THE ALEXANDER SURGICAL TECHNIQUE FOR THE TREATMENT OF SEVERE BURNS

LA TECHNIQUE CHIRURGICALE D’ALEXANDER DANS LE TRAITEMENT DES BRÛLURES GRAVES

Gasperoni M.,¹ Neri R.,¹ Carboni A.,¹ Purpura V.,¹ Morselli P.G.,² Melandri D.¹

1 Burns Intensive Care Unit and ‘Regione Emilia Romagna’ Skin Bank, Bufalini Hospital, Cesena, Italy
2 Alma Mater Studiorum, University of Bologna, Italy

SUMMARY. The extensive loss of skin in burned patients is a critical clinical condition, and the choice of an effective technique to cover and protect the damaged area has always been a challenge in the surgical field. Despite its wide clinical use, there is little data in the literature on the Alexander technique to treat severe burns, while several studies have focused on alternative approaches. The present study aims to evaluate the effectiveness of the Alexander surgical technique on 117 patients with severe burns. The characteristics of the burned patients, factors related to etiology of burns as well as adverse prognostic factors and their incidence in discharged versus deceased patients were also taken into account. Finally, a comparison is made with an alternative surgical procedure described in the literature. Our results show a satisfactory level of survival for patients with severe burns surgically treated with the Alexander technique, accounting for 63% of all clinical cases reported here. This treatment is also less expensive and more rapid than the alternative approach we compared it with. The Alexander technique is a lifesaving method for the treatment of severe burns that provides a satisfactory chance of survival at lower cost than the alternative surgical procedure examined.

Keywords: burn treatment, Alexander technique, homologous skin, skin graft

RÉSUMÉ. Une vaste perte de substance cutanée chez les brûlés détermine un état clinique critique, et le choix d’une technique efficace pour couvrir et protéger les zones détruites a toujours été un challenge chirurgical. Malgré sa large utilisation, il y a peu de références dans la littérature sur l’utilisation de la technique d’Alexander dans le traitement des brûlures graves, alors que différentes études insistent sur d’autres approches. Cette étude a pour but d’évaluer l’efficacité de la technique chirurgicale d’Alexander sur 117 patients présentant des brûlures graves. Les caractéristiques de ces brûlés (étiologie, facteurs pronostiques défavorables et leur incidence sur la sortie de l’hôpital) ont été prises en compte, comme celles des patients décédés. Enfin, la comparaison est faite avec les autres procédés alternatifs chirurgicaux décrits dans la littérature. Nos résultats montrent un taux satisfaisant de survie chez les patients présentant des brûlures graves traitées par la technique d’Alexander: 63% de tous les cas cliniques rassemblés ici. Le traitement est aussi moins cher et plus rapide que dans les techniques alternatives. La technique d’Alexander est une méthode de sauvetage pour le traitement des brûlures graves qui offre une chance satisfaisante de survie à un coût moindre que les autres techniques alternatives.

Mots-clés: traitement des brûlés, technique d’Alexander, homogreffes, greffes cutanées

Introduction

Burns are acute and traumatic clinical conditions that still occur for several different reasons. Patient survival could be compromised by severity as well as depth and extension of the damaged area. On the other hand, functional and aesthetic recovery of the lesion is the main aim when the burn covers less than 30% of total body surface area (TBSA). However, in all clinical conditions the surgical treatment used during the acute phase of burn plays a key role in clinical outcome, and early excision of necrotic tissue followed by skin graft remains the treatment of choice. In particular, the gold standard for treating extensive burns is still the use of homologous skin since there is not enough autologous skin from healthy donor sites to treat this clinical condition. In fact, although the autologous split-thickness skin graft was the first clinical application introduced by Reverdin,³ it was quickly replaced by homologous skin graft for the treatment of severely burned patients, as reported in several scientific publications.¹²⁴ In addition, the creation of the US Navy Skin Bank at Bethesda made it easier to procure.⁵ Thus, the availability of homologous skin from the tissue bank in combination with the intuition of the surgeon, Alexander, led to the development of the ‘sandwich’ grafting technique in 1981.⁶ In this surgical procedure, homologous skin covers and protects the underlying widely expanded autologous skin, acting as a physiological/mechanical barrier able to stimulate its engraftment. The good clinical results obtained using this surgical procedure to treat severely burned patients gave rise to the development of several tissue banks in order to

¹ Corresponding author: Valeria Purpura, Viale Ghirotti n. 286, Cesena, Italy. Tel.: +39 0547352919, +39 3282490018; fax: +39 0547394327; email: valeria.purpura@auslromagna.it
Manuscript: submitted 05/05/2016, accepted 21/10/2016.
immediately provide the amount of homologous skin required. To date, the Alexander surgical technique has been widely used for the clinical treatment of severe burns. On the other hand, few studies have been published since the first one on its clinical application appeared in *Trauma Journal* in 1981.6

This study aims to report the effectiveness of the Alexander surgical technique applied on 117 patients with severe burns admitted to the Burns Centre of “Bufalini” Hospital over the last 10 years. The characteristics of burned patients, factors related to etiology of burns as well as adverse prognostic factors and their incidence in discharged versus deceased patients were taken into account in order to have an overview of the clinical cases described here and their relation to clinical results. Finally, the Alexander technique is compared with an alternative surgical technique used to treat severely burned patients.

**Materials and methods**

We decided to evaluate the effectiveness of the Alexander surgical technique used to treat patients with severe burns admitted to the Burn Centre of “Bufalini” Hospital over the last ten years. A total of 117 burned patients treated with this technique between 2004 and 2014, on whom autologous/homologous skin graft was performed in the same surgical operation, were selected for this study. More than 1000 cm² of homologous skin was defined as a threshold to select patients. Characteristics of the burned patients, factors related to etiology of burns as well as adverse prognostic factors and their incidence in discharged versus deceased patients were recorded and are reported in *Tables I, II and III* respectively. Moreover, microbiological infections observed in the burned damaged area of patients admitted from 2004 to 2007 (Group 1) and from 2011 to 2014 (Group 2) were also evaluated, as shown in *Fig. 1*.

Considering that severely burned patients show high immunosuppression, we also evaluated their profile of infection during recovery. In particular, we considered all pathogens identified in the following biological samples of patients: exudates derived from cutaneous lesions, blood

<table>
<thead>
<tr>
<th>CHARACTERISTICS OF BURNED PATIENTS</th>
<th>MEAN VALUE ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE</td>
<td>60±22 years</td>
</tr>
<tr>
<td>SEX</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>69</td>
</tr>
<tr>
<td>Female</td>
<td>48</td>
</tr>
<tr>
<td>TIME OF RECOVERY</td>
<td>49±30 days</td>
</tr>
<tr>
<td>SURGICAL OPERATIONS/PATIENT</td>
<td>2±1</td>
</tr>
<tr>
<td>AUTOLOGOUS/HOMOLOGOUS SKIN GRAFT EXPANSION RATIO</td>
<td></td>
</tr>
<tr>
<td>4:1/2:1</td>
<td>71</td>
</tr>
<tr>
<td>6:1/2:1</td>
<td>37</td>
</tr>
<tr>
<td>9:1/2:1</td>
<td>9</td>
</tr>
</tbody>
</table>

**Table II -** List of factors related to etiology of burns in the 117 burned patients

<table>
<thead>
<tr>
<th>FACTORS RELATED TO ETIOLOGY OF BURNS</th>
<th>MEAN VALUE (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCIDENTAL EVENTS</td>
<td>80%</td>
</tr>
<tr>
<td>SELF-HARM</td>
<td>20%</td>
</tr>
<tr>
<td>Self-harm in the workplace</td>
<td>8%</td>
</tr>
<tr>
<td>FIRE</td>
<td>90%</td>
</tr>
<tr>
<td>BOILING LIQUIDS</td>
<td>6%</td>
</tr>
<tr>
<td>OTHERS</td>
<td>4%</td>
</tr>
</tbody>
</table>

**Fig. 1 -** Comparison of microbiological infections between Group 1 (2004-2007) and Group 2 (2010-2014).
cultures taken during febrile peaks, tracheal aspirates performed in intubated or tracheostomized patients, expectorate or central venous catheter (CVC). In addition, we split patients into two different groups in order to identify a possible change in the incidence of pathogens over these ten years. Thus, burned patients admitted to our hospital from 2004 to 2007 were included in Group 1, while patients admitted from 2011 to 2014 formed Group 2. We purposely have not considered patients admitted from 2008 to 2010 in order to create a period of separation between infections in the two different groups analyzed.

Statistical analysis was performed to evaluate the average and the standard deviation of characteristics of burned patients, factors related to etiology of burns as well as adverse prognostic factors. Student’s t test was performed to compare the incidence of adverse prognostic factors in discharged versus deceased burned patients.

Finally, in order to evaluate the possible advantages of using the Alexander technique, we compared our results with those in the literature achieved using other alternative approaches. In particular, we compared the Alexander technique to cultured epithelial autograft (CEA).

**Results**

Our results show a satisfactory level of survival for patients with severe burns after surgical treatment with the Alexander technique, accounting for 63% of all the clinical cases described here. In particular, burns prevalently affected people in the 40-80 year-old age group, with a slightly higher incidence in males (Table I). All these patients were admitted to the Burn Centre for an average of 49 ± 30 days, in which 2 ± 1 surgical operations were performed using the Alexander technique to treat the burned area (Table I). Expansion of autologous/homologous skin in a ratio of 4:1/2:1 was used to cover the damaged area in 71 clinical cases, while a higher skin expansion ratio of 6:1/2:1 or 9:1/2:1 was used to treat 37 and 9 patients respectively (Table I). Moreover, the burn injuries were prevalently due to accidental events, accounting for 80% of all the clinical cases described here, while the remaining 20% were the result of self-harm, also carried out in the workplace (Table II). The main burning agent was fire, with an incidence of 90% of all the clinical cases described here. On the other hand, boiling liquids and other agents such as chemical substances or electrical discharges accounted for 6% and 4% of burns respectively (Table II).

As expected, deceased patients showed significantly higher percentages of TBSA affected by extensive and deep burns than discharged patients (Table III). As shown in Table III, a higher percentage of patients (68%) were in class 5 of the Roi index 2 while 12%, 9%, 4% and 7% of them were in class 4, 3, 2 and 1 respectively. As expected, all deceased patients showed a significantly higher mean Roi index value (0.93 ± 0.13) than discharged patients (0.68 ± 0.30) (Table III). Among adverse prognostic factors, we identified inhalation injury during admission in 23% of all burned patients. Mechanical ventilatory support was needed in 61% of the clinical cases described here. In particular, 89% of patients with mechanical ventilatory support underwent surgery to create a temporary tracheostomy. As shown in Table III, a significantly higher number of patients affected by inhalation injury died (15%) while the remaining 8% survived. Similarly, a significantly higher number of patients treated with mechanical ventilatory support died (35%) compared to 26% that survived (Table III).

Results show that the incidence of some pathogens such as Staphylococcus haemolyticus or Stenotrophomonas maltophilia did not differ in the two periods analyzed (Fig. 1). On the other hand, some infections due to Escherichia coli, Candida albicans, Klebsiella pneumoniae or Staphylococcus aureus were more evident in Group 1, while their incidence decreased in Group 2, demonstrating the effectiveness of the therapy used against these pathogens in recent years. An evident reduction of infections induced by Staphylococcus epidermidis, Pseudomonas aeruginosa or Aspergillus fumigatus was also identified in Group 2. In contrast, an increasing incidence of infections induced by Enterococcus faecalis as well as Acinetobacter baumannii was identified in recent years (Group 2) despite an improvement in treatments used against these pathogens (Fig. 1). In particular, Acinetobacter baumannii is considered a major cause of nosocomial infections in immunosuppressed patients in intensive care wards.

Comparing the Alexander technique with cultured epithelial autograft (CEA), we found that CEA treatment required at least 132 days of recovery, as previously described, while time of recovery for our clinical cases treated with the Alexander technique was 49 ± 30 days. In fact, time to wound closure is longer for the CEA technique than for the Alexander technique, which requires 2-3 weeks, as identified in this study. The first surgical operation using the Alexander technique was performed 5 ± 2 days after admission to the intensive care unit, and an additional 5 ± 2 days were required for the second surgical treatment. Then, the third application of the Alexander technique was performed for only a few patients another 5 days later. In contrast, 2 weeks are required just for the in vitro culture of keratinocytes when the CEA technique is applied, in order to create layers or suspension of this type of cells for the burn treatment. 10 The time required for cell culture could be even longer in elderly patients, who suffer burns more frequently. Furthermore, the skin biopsy used to culture and enhance cells in vitro is obtained 7 days after the patient is admitted, during early escharotomy. Thus, a first coverage of the burn is only obtained after 3 weeks and, in turn, a temporary graft of homologous skin is required to cover the damaged area, increasing risk of infection as well as loss of blood. On the other hand, the Alexander technique requires only homologous skin, which makes this treatment cheaper than the alternative one. In addition, an engraftment of autologous skin corresponding to 95%-99% is obtained when the Alexander technique is applied, while it does not exceed 60% using the CEA technique, probably as a consequence of the missing dermal layer in the damaged area in which keratinocytes are applied.

**Discussion**

Finding an effective technique to treat severe burns has always been a challenge in the surgical field. Among the different reconstructive approaches, the Alexander surgical procedure has been widely used, even though few studies in the literature have reported using it. Thus, our aim here was to evaluate the effectiveness of this approach on patients with severe burns admitted to our burn centre over the last ten years. We also evaluated the characteristics of burned patients, factors
related to etiology of burns as well as adverse prognostic factors and their incidence in discharged versus deceased patients in order to have an overview of the clinical cases described here and their relation to clinical outcomes. Thus, we identified a satisfactory level of survival for patients with severe burns who were surgically treated with the Alexander technique, accounting for 63% of all the clinical cases described here.

In particular, we found that severe burns preferentially affected patients of 60 ± 22 years, according to general epidemiologic data about people more prone to burns. In fact, bad habits as well as fragility, which increases with age, are both frequently associated with burn injuries. For all patients, time of recovery was relatively short, ranging from a minimum of 19 days to a maximum of 79 days, and only a few patients required a third surgical operation. Moreover, the low ratio of autologous/homologous skin expansion in most of the clinical cases described here ensured satisfactory skin engraftment as well as functional and aesthetic recovery of the damaged area. In fact, a low number of surgical operations as well as a low as possible ratio of autologous/homologous skin expansion are both related to better skin engraftment and functional and aesthetic recovery of the damaged area. However, a high ratio of skin expansion is required when donor sites are not sufficient to totally cover the damaged area, which in turn affects clinical outcome. As expected, burns mainly occurred due to accidental events, but it is noteworthy that the few cases due to self-harm also occurred in the workplace (8%). In addition, burns are mainly caused by fire, often as a consequence of inappropriate use of inflammable liquids in the household, which makes it the burning agent most frequently involved in burn incidents, as previously reported.

Among the adverse prognostic factors, we found that a high mean value of both extension of burns and their depth played a role in final clinical outcome. In fact, the deceased patients in our study showed a significantly greater extension and depth of burns than discharged patients. In addition, the fact that most patients were in class 5 of the Roi index demonstrated their high risk of mortality. Inhalation injury is also a prognostic factor for mortality in burned patients, as previously described. In our clinical cases, it was mainly identified in deceased patients as expected. Moreover, the use of mechanical ventilatory support during recovery was frequently required for the burned patients described here and it was an adverse prognostic factor for them.

Analysis of previous and current profile of infections in patients affected by severe burns identified Acinetobacter baumannii as the main cause of nosocomial infections in recent years. This might be due to the pathogen’s physical resistance in the environment for 30 days in dry conditions, multiple modes of transmission and its resistance to antibiotic therapies, probably as a consequence of previous overuse. Thus, the effective therapy used against this type of pathogen is colistin, despite its toxic side effects.

Finally, comparison with the CEA approach also showed one advantage in using the Alexander technique. It requires less time to cover the burned area than the CEA technique, and it reduces the risk of infection in the damaged area, making the management of burned patients easier. Moreover, all cellular components are maintained in the split thickness autologous skin when the Alexander technique is used, ensuring skin engraftment in 95-99% of clinical cases. On the other hand, skin engraftment after CEA technique does not exceed 60%, and sometimes the failure of engraftment could have severe consequences for the management of the patient. It has been hypothesized that CEA treatment could also be involved in tumoral development since keratinocytes are stimulated to grow quickly in vitro in order to reduce the time required to obtain the layers. However, this possibility is negligible considering that the development of tumors has been previously described in only one clinical case after the use of the CEA technique. On the other hand, the risk of developing tumors after using the Alexander technique is comparable to that of squamous cell. The layer of keratinocytes used in the CEA technique is difficult to handle, easily infected and fragile due to the absence of both a dermal layer and other cellular components such as endothelial cells and melanocytes required for vascular stimulation and skin protection against UV rays respectively. To date, several dermal substitutes have been developed as products of tissue engineering to overcome these problems and they are actually applied on burned patients, improving engraftment of the layer of keratinocytes. However, the use of dermal substitutes further increases the cost of CEA treatment.

Conclusions

In conclusion, the patients affected by burns in our study were a similar age to those frequently identified for this clinical condition. They were admitted for a relatively short period of time, during which they underwent a normal amount of surgical operations using the Alexander technique. In most of them, a low ratio of autologous/homologous skin expansion was related to better skin engraftment. On the other hand, a high number of clinical cases showed a high risk of mortality according to the Roi index, as well as wide and deep burns frequently affected by different types of pathogen. Moreover, mechanical ventilation was frequently required and inhalation injury was evident in some clinical cases. Thus, considering that rate of survival was 63%, we can conclude that the Alexander technique is an effective surgical approach to treat burned patients, able to improve their chances of survival. The Alexander technique is easily applied, relatively safe and not very expensive considering the results obtained. On the other hand, issues related to resistance of pathogens to therapy should be taken into account in order to improve the management of severely burned patients and, in turn, their clinical outcomes.
BIBLIOGRAPHY


No grant or other financial support was used in the study.