Hence, it is difficult for us to find out the mortalities of extensively burned patients at different hospitals besides our own institute and to thereby improve the therapeutic level of treatment for severe burn cases at own institute. To clarify the therapeutic level of treatment at one’s own institute is intrinsically important, and to obtain information on the outcomes in different hospitals besides one’s own institute can greatly help us to improve the treatment of such patients, as well as improving the systemic environment.

In Japan there are very few large scale burn centers, and the number of extensively burned patients with over a 20% total body surface area (%TBSA) at each Japanese hospital is pretty small, e.g. the number of patients at our hospital, the National Defense Medical College (NDMC) hospital, is below 10 per a year. As a result, we consider it appropriate that Japanese hospitals should evaluate their own therapeutic level regarding the treatment of major burns. Moreover, it is noteworthy that we also clarify the international therapeutic level for extensively burned patients. In the Second Military Medical University of China, the survival rate of major burn patients with a TBSA of over 70% was excellent, namely approximately 40%, from 1989 to 1996 (Liu et al. 1998). We therefore tried to compare the outcomes of extensively burned patients between the NDMC hospital of Japan and the Changhai Hospital of the Second Military Medical University (SMMU) of China. We hypothesized that in making such a comparison we might be able to improve the outcomes of extensively burned patients by evaluating the difference in the clinical treatments between the two hospitals.

The aim of this study was to compare the outcomes of extensively burned patients between a Chinese hospital and a Japanese hospital, and to elucidate any differences in the clinical treatment of severe burns between both countries.

METHODS

Patients and methods

Thirty-four burn patients who were admitted to the Department of Traumatology and Critical Care Medicine of NDMC hospital in Japan and 95 burn patients who were admitted to the Burn Center of Changhai Hospital of SMMU in China, i.e., a total of 129 patients, were included in this study. These patients were admitted to the above hospitals within 3 days of suffering burns from January 1, 1999 to December 31, 2003 and their total body surface areas were all greater than 20%. All patients were between 0 and 81 years of age (mean ± s.d., 35 ± 21). Flames caused 87 of 129 injuries, and scalding caused 42 injuries. The total body surface area (TBSA) of the burned patients ranged from 20-100% with a mean of 45%, and the burn index (BI) of these patients ranged from 10-100 with a mean of 31. The BI was calculated for each patient as follows: BI = 1/2 × TBSA of deep partial-thickness burn + TBSA of full thickness burn. Forty-eight of the 129 patients were complicated by inhalation injuries. The outcome was assessed at the period of each patient’s discharge from the hospital. Although 17 patients eventually died, 4 of the 8 deceased patients at NDMC hospital and 7 of the 9 deceased patients at Changhai Hospital of SMMU were hospitalized for longer than 7 days. For the surviving patients, the average hospital stay at NDMC was 79 days (min 8 - max 277), while the same stay at SMMU was 46 days (min 8 - max 154). We investigated the characteristics of the patients at each hospital, and compared the survival rate between two hospitals based on the burn surface area or the BI. The outcomes of the patients at the two hospitals were also analyzed using a multivariate analysis. Moreover, we examined the complications during the hospital stay in each patient and the death causes of the deceased patients, and also compared the morbidity rates of wound infection, pneumonia or septic shock between the two hospitals.

The basic treatment principals for extensively burned patients were almost the same in both hospitals. The clinical treatment at both hospitals was as follows. 1. Fluid resuscitation: Lactated ringer solution was used for the initial resuscitation, and the infusion rate was determined by the Parkland Formula (Moyer et al. 1965) based on the extent of burn and body weight. Infants and young children received fluid with 5% dextrose at a maintenance rate in addition to the resuscitation fluid of Ringer’s Lactate 3 - 4 ml/kg/ %burn/day. 2. Assessment of urine output: We inserted and kept the Foley catheter
in patients with a TBSA of greater than 20%. An adequate urine output was 0.5 - 1.0 ml/kg/hour in adults and 1.0 - 1.5 ml/kg/hr in a child less than 30 kg. 3. Airway management: Patients with carbon monoxide poisoning and/or inhalation injury immediately received humidified 100% oxygen by mask until the carboxyhemoglobin level was reduced to less than 10%. Endotracheal intubation or a tracheostomy was indicated in the airway obstruction or the respiratory dysfunction after resuscitation at the acute phase. 4. Escharotomies and Fasciotomies: These were required to permit normal ventilation and to maintain peripheral perfusion, particularly in patients with deep circumferential limb or truncal burns. 5. Wound care: Debridement and the application of topical antimicrobials was usually necessary for burn wound care. The full thickness burn area was basically treated by silver sulfadiazine cream once per a day. 6. Excision and grafting. We performed an early surgical excision and grafting as early as possible for the sake of diminishing the local and systemic infection and for maintaining the organ functions. The followings shows our standard procedure for the excision and grafting in extensively burned patients. Split thickness skin grafts were harvested from the scalp, anterior torso and thighs and the other non-injured skin area at a thickness of from 0.15 - 0.3 mm. The burned skin and eschar was excised and debrided down with a electrical, or surgical knife up to fresh bleeding tissue to prepare for the grafting. The harvested skin grafts were meshed to expand their surface area at a 1 : 3 ratio by putting them through a mesher machine or they were cut into the shape of a small stamp for surgical grafting. The meshed skin grafts or the stamp skin grafts were then positioned over the prepared wounds, and they were secured with staples and sutures if necessary. Although the above the treatment principals for severe burn patients were the same, there were some differences in the treatments between the two countries. We therefore herein describe and discuss the characteristics of the patients and any differences in the clinical treatments regarding both countries.

**Statistical analysis**

The age, burn surface area and BI in Table 1 were all expressed as the means ± s.d., and any differences between the two hospitals were analyzed using Student’s unpaired t-test. Any differences in gender, burn mechanisms (flame or scald), suicide, inhalation, wound infection, pneumonia and septic shock between the two hospitals were analyzed using the chi-square test with Yates’s continuity correction. Moreover, the relationship among the mortality and the following various factors were analyzed by a stepwise logistic regression analysis (Wald’s backward elimination method), using the mortality (dead: 0, survived: 1) as a criterion variate and the burn surface area, burn index, age, inhalation (no: 0, yes: 1), gender (male: 0, female: 1), burn mechanisms (scald: 0, flame: 1), burn induced by suicide (no: 0, yes: 1), country (Japan: 0, China: 1) as explanatory variates. A value of \( p < 0.05 \) was considered to indicate statistical significance. A logistic regression analysis was used to predict the outcome from a set of variables that may be continuous, dichotomous, or a mixture of any of these. The goal of a logistic regression is to correctly predict the category of outcome for individual cases using the most parsimoni-

<table>
<thead>
<tr>
<th></th>
<th>SMMU of China ((n = 95))</th>
<th>NDMC of Japan ((n = 34))</th>
<th>(p)</th>
</tr>
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<tbody>
<tr>
<td>Age</td>
<td>32 ± 19</td>
<td>44 ± 24</td>
<td>0.005</td>
</tr>
<tr>
<td>Gender (male : female)</td>
<td>77 : 18</td>
<td>22 : 12</td>
<td>0.062</td>
</tr>
<tr>
<td>Burn mechanisms (flame: scald)</td>
<td>60 : 35</td>
<td>27 : 7</td>
<td>0.092</td>
</tr>
<tr>
<td>Suicide rate (%)</td>
<td>1.1</td>
<td>41.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Burn surface area (%TBSA)</td>
<td>43 ± 25</td>
<td>50 ± 23</td>
<td>0.132</td>
</tr>
<tr>
<td>Burn index</td>
<td>29 ± 25</td>
<td>36 ± 24</td>
<td>0.132</td>
</tr>
<tr>
<td>Inhalation (%)</td>
<td>30.5</td>
<td>55.9</td>
<td>0.013</td>
</tr>
<tr>
<td>Survival rate (%)</td>
<td>90.5</td>
<td>76.5</td>
<td>0.072</td>
</tr>
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</table>

SMMU, Burn Center of Changhai Hospital of the Second Military Medical University in China; NDMC, Department of Traumatology and Critical Care Medicine of the National Defense Medical College Hospital in Japan.
A stepwise logistic regression analysis (Wald’s backward elimination method) is used in a variable selection in the principal component analysis. According to this procedure, variables are discarded among the existing variables in each step in such a way based on the Wald test, and based on the results we can identify any intrinsic relationships between the outcome and explanatory variates.

RESULTS

The characteristics of the extensively burned patients at each hospital are shown in Table 1. Fourteen of the 34 patients (41.2%) at NDMC hospital and 1 of the 95 patients (1.1%) at Changhai Hospital of SMMU were injured by attempted suicide. At NDMC hospital and at SMMU hospital the mean TBSA of the burned patients was 50% and 43%, the mean BI of these patients was 36 and 29, and the mean age of these patients was 44 and 32, respectively. The results of gender, burn mechanisms and inhalation rate at both hospitals are also shown in Table 1. The age ($p = 0.005$), suicide rate ($p < 0.001$) and inhalation rate ($p = 0.013$) were all significantly higher at NDMC hospital in Japan than at SMMU hospital in China. The gender, burn mechanisms, burn surface area and burn index between the two hospitals were not significantly different, and the survival rate between them was also not significantly different ($p = 0.072$).

Comparisons of the survival rate between the two hospitals are shown in Figs. 1 and 2 based on the burn surface area and the BI, respectively. The survival rate of SMMU was greater than that of NDMC based on the burn surface area, especially in patients with burns with a TBSA of greater than 80% in Fig. 1, and based on the burn index, especially with a BI of greater than 60 in Fig. 2. Moreover, the burn index and country significantly influenced the survival in extensively burned patients using the stepwise method of a logistic regression analysis, i.e., the survival rate at SMMU of China was significantly higher than that at NDMC of Japan according to the odds ratio and $p$ value in a multivariate analysis as shown in Table 2.

The causes of direct death at NDMC hospital were renal failure (2 cases), circulatory failure (3 cases) and sepsis & multiple organ failure (3 cases), and those at SMMU hospital were circulatory failure (2 cases) and sepsis & multiple organ failure (7 cases). Regarding the morbidity rates in the 34 patients of NDMC and the 95 patients of SMMU, wound infection was 58.8%, 41.1%, pneumonia 44.1%, 15.8%, and septic shock 11.8%, 7.4%, respectively. The morbidity rates

Fig. 1. Comparison of the survival rate based on the burn surface area between the two hospitals. The survival rate of the patients at SMMU hospital exceeded that of the patients at NDMC hospital based on the burn surface area, especially in patients with a TBSA of greater than 80%. We show the number (survivors/patients) which was used to calculate the survival rate on each column bar.
for wound infection or septic shock between two hospitals did not significantly differ, but those for pneumonia significantly differed ($p < 0.001$).

Regarding the therapy for extensively burned patients in Japan and China, we noticed two different points, i.e., one was the timing for performing a tracheostomy and the other one was the grafting procedure. At SMMU, a tracheostomy is routinely performed in the extensively burned patients with a TBSA of greater than 70% or in patients with severe inhalation injury as soon as possible. On the other hand, a tracheostomy is not routinely performed in the early phase of extensively burned patients in Japan, since intubation is preferred. Moreover, a traditional Chinese operation, called either microskin grafting or intermingled skin grafting, using alloskin is performed as the grafting method for extensively burned patient at SMMU hospital of China, while such operations are not performed at NDMC of Japan. In addition, the initial surgical excision and grafting ranged from day 0 - 27 with a median of day 6 at NDMC of Japan ($n = 21$), and that at SMMU of China ranged from day 2 - 49 with a mean of day 5 ($n = 53$). An operation performed within 48 hours after suffering burn injury (an immediate operation as defined by the Japanese Society for Burn Injuries) was performed in 6 of 21 patients (28.6%) at NDMC of Japan, and in 6 of 53 patients (11.3%) at SMMU of China. An early operation within 7 days after suffering burn injury was performed in 15 cases (71.4%) at NDMC, and in 39 cases (73.6%) at SMMU.

**DISCUSSION**

The statistics regarding burn mortality were reported in 1949 by Bull and Squire of Birmingham, England (Bull and Squire 1949), and later Bull and Fisher showed the approximate mortality probabilities for various combinations of age and body surface area (Bull and Fisher 1954). Using similar computations based on a

Table 2. A result of a stepwise logistic regression analysis

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<thead>
<tr>
<th>Explanatory variate</th>
<th>Odds ratio</th>
<th>95% confidence</th>
<th>$p$</th>
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<tbody>
<tr>
<td>Burn index</td>
<td>1.141</td>
<td>1.065 - 1.223</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Country</td>
<td>0.051</td>
<td>0.004 - 0.705</td>
<td>0.026</td>
</tr>
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Fig. 2. Comparison of the survival rate based on the burn index between the two hospitals.
The survival rate of the patients at SMMU hospital exceeded that of the patients at NDMC hospital based on the BI, especially in patients with a BI of greater than 60. We show the number (survivors/patients) which was used to calculate the survival rate on each column bar.
statistical analysis, two other investigators also made excellent reports on burn mortality (Barnes 1957; Pruitt et al. 1964), i.e., Barnes reported the mortality of 785 burn patients over a 15-year period at the Massachusetts General Hospital, while Pruitt et al. (1964) published a study of 1,100 burn patients treated at the Surgical Research Unit at the Brooke Medical Center from 1950 to 1960. These institutes were the leaders in clinical therapy for extensively burned patients in the world in those days, and the data on mortality at that time were important information which helped other treatment centers to improve their own mortality rates. Likewise, mortality studies at burn centers or data derived from reports of multiple institutes (Muramatsu et al. 1996; Kobayashi et al. 2005) are also useful for comparison purposes. Although we suppose that the therapeutic levels for major burns in Japan or China are comparatively high among most countries, we did not have sufficient information regarding the therapeutic levels of different burn centers.

It is noteworthy that the suicide rate of the patients was significantly higher at NDMC than at SMMU. It is hard for us to treat burn patients who attempt suicide because they occasionally refuse to cooperate with the physician or paramedical staff regarding the treatments, voluntary rehabilitation, eating moderately, and so on (Yanagawa et al. 2005). Hence, SMMU hospital has an advantage in relation to the patients’ background. The age and inhalation rates were also more favorable at SMMU than at NDMC. Moreover, the burn surface and burn index of NDMC also tended to be higher than those of SMMU. The burn magnitude also tended to be more severe at NDMC than at SMMU. As a result, the survival rate was lower at NDMC (76.5%) than at SMMU (90.5%). However, the survival rate of the patients with a TBSA of greater than 80% or a BI of greater than 60 was completely different between NDMC and SMMU as shown in Figs. 1 and 2. The survival rate of SMMU hospital clearly exceeded that of NDMC hospital for extremely severe burns. According to a report of 11 burn units of Tokyo city in Japan (Muramatsu et al. 1996), the survival rate of NDMC hospital was relatively good, i.e. the rate of NDMC hospital based on the burn index was higher than the average survival rate at the top-level 11 burn units in Tokyo, Japan. In addition, we showed that the difference of country (NDMC of Japan and SMMU of China) significantly influenced the outcome of extensively burned patients using Wald’s backward elimination method for the logistic regression analysis. As a result, such differences between the two burn centers seem to be due to differences in the treatments between SMMU and NDMC.

At Changhai hospital of China, a tracheostomy is routinely performed in extensively burned patients with a TBSA of greater than 70% or in patients with severe inhalation injury even if burn wounds are seen in the anterior cervical area. In Japan, a tracheostomy in burned patient is avoided if at all possible, because a tracheostomy located in an area of a cervical burn wound has the possibility developing inflammation, thus leading to the possible induction of pneumonitis. However, we suppose that an immediate tracheostomy is a good way to clearly maintain the airway, and the possibility of subsequent pneumonitis induced by tracheostomy is probably low. Our present data showing that the morbidity rate of pneumonia at SMMU hospital was significantly lower than that at NDMC hospital supports this hypothesis. Moreover, an immediate tracheotomy may accelerate early enteral feeding via the enterogastric tract as quickly as possible, which thus might influence the mortality of severe burn patients. It is possible for patients with a tracheostomy to drink and eat voluntarily, whereas it is impossible for patients under intubation to do so. When severe burn patient accidentally have food enter the trachea, a tracheostomy is a good way to avoid asphyxiation or the subsequent development of pneumonitis. Many articles have reported that enteral nutrition minimizes bacterial translocation (Inoue et al. 1989), suppresses the hypermetabolic response to stress (Lowry 1990), and is also associated with a lower incidence of metabolic derangements (Braga et al. 2001), septic morbidity (Moore et al. 1992), and a higher survival rate (Herndon et al. 1989) in comparison to intravenous nutrition support. A tracheostomy performed
immediately after admission at SMMU hospital of China might therefore be associated with early enteral nutrition in severe burn patients, thus leading to a better survival rate.

In China, microskin grafting (Zhang et al. 1988; Lin 1994) and intermingled skin grafting (Yang et al. 1980, 1982) are performed as the main grafting procedures for extensively burned patient at large burn centers. Although porcine skin used to be used in microskin grafting or intermingled skin grafting in China, alloskin is now regularly available. However, such operations are seldom seen in Japan and have never been performed at NDMC. Microskin grafting has been developed from the patch skin grafting method of Gabarro (1943) and is an effective procedure by which an extensive burn wound may be successfully covered with a very limited amount of autoskin grafts. Microskin grafts are “cultured” in vivo without any equipment and grow underneath a viable allograft, and the highest expansion ratio of autoskin to the recipient area has been shown to reach 1:18 (Zhang et al. 1988). The idea of intermingled skin grafting is similar to microskin grafting. The intermingled transplantation of auto- and allografts together with a staged excision of the full thickness burn eschars constitutes a simple and practical method which leads to the successful management of certain extensively burned patients. Slits are made 1 cm apart on a large sheet of allograft which is then grafted onto the eschar-excised surface. When the alloskin covers the eschar-excised wound, we then tightly fix it to the wound, so a slit on the alloskin is made which looks like an oval-shaped hole. After 1 to 2 days, if the allograft survives, then the effect of the hole is to provide us a way to inlay a small piece of autoskin under the alloskin. Generally speaking, the autografts can expand to 6 to 10 times their original size after the intermingled transplantation with allografts (Yang et al. 1982). Under ordinary conditions the onset of acute rejection of the allograft in an extensively burned patient is around day 20 post grafting (Chambler and Batchelor 1969). A process called the “sandwich phenomenon” finally occurs within about 20 days. That is to say, the autoepidermis thus begins to creep between the allo-epidermis and the dermis. As a result, the microskin grafting and intermingled skin grafting using alloskin performed in China thus appear to be useful operations for extensively burned patients. However, these operations using alloskin are difficult to perform in Japan. One reason for the difference between China and Japan in this regard is that alloskin is still not universally available in Japan because the system for supplying it to the whole country has yet been fully established, except for the Tokyo skin-bank network (TSBN). This network was established in 1994 in Tokyo, Japan, and has gradually been extended to the whole country under the control of the Japanese Association for Burn Injuries (Shimazaki et al. 2000). The TSBN is, however, still developing as an organization, and it does not yet have a sufficient supply of alloskin for extensively burned patients throughout the country. Therefore, it is difficult to perform microskin or intermingled skin grafting using a large amount of alloskin at present in Japan. Last year, the TSBN changed its name to the Japan skin-bank network (JSBN) as its organization expanded to the whole country. The JSBN probably combines the Kansai skin bank (local district skin bank) this year, and we now hope that the JSBN can in the future supply sufficient alloskin to the whole country.

In summary, we compared the outcomes of extensively burned patients with a TBSA of greater than 20% between the two hospitals, SMMU in China and NDMC in Japan, and found the outcomes of the patients to be significantly better at the Chinese hospital than at the Japanese one. The excellent outcomes of extensively burned patients in China are considered to be due to the Chinese custom of performing an immediate tracheostomy and also by performing a traditional Chinese operation, called either microskin grafting or intermingled skin grafting, using alloskin.

References


