Significant Reductions in Mortality for Children With Burn Injuries Through the Use of Prompt Eschar Excision

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During the past 19 years, mortality due to burn injuries has markedly declined for children at the Boston Unit of the Shriners Burns Institute (SBI), dropping from an average of 9% of SBI admissions during 1968–1970 to an average of 1% during 1981–1986. Detailed statistical analysis using logistic regression was necessary for determining whether this decline in mortality was explained by changes in patient characteristics, such as age or burn size, which are known to strongly influence the outcome of burn injuries. This dramatic decline in mortality during the past 19 years was not the result of change in the age of the patients or their burn sizes; rather, it may be attributed to improvements in burn care. Results of this statistical analysis indicated that, for burn injury patients whose ages ranged from 11 days to 19 years, age had no demonstrable effect on survival from a burn injury. Children survived burn injuries at least as well if not better than the young adult (20–29 years of age). Also, infants (less than 1 year old) survived as well as other children (2–19 years old). Dramatic improvement in survival occurred in patients with burns covering more than 50% of the body surface area. Since 1979, mortality has been essentially eliminated for patients with burn sizes less than 70% of the total body surface area (of 296 patients with burns covering 15–69% of the total body surface area, only two patients died). During the period 1979–1986, 29 of 37 patients (78%) survived an 80% or greater total body surface area thermal injury.

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MANY CHANGES IN THE TREATMENT of the burn-injured child have taken place during the past 19 years. As a result of these changes, the survival rate of children with these thermal injuries has increased, and may be equivalent to or higher than that of young adults with similar injuries. This improvement in survival also seems to include the young infant (less than 1 year old). Others have reported that children survive the burn injury as well as adults,[1-7] although further studies have indicated that children (especially those younger than 2 years old) do not fare as well as their young adult counterparts.[8-17]

In this study, we have examined mortality data at the Boston Unit of the Shriners Burns Institute (SBI) of the period 1968–1986. This study has included logistic regression analysis to determine the statistical significance of the influence of patient characteristics on survival when recognized factors that are known to strongly influence mortality, such as age and burn size, are controlled. Logistic regression analysis allows for the comparison of survival data for different patient series at different times, both within and between institutions.

This study was undertaken to assess the following: 1) whether there are significant differences in mortality within the period of study (1968–1986), 2) if mortality has changed over time, whether these changes can be attributed to variations in the age, burn size, or treatment instituted during the study, and 3) whether the survival of an infant is different from the expected survival of a young adult with an equivalent injury. Finally, the results of this analysis are compared with a statistical study, using probit analysis of the care of pediatric burn patients who were treated at the Massachusetts General Hospital (MGH) during the years 1939–1954 and 1955–1970 before the SBI opened and was fully operational. This comparison provides a continuous period of survival rates at a single institution over a 48-year period.[8,9]

This work was supported by NIH Grant GM 21700 and by the Shriners of North America. Ronald G. Tompkins is an American Surgical Association Foundation Fellow and is the recipient of an NIH Clinical Investigator Award DK01746.

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Submitted for publication: February 3, 1988.

Methods

Tabulated data were analyzed for 1696 patients younger than 20 years of age admitted to SBI since its opening on November 2, 1968 until December 31, 1986. These patients were admitted within 60 days of receiving their burn injuries for treatment of cutaneous thermal injuries. Of these 1696 admissions, 22 patients were admitted but were not treated; these 22 nontreated patients were excluded from further analysis. Of the excluded patients, 15 were considered brain-dead upon admission and were not treated, three received an unsuccessful cardiovascular resuscitation within the first few hours of admission, two were transferred *in extremis* from other hospitals 1 week after receiving the burn, one patient suffered an unusually severe hemolytic process and died during the initial resuscitation efforts, and one patient had received a 100% body surface area (BSA) full-thickness burn injury and was not treated. The following data were tabulated: 1) age of the patient, 2) extent of the burn (summation of second and third degree burn, percentage of the BSA), 3) gender of the patient, 4) date of burn, 5) date of admission, and 6) date of discharge.

The initial 200 patients who were admitted to SBI with burns between 10% and 65% BSA were treated with either of two treatment methods: 1) excision of the burn eschar, immediate wound closure, and topical treatment with silver nitrate, or 2) silver nitrate therapy with spontaneous (delayed) eschar separation and wound closure.[18] After comparison of the results of these two treatment methods, all subsequent patients were treated with primary excision of the eschar, immediate wound closure, and silver nitrate topical therapy. In these initial patients, the primary excision had been performed between 12 hours and 18 days after the burn injury. After 1972 and as experience with the method was gained, the primary excision was performed as soon as possible after admission and was usually performed within the first 48–72 hours of admission (prompt excision). As a general rule, not more than 15–20% BSA (not including the donor skin harvest) was excised during a single operation. The burn wound eschar was removed, using either full-thickness fascial excision or sequential excision.[19] The wound was closed by grafting with one or a combination of the following: autologous skin (autografts), cadaver skin (allografts), porcine skin (xenografts), and skin substitutes.[20–22] Wounds (unexcised eschar and newly grafted skin) received topical treatment with 0.5% aqueous silver nitrate. Patients with burns greater than 10% BSA were treated in Bacterial Controlled Nursing Units (BCNU) to diminish the incidence of bacterial cross-contamination and to maintain the patient in an environment with an elevated ambient temperature and relative humidity.[23]

For the purposes of analysis, the patients were divided into groups based on patient characteristics. Patients were categorized by age, using five groups chosen to represent age groups of similar risk: less than 1, 1, 2–5, 6–12, and 13–19 years of age. The burn sizes of the patients were examined in deciles (0–9, 10–19, 20–29 . . .) and by a four-level classification of burns: 1) small burns (<15% BSA), 2) moderate burns (15–49% BSA), 3) large burns (50–69% BSA), and 4) massive burns (≥70% BSA), as previously described.[24] The patients were also divided in four groups of similar numbers, according to dates of admissions: 1968–1973, 1974–1978, 1979–1982, and 1983–1986.

Initial analyses were performed to describe the characteristics of the patient population. Further analyses using logistic regression techniques were used to examine each of the characteristics of interest singly, to assess its unadjusted association with mortality. Lastly, multivariable logistic models were fit in order to examine the importance of each characteristic on the probability of death, while adjusting for the presence of the others. Changes in mortality over years not accounted for by changes in patient characteristics, such as age or burn size, are ascribed to changes in the effectiveness of treatment.

A generalized linear interactive modeling system, GLIM System, Release 3.77™ (Numerical Algorithms Group, Ltd., Oxford, UK), was used to fit the logistic models. The logistic regression model assumes that the odds of mortality are given by (equation 1):

$$\mathrm{Exp}(A + B_1X_1 + B_2X_2 + \cdots B_nX_n)$$

where $X_1, X_2, \cdots$ and X_n are independent patient characteristics, and A and B_1, B_2, and $\cdots$ and B_n are coefficients associated with the patient characteristics that indicate the magnitude of the influence of the corresponding characteristic on mortality. Combinations of the population characteristics were considered in the model as a sum of terms that included linear, quadratic, and first-order interactions. The best-fitting multivariable model was found by entering the tabulated patient characteristics and all two-factor interactions (*e.g.*, AGE^2, age by percentage of BSA, and age by gender). The statistical significance of each term was assessed one-by-one, using the likelihood ratio test that determines whether a specified term (*e.g.*, year of admission), significantly affects mortality after the other terms are taken into account. Terms that were not statistically significant at $p < 0.05$ were dropped from the model until it was reduced to one containing only statistically significant terms. Two-factor interactions of remaining terms were allowed to re-enter the model if their associated p-values were no greater than 0.05.

Results

There was a total of 1674 patients included in the study. Of these, 1604 patients (96%) survived. One thousand

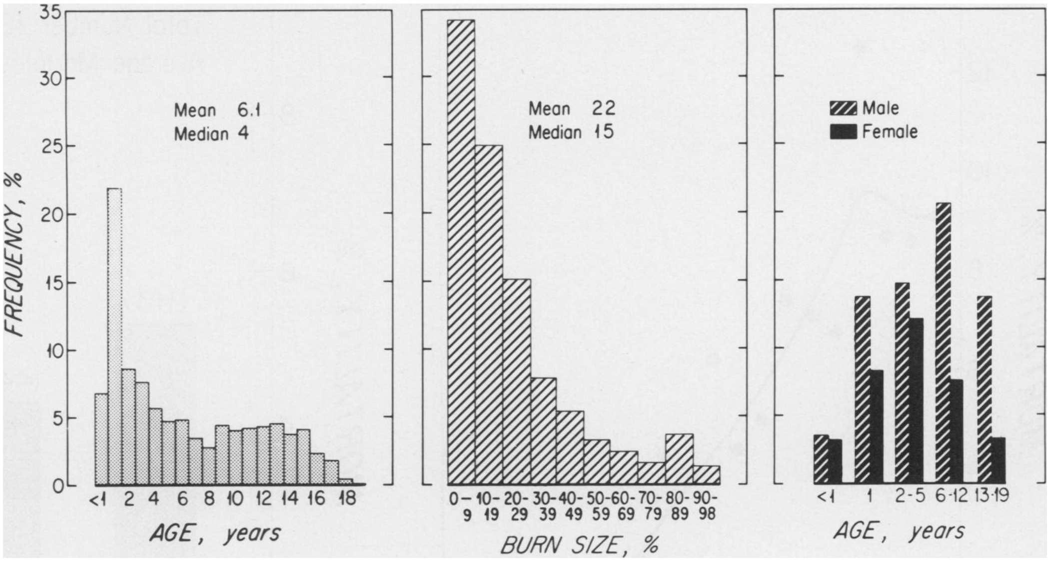


FIG. 1. Distributions of ages, burn sizes (%BSA), and age by gender. (Left) Frequency distribution plot for ages for the 1674 patients is not normally distributed. Except for patients 1 year of age, the distribution is almost uniform. (Center) Frequency distribution plot for %BSA of the total 1674 patients, also, is not normally distributed, and is comparable to burn size distribution for other pediatric burned patient populations.[4] (Right) Gender frequency distributions for patients younger than 6 years old show that the frequency of boys is comparable to that of girls, but that boys predominate the frequency distributions of the older children when children become more active and independent.

one hundred and one of these patients (66%) were men. The average age was 6.1 years (range: 11 days to 19 years). Patients one year of age constituted the age group most frequently seen, representing 22% of the patients (Fig. 1). One hundred thirteen patients (6.8%) were infants (less than 1 year old). The mean burn size was 22% BSA (range: 1–98%). The most frequent burn size was less than 10% BSA (Fig. 1). Forty-nine per cent of the patients had small burns (<15% BSA); 12% (208 patients) had burns that were 50% BSA or greater. The number of admissions increased from 13 patients in 1968 to an average of 99 patients per year since 1970. Approximately half of the patients were admitted within 24 hours of receiving their injury, 60% were admitted within 48 hours, and 82% were admitted less than 1 week after receiving the burn. Forty-five patients (2.7%) were admitted more than 30 days after receiving their burns. The distribution of males and females was similar for patients younger than 6 years old (Fig. 1). In patients more than 6 years old, males were seen two to four times as frequently as females.

Single Factor Analysis

Overall mortality declined significantly during the 19 years of the study, with $p < 0.001$ (Fig. 2). The average annual mortality was 9% during the early years of the study (1968–1970), whereas the mortality declined to an average of $1 \pm 0.9\%$ (mean ± SD) in the most recent 6-year period (1981–1986). In Figure 2, the curve is the result of applying the Hanning smoother to the annual average mortality rates.

Burn size also had a statistically significant effect on mortality ($p < 0.001$), with a marked increase in mortality as the burn size increased to more than 50% BSA (Fig. 3). The mortality for small burns (<15% BSA) was 0%; the mortality rose steeply for burn sizes ≥50% BSA, increasing to a 65% mortality for burns 90–98% BSA.

For the young ages in this study group (11 days to 19 years), no consistent age trend was found in mortality for the sample population as a whole (Fig. 4). For the total group, the mortality was 4.2%. For the patients 1–2 years old, mortality dropped significantly to 0.8%. The mortalities for both the patients of the less than 1-year-old group and for those of the 6–12-year-old group were greater than the overall mortality (4.2%). The low mortality for the 1–2-year-olds may be partially explained by their having fewer than average large and massive burns (≥50% BSA), as shown in Figure 5. However, the infants (less than 1 year old) had a higher than average mortality, even though this same group also had a low incidence of large and massive burns.

In every age group, mortality increased with increasing burn size. Within each class of burn sizes, there was a tendency toward decreasing mortality with age, although the rate of change in mortality that occurred with age varied across burn sizes. Table 1 shows patterns of mortality based on the patients' ages for the four burn-size classes. All patients with small burns survived; mortality for patients with moderate burns was higher for infants (8.9%) than for older patients (1.3%, on the average); and for massive burns, the oldest patients had slightly lower mortality (27% for patients 13–19 years old *vs.* 43% for patients younger than 13 years old). For patients with large burns, mortality decreased for those aged 2–5 years, increased for 6–12-year-olds, and decreased again for those 13–19 years old (Table 1). The optimal method for determining whether age has a significant effect on mortality requires multivariate logistic modeling in order to control

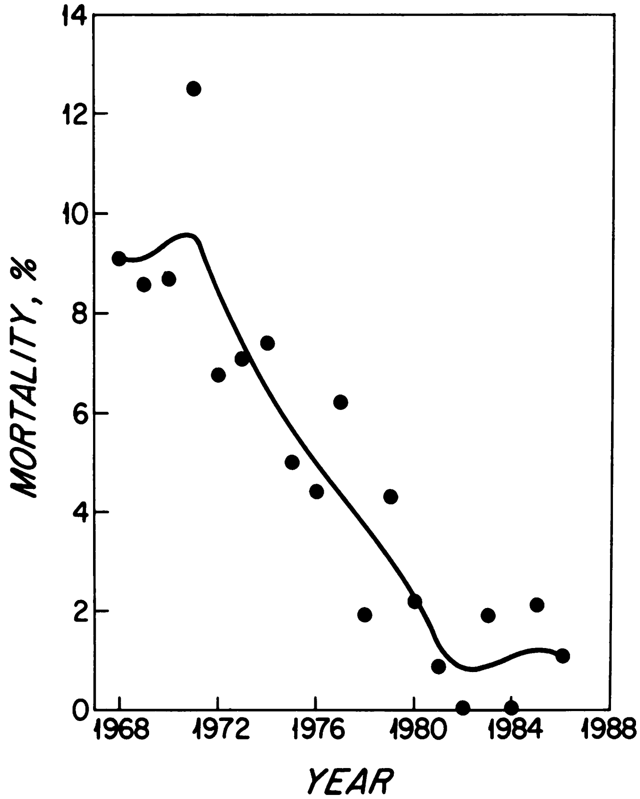


FIG. 2. Overall mortality *versus* year. The ordinate is the number of patients who died during a given year divided by the total number of admissions for the same year. The year 1968 represents the opening of the SBI; SBI was not fully operational until 1970. The overall mortality has markedly declined, from an annual average of 9% of SBI admissions during 1968–1970 to an annual average of 1% during 1981–1986.

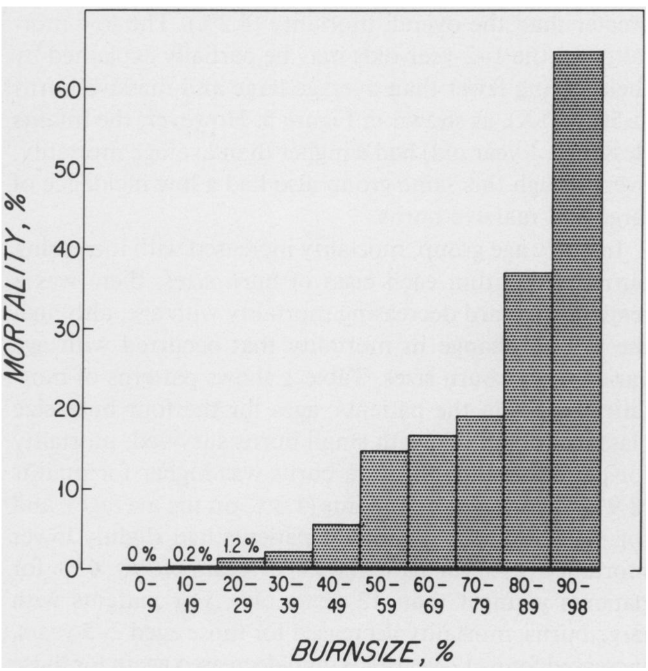


FIG. 3. Mortality *versus* burn size. Mortality is markedly associated with burn size, especially when the burn size is greater than 50 %BSA. The dependence of mortality upon burn size is nonlinear and appears exponential in character.

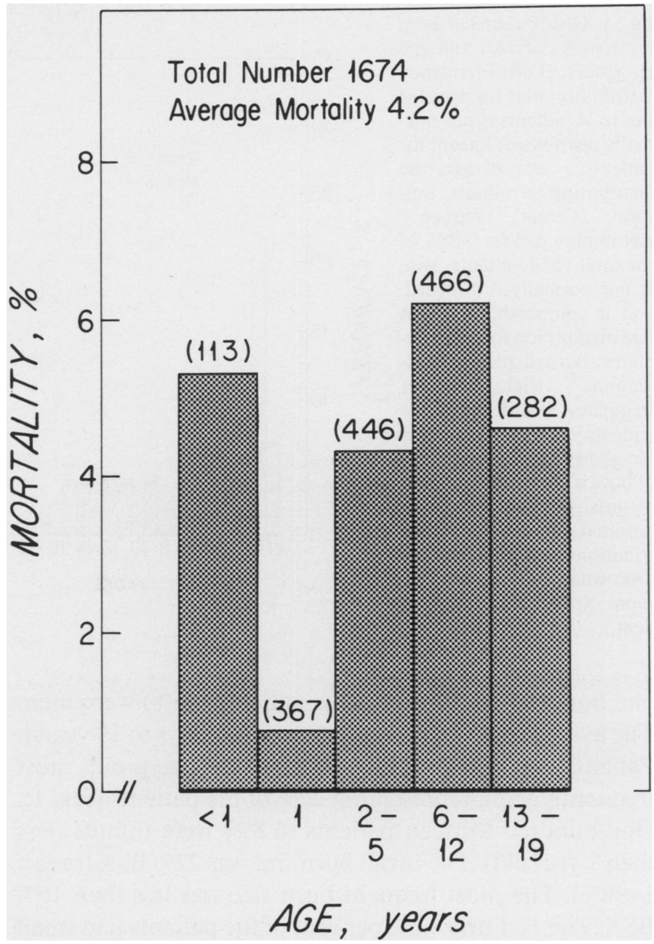


FIG. 4. Mortality *versus* age. Age does not show a consistent effect on mortality in this pediatric population (ages range of 11 days–19 years).

for effects of other variables, such as burn size and year of injury, which also influence mortality.

Time from burn injury to admission to SBI significantly influenced mortality. For patients admitted to SBI less than 30 days after receiving their burn injuries, mortality increased as delay in time to admission increased (Fig. 6A). None of the patients admitted 30 days or more after receiving their injury died. Because of the significant change in mortality at approximately 4 weeks, the univariate logistic model that best describes the effect of time to admission on mortality includes both a linear and a quadratic term to describe this statistically significant effect ($p = 0.017$).

A more detailed description of mortality for the 1368 patients who were admitted during the first week after receiving their burns is shown in Figure 6B. The mortality for patients admitted within 12 hours was 3.2%, which was lower than the average mortality for the patients admitted during the first week (3.8%). For patients in whom treatment was initiated before transfer, mortality increased with time to admission up to the third day. Average mortality was lowest for patients transferred on the third and

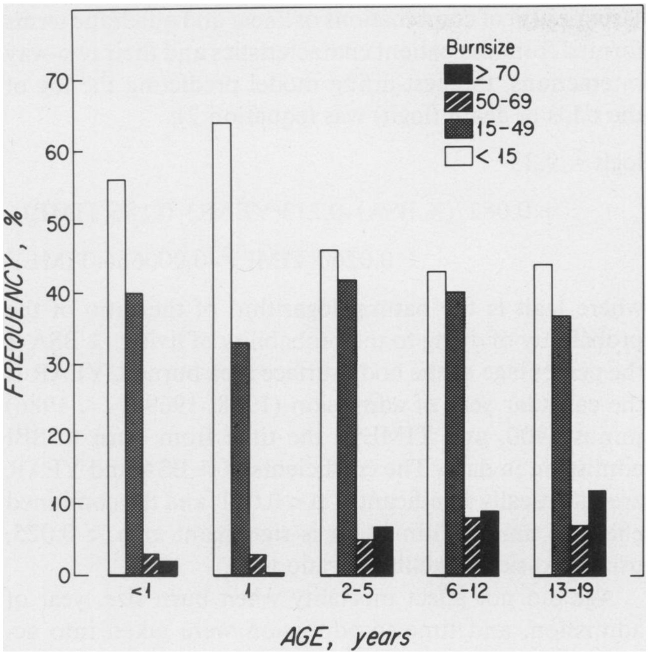
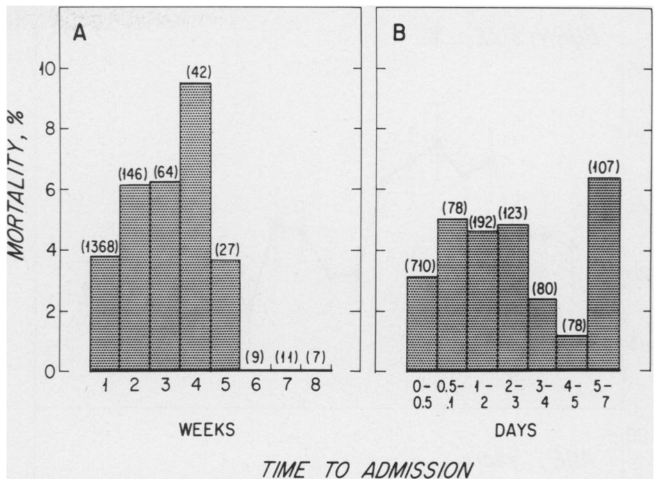


FIG. 5. Distribution of age by burn size. Patients younger than 2 years of age have fewer large and massive burn injuries than the older children. The frequency of these large and massive burns increases linearly with age as children become more active and independent.



FIGS. 6A and B. Mortality *versus* time to SBI admission. (A) Mortality for patients who were admitted to SBI 1-8 weeks after receiving burn injury. (B) Detailed mortality of those patients admitted during the first week.

fourth days. This reflects patients who survived resuscitation and were transferred before becoming septic. This group of patients did not include those who were unsuccessfully resuscitated elsewhere, but only represents patients who were healthy enough to survive resuscitation and transfer. Average mortality for patients transferred after the fourth day postburn was higher than for those transferred during all previous periods and was similar to that of patients transferred during the second week.

The overall mortality for females (4.9%) was higher than the corresponding mortality for males (3.8%). This difference in mortality was not statistically significant.

Multivariate Analysis

Overall mortality declined during the period of 1968–1987, as seen in Figure 2. Because age, burn size, time to admission, and treatment all influence burn mortality, the decline in overall mortality may have been the result of changes in these factors over the period of study. The annual average age of patients remained essentially constant at 6 years throughout the study period 1968–1986 (Fig. 7). The annual average time to admission decreased slightly from an average of 7.1 days during the first 3 years of SBI operation (1968–1970) to an average of 3.9 days during the last 3 years (1984–1986), as shown in Figure 7. The annual average burn size initially increased from 22% in 1968 to 30% in 1973, and thereafter decreased to 19% in 1986 (Fig. 7). When the total sample was divided into four "year of admission" groups and four burn-size groups, as described in the Methods section, there was an increasing proportion of patients with small burns (<15% BSA) and a decreasing proportion of moderate and large burns (15–49% and 50–69% BSA) over time, as shown in Figure 8. The frequency of massive burn injuries remained constant at 2% of patients admitted. Therefore, a decrease in the average burn size may partially account for the overall declining mortality.

TABLE 1. *Mortality Based on Patient Age and Burn Size*

Age (Years)	Burn Size % Mortality (Number of Patients) 1–14% BSA	15–49% BSA	50–69% BSA	70–98% BSA	Total
<1	0 (63)	8.9 (45)	* (3)	* (2)	5.3 (113)
1	0 (234)	1.7 (120)	8.3 (12)	* (1)	0.8 (367)
2–5	0 (203)	2.2 (186)	4.2 (24)	42.0 (33)	4.3 (446)
6–12	0 (198)	0.5 (188)	24.0 (38)	45.0 (42)	6.2 (466)
13–20	0 (125)	1.0 (104)	15.0 (20)	27.0 (33)	4.6 (282)
Total	0 (823)	1.9 (643)	15.0 (97)	39.0 (111)	4.2 (1674)

* Percent mortality omitted if less than 5 patients in the group.

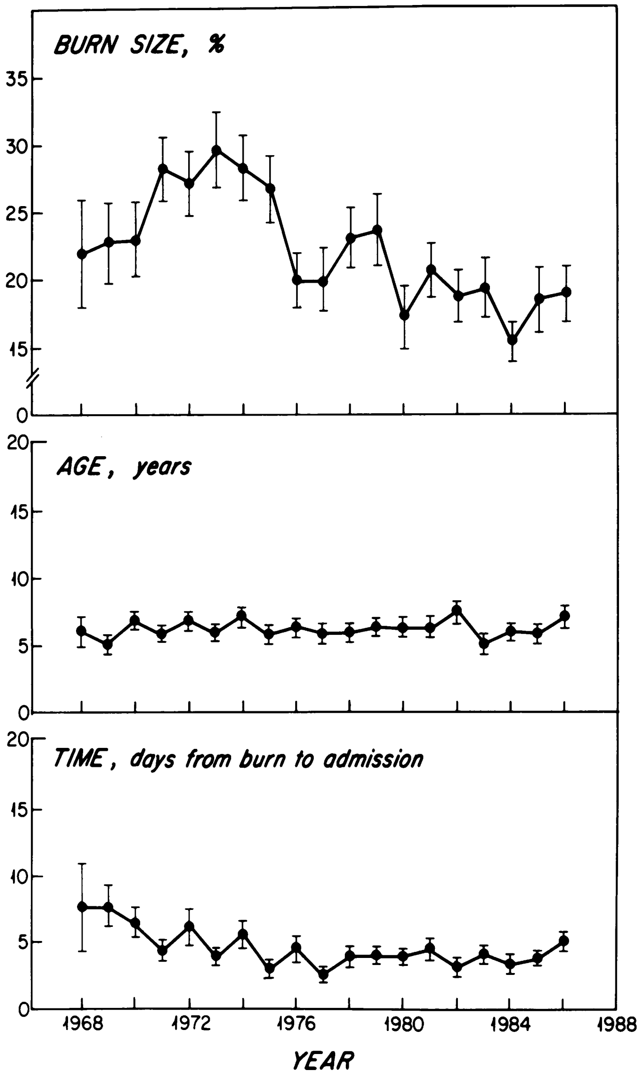


FIG. 7. Average burn size, age, and time to admission *versus* year. The abscissa is year for each variable. The ordinate is %BSA, age in years, and time to admission in days. The average annual %BSA increased initially and then decreased over the 19 years of the study; the annual average age does not change over the 19-year period; the average time to admission declined slightly over the 19 years period. (Mean ± SEM)

Reduced mortality over time occurred most dramatically in the large (50–69% BSA) and massive burns (≥70% BSA), based on a comparison of patient mortality, using the four time periods and burn size classes (Fig. 9). The mortality for large burns declined from 29% of the earlier period (1968–1973) to 0% in the later period (1983–1986); likewise, the mortality decreased from 60% to 23% for the massive injuries. This analysis reflects a general trend of improvement in mortality for burn sizes ≥15% BSA.

Logistic regression analysis permitted a determination as to whether age, burn size, year of admission, time from burn to admission, and gender were significantly associated with mortality after adjusting for the variations in frequencies with respect to one another (Figs. 5 and 8).

Using a sum of combinations of linear and quadratic terms formed from the patient characteristics and their two-way interactions, the best-fitting model predicting the log of the odds of death (logit) was (equation 2):

$$\text{logit} = 9.33 + 0.0827(\%\ \text{BSA}) - 0.213(\text{YEAR}) - 0.186(\text{TIME}) + 0.0260(\text{TIME})^2 - 0.000666(\text{TIME})^3$$

where logit is the natural logarithm of the ratio of the probability of dying to the probability of living, % BSA is the percentage of the body surface area burned, YEAR is the calendar year of admission (1968, 1969, . . . 1986) minus 1900, and TIME is the time from burn to SBI admission in days. The coefficients of % BSA and YEAR are statistically significant at $p < 0.001$, and the combined effect of time to admission is significant at $p < 0.025$, using two-sided likelihood ratio tests.

Age did not affect mortality when burn size, year of admission, and time to admission were taken into account. This was suggested in Table 1, in which age did not show a consistent pattern of mortality at different burn sizes. Gender also did not influence mortality. In addition, no potential interaction terms such as % BSA and YEAR, and no quadratic terms such as $(\%\ \text{BSA})^2$

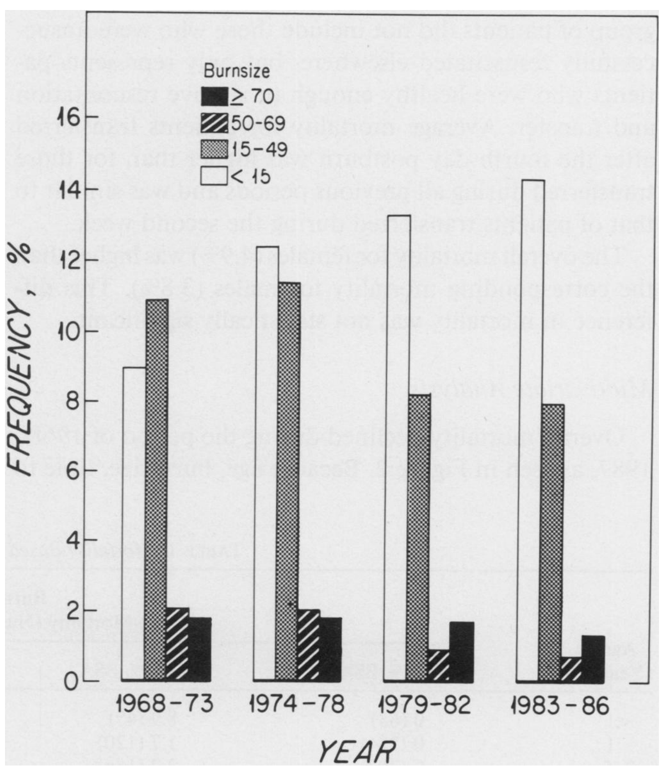


FIG. 8. Distribution of burn size by year. The decrease in annual average burn size may be explained by an increasing frequency of small burn sizes. Frequencies of large and massive burn sizes were constant over time.

were statistically significant. As seen in Equation 2, the mortality was optimally described by only three of the five independent patient characteristics studied (burn size, year of admission, and time to admission). This had been suggested by data shown in Figures 2, 3, and 6, which demonstrated the strong influences of these characteristics.

The logistic model closely agreed with the raw clinical data, as shown in the plot of survival *versus* year for burn size groups (Fig. 10). The filled symbols are the raw clinical data previously shown in Figure 9; the smooth curves (A–D) are theoretical values resulting from Equation 2 with % BSA = 6.6, 26, 57, and 83, respectively. The % BSA values used for each of the smooth curves were taken from the average burn sizes of the clinical data for indicated burn size groups.

Discussion

Mortality has markedly diminished in recent years for children with burn injuries. The overall mortality at the SBI (Boston Unit) has decreased from an average mortality of 9% of admissions for the years 1968–1970 to an average mortality of 1% for the more recent period of 1981–1986. This diminished mortality may be the result of at least three factors that are recognized as determinants of mortality in the burn injury: 1) changes in burn sizes of the patients over the period of study, 2) changes in ages of the patients over the period of study and 3) improvements in the overall treatment of the burned patients. In addition to the above determinants of mortality, in this pediatric patient population, time to admission was also found to significantly influence mortality. No single factor—burn size, age, or time to SBI admission—completely accounted for the observed diminished mortality. As a result of detailed statistical analysis, including multivariable logistic regression to control for age and burn size, statistically significant increased surfival of the pediatric burn patient at SBI may be attributed to improvements in treatment.

Improvements in burn care of the pediatric patient have paralleled the previously reported improvements in burn care treatment of adult patients at the Massachusetts General Hospital (MGH).[8,9,24] Before 1970, when the SBI began full operation, all burn patients, including the pediatric patients, were admitted to the MGH; since 1970, patients under the age of 15 have been treated at the SBI. Barnes reported detailed studies using univariate probit analysis on these pediatric patients treated at MGH during the periods 1939–1954 and 1955–1970.[8,9] Univariate probit analysis with comparison of the LA_{50} (lethal burn size area for 50% of the patients) for the two time periods (1939–1954 *vs.* 1955–1970) did not show significant differences in survival between these two periods. Therefore, the data shown in Table 2 is from the 1939–1954 period and is considered representative of both periods. Although

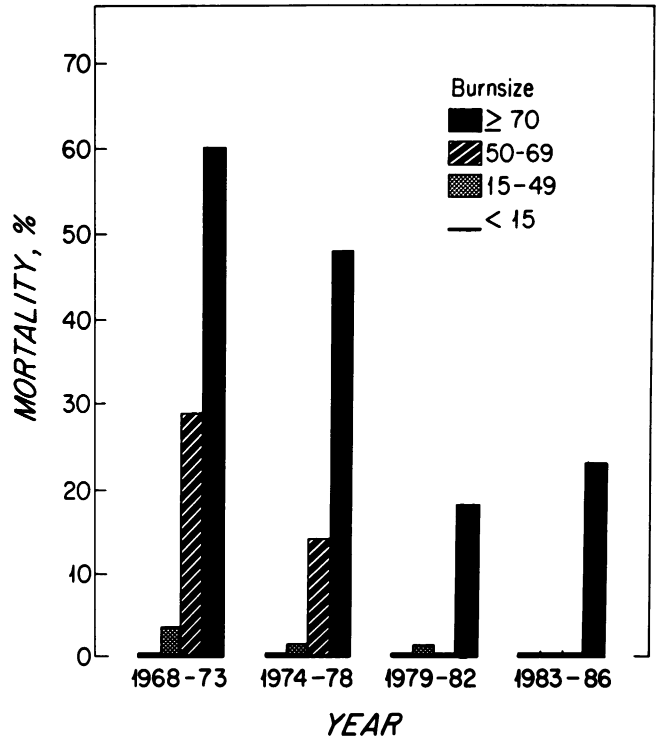


FIG. 9. Mortality *versus* time by burn size. Mortality has markedly declined in the massive burn size group. Mortality has been essentially eliminated in moderate and large burn sizes of 15–69% BSA during the most recent time period (1983–1986).

the overall mortality was similar for the 1939–1954 period (4.6%) as compared with the recent 1968–1986 period (4.2%), there has been dramatic progress in survival within

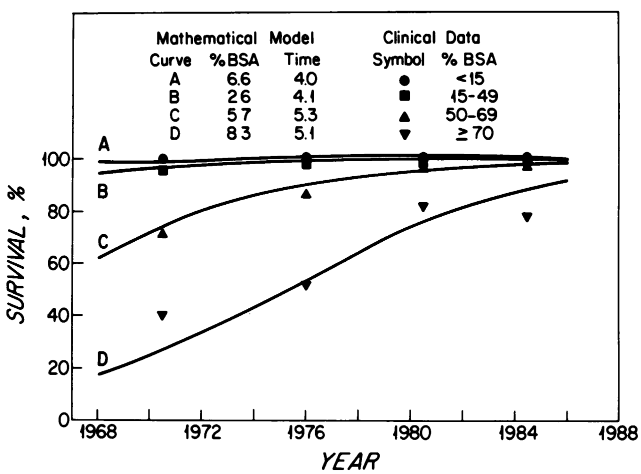


FIG. 10. Logit curves of survival *versus* time for selected burn sizes. The ordinate is survival and abscissa is year of SBI admission. The smooth contour curves are the results of the logit function (Equation 2) with the indicated %BSA and TIME that were averages of these parameters in these %BSA groups. The solid data points represent patient survival data taken for the indicated burn size groups and plotted *versus* year. Because the patient data was plotted at the midpoint of each 4-year group, each data point has variances in both the *x* and *y* directions, which are not shown.

TABLE 2. *Mortality Burn Size*

Burn Size	1939–54* % Mortality (Number of Patients)	1968–86 % Mortality (Number of Patients)
1–4% BSA	0 (85)	0 (289)
5–14% BSA	0 (89)	0 (534)
15–24% BSA	0 (23)	0 (312)
25–34% BSA	11.0 (9)	0.6 (181)
35–44% BSA	50.0 (4)	4.2 (118)
45–100% BSA	100.0 (7)	25.0 (240)
Total	4.6 (217)	4.2 (1674)

* Data from 1939–1954 is shown; data from 1955–1970 is not shown.

burn size groups and especially in moderate and larger burns sizes. In the earlier period (1939–1954), there were no survivors of burn sizes greater than 45% BSA. Even taking the patients in the current study (1968–1986) as an entire group, the expected mortality for the current study is dramatically lower than that of the previous studies (1939–1970). In addition, as seen in Figures 2 and 10, even the expected mortality rates of the current study have declined dramatically from 1968 to 1987.

Many reports have suggested that children, particularly small children (less than 4 years of age) had a diminished probability of surviving as compared with the expected survival of young adults (20–29 years old) with equivalent burn injuries.[8–17] Survival curves (plots of survival rates *vs.* age for various burn sizes) have been reported that demonstrate peaks in survival in the 20–29-year decile, with decreased expected survival for either younger or older patients with equivalent burn injuries.[10] On the other hand, recent reports agree with those suggesting that the expected survival for children with burn injuries is at least as good as if not better than the survival of young adults with equivalent burn injuries.[1–7] As a result of the detailed statistical analysis of this report, we believe that young children, including infants, survive burn injuries as least as well as young adults,[24] and that, according to the logistic model, within the young age group (11 days to 19 years), age does not influence survival at all.

The mortality results described in this report are consistent with the recent experience of others.[4,5,25] In a comparable pediatric age group, Herndon reports an overall mortality of 2.7% during the years 1982–1986 for 1057 patients, as compared with 1% during the years 1981–1986 in this report.[4] In particular, he noted a decreased mortality (41% of 32 patients) for patients with burn sizes 80% or greater; this bears comparison with the results of the present study, which demonstrates a mortality of 22% for 37 patients with a burn size of 80% or greater during the years 1979–1986. The LA_{50} of the two studies was also comparable with a LA_{50} of 95% BSA that was reported by Herndon for the period 1982–1986; the present series shows an LA_{50} of 99% BSA for the year 1984. This latter estimate results from Equation 2 using a logit(0.5), YEAR = 84, and TIME = 3.2 (average time to SBI admission in 1984). In another recent report, Bowser also reports excellent survival of children with burn injuries with an LA_{50} of 82% BSA for those 4 years old or younger during the period 1975–1980.[5]

Presence of significant pulmonary burn injury is considered an important determinant of the mortality of a given patient.[25,26] We do not believe that the frequency of the pulmonary burn injury of these patients has changed over the period of study (1968–1986), and therefore, we do not believe that the improvements in survival can be attributed to differences in the frequency of pulmonary burns. We have not included pulmonary injury as a mortality determinant in this study because we may only document a pulmonary injury in the emergency ward as being present, and have not been able to accurately predict its severity.

In this study, both the descriptive and statistical data strongly indicate that the improvement in mortality from 1968–1986 is substantially due to improvements in patient treatment. Without a controlled study, it is not possible to identify any single treatment factor. However, the particular patient population described in this study has received the benefits of many investigations that resulted in improvements in the care of burned patients. During 1969–1974, a prospective trial of primary excision and immediate wound closure was conducted in patients at the SBI.[18] Results of this trial suggested an improved survival rate and a shortening of the length of hospitalization. Based on this experience, combined with substantial improvements in anesthetic techniques,[27] prompt excision and immediate wound closure became the standard treatment at SBI. The experience of other groups using this approach has been similar.[28–34] Early experience with skin banking and preservation of human skin resulted in the availability of allografts for wound closure.[20] Bacteria Controlled Nursing Units (BCNU) were developed to reduce bacterial cross-contamination among the patients and to provide a controlled environment of elevated ambient temperature and relative humidity for the individual patient.[23] Recent experience with similar techniques has also confirmed the benefits of isolation methods in the prevention of bacterial cross-contamination.[35] In these same patients, it was reported that there was a dramatic improvement in survival from massive burn injuries, using immunosuppression with azathioprine or antithymocyte globulin (ATG), along with longer-term wound closure with cadaver donor skin grafts.[36,37] More recently, skin replacement with both artificial skin and cultured epidermis to provide immediate physiologic wound closure has been studied in these patients, yielding encouraging results.[21,22]

Many other improvements in the total care of these patients have also contributed to their improved survival. In particular, these improvements include highly skilled nursing care, as well as attention to nutrition, respiratory care, and preventive antibiotics. In addition, other changes in patient care have occurred. Improvements in topical wound management now allow increasing numbers of patients with smaller acute burns to be treated as outpatients. Because the treatment method of prompt excision and immediate wound closure requires that most of these treatment modalities be used simultaneously to optimize the physiologic, metabolic, and immunologic status of the patient, it will be impossible to separate the individual influences of these improvements in patient management on survival from the influence of excisional treatment methods alone.

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