Observational Study

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Improvement in mortality at a National Burn Centre since 2000

Was it the result of increased resources?

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Abstract

The aim of this study was to find out whether the charging costs (calculated using interventional burn score) increased as mortality decreased.

During the last 2 decades, mortality has declined significantly in the Linköping Burn Centre. The burn score that we use has been validated as a measure of workload and is used to calculate the charging costs of each burned patient.

We compared the charging costs and mortality in 2 time periods (2000–2007 and 2008–2015). A total of 1363 admissions were included. We investigated the change in the burn score, as a surrogate for total costs per patient. Multivariable regression was used to analyze risk-adjusted mortality and burn score.

The median total body surface area % (TBSA%) was 6.5% (10–90 centile 1.0–31.0), age 33 years (1.3–72.2), duration of stay/TBSA% was 1.4 days (0.3–5.3), and 960 (70%) were males. Crude mortality declined from 7.5% in 2000–2007 to 3.4% in 2008–2015, whereas the cumulative burn score was not increased ($P=.08$). Regression analysis showed that risk-adjusted mortality decreased (odds ratio 0.42, $P=.02$), whereas the adjusted burn score did not change ($P=.14$, model R^2 0.86).

Mortality decreased but there was no increase in the daily use of resources as measured by the interventional burn score. The data suggest that the improvements in quality obtained have been achieved within present routines for care of patients (multidisciplinary/orientated to patients' safety).

Abbreviation: TBSA% = total body surface area %.

Keywords: burn, cost, hospital billing charge, interventional score, mortality, resources, survival

1. Introduction

Mortality is one of the most important outcome of burn care, and many studies have tried to predict it.[1–4] In recent years there has been a reduction from 54%–100% to 4%–6%,[4–6] and this is usually attributed to improvements in the quality of care.[7,8] However, the association between the resources needed for these improvements and the decreased mortality have not been clarified.

The first improvement was in the early 1940s when resuscitation was helped by infusions, accessibility to blood banks, and antibiotics.[7] Other influential factors were the introduction of intensive care and increased insight into the pathophysiology of burns.[9] The investment in the development of more reliable dressings also helped to improve outcome.[4,8]

A few reports have shown that costs can be reduced without adverse effects on care.[10] To improve outcome without increasing resources is, however, difficult. We know of no previous studies that have investigated how improved survival is affected by use of resources in the care of burns.

It is difficult to estimate what resources are required. One way is to use recorded workload or intervention scores.[11] The Linköping burn interventional score[12] has been validated and has been used to calculate the cost of each burned patient since 1993. We hypothesized that the total costs will increase in parallel to the improvement of mortality rates. Our aim was to examine whether total costs/patient (measured as adjusted interventional burn score) increased during the years 2000 to 2015 in parallel with survival.

2. Patients and methods

All patients admitted to Linköping University Hospital Burn Centre between January 1, 2000 and October 31, 2015 were included in the study. The time period was divided into 2: early (2000–2007) and later (2008–2015). We analyzed data from the prospectively maintained burn registry, in which the nursing staff enter all patients' data daily (the Burn Unit Database).[12] An approval of data handling and publishing has been obtained by the regional ethical committee.

Patients were treated according to a protocol that included early excision and grafting,[12] revision of the wound every

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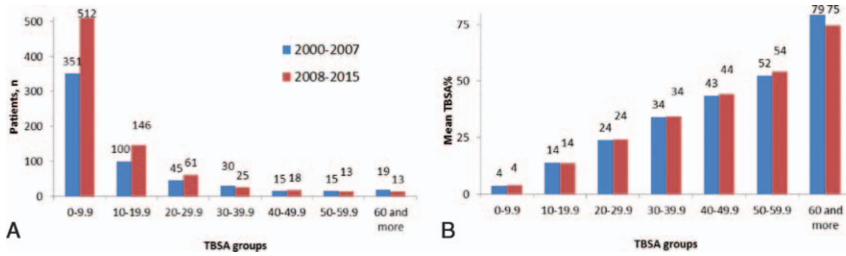

Figure 1. A comparison between the number of patients and the mean total body surface area % burn among different groups in the early and later periods.

second day, standard ventilation,[13,14] fluid management,[15] and early enteral nutrition. All burned patients who required intensive care were managed by both the intensive care physicians and the plastic surgeons daily. All infected wounds were followed up weekly or more often by an infection consultant together with the attending surgeon who planned antibiotic treatment.

Minor burns were treated by early tangential excision and covered with meshed split thickness skin grafts. Major burns had staged excisions and were covered with xenografts to allow clear demarcation of the wound bed, followed by later autografting.[16–18]

The burn score was calculated daily based on recordings of the following: surveillance, respiration, circulation, wound care, mobilization, results of laboratory tests, infusions, and operations.[12] Each of the variables were given a score from 0 to 4 except for the operation, which was calculated based on the duration of operation and type of dressing, where 1 hour = 2 points (Supplemental file 1, http://links.lww.com/MD/B697). The hospital charging bill was based on the cumulative burn score, which was the sum of the total daily burn scores for the patient during the whole admission. Mortality was defined as death during the admission at the burn center.

2.1. Data analysis and statistics

Data were analyzed with the help of STATA (STATA V.12.0, Stata Corp. LP, TX), and presented as median (10–90 centiles) unless otherwise stated. The significance of differences between variables was assessed with the aid of the Mann–Whitney *U* test and the χ^2 test. Multivariable logistic regression was used to assess the significance of changes in risk-adjusted mortality over time with adjustment for total body surface area% (TBSA%), age, and sex. Changes of the adjusted interventional burn score over time were analyzed using multivariable regression analysis with adjustment for TBSA%, age, sex, cause of burn, mortality, satellite referral (those who were referred from outside the catchment area for the Department of Plastic Surgery, Hand Surgery, and Burns), and duration of stay. Probabilities of less than 0.05 were accepted as significant.

3. Results

A total of 1363 patients were included. There was a 37% (213) increase in the number of total admission in the late period, however most of them had TBSA burns less than 20% (Fig. 1, Tables 1 and 2).

As patients with TBSA% of less than 20% were responsible for most of the increase in admissions in the late period, median TBSA% declined from 7% in the early period to 6.1% in the late period while crude mortality dropped by more than 50%.

Satellite referral increased from one third of the total admissions in the early period to more than half the admissions in the later period. Unadjusted median burn scores for each day of admission did not differ between the 2 periods (Table 1).

Table 1

Details of patients and scores.

	Total (n = 1363)	2000–2007 (n = 575)	2008–2015 (n = 788)	*P* value
Mortality	70 (5.1)	43 (7.5)	27 (3.4)	<.001
Total score	34.0 (7.0–348.0)	32.0 (6.0–320.0)	36.0 (7.0–352.0)	.22
Operation score	4.0 (0–30.0)	4.0 (0–22.0)	4.0 (0–37.0)	.51
Patients operated on	976 (72)	411 (71)	565 (72)	.93
TBSA%	6.5 (1.0–31.0)	7.0 (0.6–35.0)	6.1 (1.0–27.0)	.26
Superficial second degree	2.0 (0–12.0)	1.5 (0–12.0)	2.0 (0–11.5)	.05
Deep second degree	0.5 (0–9.5)	0.5 (0–9.5)	0.5 (0–9.5)	.07
Full thickness burn	0 (0–14.0)	0.3 (0–19.0)	0 (0–10.0)	<.001
Median (10–90 centile) age, years	32.9 (1.3–72.2)	34.0 (1.5–73.0)	32.4 (1.2–72.0)	.18
Male sex	960 (70)	409 (71)	551 (70)	.63
Total duration of stay, days	8.0 (2.0–36.0)	7.0 (2.0–33.0)	8.0 (2.0–37.0)	.04
Duration of stay/TBSA%	1.4 (0.3–5.3)	1.2 (0.3–5.8)	1.5 (0.4–5.3)	.004
Satellite referrals	621 (46)	199 (35)	422 (54)	<.001
Patients who required MV	278 (20)	123 (21)	155 (20)	.44
Patients with sedation dressing	841 (62)	293 (51)	548 (70)	<.001
Burn score/duration of stay	4.5 (2.8–11.9)	4.5 (2.8–12.0)	4.4 (2.9–11.8)	.40

Data are number (%) of patients unless otherwise stated.

Data are presented as median and 10–90 centiles or n and %. MV = mechanical ventilation.

Mann–Whitney *U* and χ^2 tests were used, as appropriate.

MV = mechanical ventilation, TBSA = total body surface area %.

Table 2

Baux score and survival rate in the 2 time periods grouped by TBSA%.

	2000–2007			2008–2015			
TBSA%	Deaths	Survivors	Survival rate %	Deaths	Survivors	Survival rate %	*P* value
Total	43 (114)	532 (44)	93	27 (113)	761 (43)	97	.001
0–9.9	2 (96)	349 (36)	99	2 (83)	510 (35)	99.6	.70
10–19.9	5 (82)	95 (45)	95	0	146 (48)	100	.006
20–29.9	10 (103)	35 (68)	78	8 (92)	53 (65)	87	.22
30–39.9	4 (104)	26 (74)	87	4 (116)	21 (74)	84	.78
40–49.9	4 (116)	11 (77)	73	4 (121)	14 (77)	78	.77
50–59.9	5 (115)	10 (88)	67	2 (123)	11 (85)	85	.27
60 and more	13 (139)	6 (102)	32	7 (134)	6 (121)	46	.40

Data are number of patients, mean Baux score in brackets, and survival rate as percent. *P*-values are for χ^2 test for survival by TBSA% group.
TBSA = total body surface area %.

The median cumulative burn score did not change—it was 27 (6–293) among the survivors in the early period and 22 (7–86) in the later period ($P=.08$). When we analyzed TBSA% separately in groups, the only significant difference was among the survivors with the smallest burns, among whom the increase was 7 burn score points/patient. Although the burn scores were higher in the later period among the survivors with the biggest burns, they did not differ significantly (Table 3).

Regression analysis showed that risk-adjusted mortality was reduced during the later period. The odds ratio was decreased with 0.58 compared with the early period (Table 4). Table 5 shows that the burn score did not change significantly between the early and later periods after adjustment for TBSA%, age, sex, cause of burn, mortality, satellite referral, and duration of stay for each patient.

4. Discussion

We have analyzed 16 years' burn scores recorded daily from our burn center, which were used both clinically and as a reference for billing patients. We found a significant decline in risk-adjusted mortality by more than 50% without extra use of resources.

In 1949, Bull and Squire[1] suggested that the advantages in survival seen then could be attributed to advances in multiple medical treatments that had been introduced since the 1920 s, rather than to a single drug, and they anticipated that improved methods of treatment would further improve survival after burns. More recent studies have shown a decline in mortality that is probably the result of the implementation of several new techniques such as mechanical ventilation, aggressive excision of wounds, and the employment of full-time burn surgeons.[19,20]

Besides early excision of burns, other authors have attributed the decline in mortality to the team approach to burn care under the supervision of senior surgeons.[21] We had no clear delineation between the 2 study periods. The team approach was refined continuously over time with regular multidisciplinary meetings in addition to surgical management, which was directed to staged excisions.

To increase survival, more resources are usually required until you reach a certain point of design, equipment, protocols, and experience of staff. It is then about improving staff knowledge and implementing more efficient protocols. Patients with severe burns who survive require many resources because they are in hospital for a long time, and patients who die soon after admission require less.

The analysis was focused on whether more daily resources were required to increase survival. The results showed no change in the daily use of resources, and the cumulative use was slightly but not significantly higher. This tendency toward higher scores per patient is probably the result of increased survival among patients with larger TBSA% and therefore longer hospital stays compared with similar burns in the past. This is in line with the common concept that costs are increasing as more people survive major injuries.[22] We found increasing burn scores with increasing TBSA% among survivors, whereas the reverse was evident among those who died. This pattern has previously been described among similar TBSA% groups when using the "diagnosis-related groups" system.[23]

The importance of the present study was to compare mortality and quantitate resources between 2 periods during which the techniques used were similar but the staff probably became more experienced over time. This could raise the prospect of investing

Table 3

Median cumulative burn score among survivors and non survivors grouped by TBSA%.

	Survivors			Nonsurvivors		
TBSA%	2000–2007	2008–2015	*P* value	2000–2007	2008–2015	*P* value
0–9.9	13 (5–77)	20 (7–86)	<.001	107 (68–146)	583 (136–1029)	.67
10–19.9	74 (13–207)	83 (12–317)	.39	121 (79–391)		
20–29.9	136 (46–482)	266 (57–880)	.11	286 (61–857)	656 (42–1308)	.15
30–39.9	396 (104–1175)	348 (35–744)	.71	346 (78–646)	415 (16–777)	.89
40–49.9	264 (151–1005)	741 (122–1257)	.29	69 (19–1920)	67 (10–2518)	1.00
50–59.9	581 (205–2186)	926 (679–1605)	.25	80 (9–143)	60 (57–62)	.86
60 and more	1367 (582–2127)	2418 (673–3325)	.39	47 (22–655)	91 (36–2873)	.39

Data are median burn score (10th and 90th centiles). *P*-values are for Mann–Whitney test for burn score by the TBSA% group.
TBSA = total body surface area %.

Table 4

Risk adjusted regression model for mortality over time.

	Coefficient	*P* value	OR	95% CI
2000–2007			1.00	
2008–2015	−0.9	.02	0.42	0.21–0.84
TBSA%	0.1	<.001	1.10	1.08–1.13
Age	0.1	<.001	1.11	1.08–1.14
Sex, male	−0.4	.28	0.67	0.33–1.39
Constant	−10.8	<.001	0.00	0.00–0.00

Multivariable logistic regression for mortality. Model pseudo R^2 0.58, $P<.001$, n=1363.
CI = confidence interval, OR = odds ratio, TBSA = total body surface area %.

Table 5

Interventional burn score analyzed by time period.

	Coefficient	*P* value	95% CI
Time period			
2000–2007 (reference)			
2008–2015	10.6	.14	−3.4 to 24.5
TBSA%	1.3	<.001	0.7 to 2.0
Age, years	0.2	.24	−0.1 to 0.5
Sex, male	17.3	.02	2.4 to 32.2
Cause of burn			
Scalds (reference)			
Hot objects	0.1	.99	−25.7 to 26.0
Chemicals	−12.6	.48	−47.4 to 22.3
Flame	−8.3	.39	−27.2 to 10.6
Electricity	−31.7	.08	−66.9 to 3.5
Other	−4.7	.81	−42.7 to 33.4
Mortality	157.3	<.001	119.2 to 195.4
Satellite referral	7.2	.32	−7.0 to 21.5
Hospital stay, days	10.2	<.001	9.9 to 10.6
Constant	−72.3	<.001	−90.9 to −53.7

Multivariable regression model R^2 0.86, $P<.001$, n=1363.
CI = confidence interval, TBSA%=total body surface area.

more in upgrading knowledge and developing skills among the staff. New treatment plans would also improve the overall outcome, including shorter duration of hospital stay, which would reduce the hospital's charges. This approach could be applicable to other specialties as well, such as general surgery and intensive care.

4.1. Limitations of the study

We did not evaluate how much staff learned, as there are no records of the courses taken and the continuous increase in knowledge and skills. The burn score measures the resources used for each patient regardless of the quality of treatment given, while outcome measures such as mortality depend on both quantitative resources and the quality of practice. The aim of the present study was not to examine the factors behind the decline in mortality.

The single-center approach is always a limitation, and it is possible that more patients could have given different results.

5. Conclusion

Mortality decreased without an increase in the daily use of resources as measured by the interventional burn score. The data suggest that the improvements in quality have been achieved within our present multidisciplinary/safety-orientated routines for the care of patients.

References

[1] Bull JP, Squire JR. A study of mortality in a burns unit: standards for the evaluation of alternative methods of treatment. Ann Surg 1949;130: 160–73.
[2] Osler T, Glance LG, Hosmer DW. Simplified estimates of the probability of death after burn injuries: extending and updating the baux score. J Trauma 2010;68:690–7.
[3] Tobiasen J, Hiebert JH, Edlich RF. Prediction of burn mortality. Surg Gynecol Obstet 1982;154:711–4.
[4] Jackson PC, Hardwicke J, Bamford A, et al. Revised estimates of mortality from the Birmingham Burn Centre, 2001–2010: a continuing analysis over 65 years. Ann Surg 2014;259:979–84.
[5] Steinvall I, Fredrikson M, Bak Z, et al. Mortality after thermal injury: no sex-related difference. J Trauma 2011;70:959–64.
[6] Sneve H. The treatment of burns and skin grafting. JAMA 1905;45:1–8.
[7] Jaskille AD, Shupp JW, Pavlovich AR, et al. Outcomes from burn injury-should decreasing mortality continue to be our compass? Clin Plast Surg 2009;36:701–8.
[8] Shakespeare PG. The role of skin substitutes in the treatment of burn injuries. Clin Dermatol 2005;23:413–8.
[9] Bloemsma GC, Dokter J, Boxma H, et al. Mortality and causes of death in a burn centre. Burns 2008;34:1103–7.
[10] Mathews JJ, Supple K, Calistro A, et al. A burn center cost-reduction program. J Burn Care Rehabil 1997;18:358–63. discussion 357.
[11] Graf J, Graf C, Janssens U. Analysis of resource use and cost-generating factors in a German medical intensive care unit employing the Therapeutic Intervention Scoring System (TISS-28). Intensive Care Medicine 2002;28:324–31.
[12] Sjoberg F, Danielsson P, Andersson L, et al. Utility of an intervention scoring system in documenting effects of changes in burn treatment. Burns 2000;26:553–9.
[13] Steinvall I, Bak Z, Sjoberg F. Acute respiratory distress syndrome is as important as inhalation injury for the development of respiratory dysfunction in major burns. Burns 2008;34:441–51.
[14] Liffner G, Bak Z, Reske A, et al. Inhalation injury assessed by score does not contribute to the development of acute respiratory distress syndrome in burn victims. Burns 2005;31:263–8.
[15] Bak Z, Sjoberg F, Eriksson O, et al. Hemodynamic changes during resuscitation after burns using the Parkland formula. J Trauma 2009; 66:329–36.
[16] Janzekovic Z. A new concept in the early excision and immediate grafting of burns. J Trauma 1970;10:1103–8.
[17] Herndon DN, Barrow RE, Rutan RL, et al. A comparison of conservative versus early excision. Therapies in severely burned patients. Ann Surg 1989;209:547–52. discussion 552-543.
[18] Still J, Donker K, Law E, et al. A program to decrease hospital stay in acute burn patients. Burns 1997;23:498–500.
[19] Gomez M, Cartotto R, Knighton J, et al. Improved survival following thermal injury in adult patients treated at a regional burn center. J Burn Care Res 2008;29:130–7.
[20] Herndon DN. Total Burn Care. Vol. 3. 2007;Saunders,
[21] Gibran NS, Klein MB, Engrav LH, et al. UW Burn Center. A model for regional delivery of burn care. Burns 2005;31(suppl 1):S36–9.
[22] Roberts G, Lloyd M, Parker M, et al. The Baux score is dead. Long live the Baux score: a 27-year retrospective cohort study of mortality at a regional burns service. J Trauma 2012;72:251–6.
[23] Saffle JR, Davis B, Williams P. Recent outcomes in the treatment of burn injury in the United States: a report from the American Burn Association Patient Registry. J Burn Care Rehabil 1995;16:219–32. discussion 288–219.