Objective Estimates of the Risk Factors for Death and Length of Hospitalization following Burn Injuries, Soroka University Medical Center, 2001–2002

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ABSTRACT: **Background:** Burn injuries are extremely common and may impose a serious load on public health around the world.
Objectives: To compare mortality rates and length of hospitalization according to the identified risk factors, extent of burn, gender and age.
Methods: In this retrospective study, data from 558 archive files of hospitalization due to burns as the diagnosis in patients of all ages, between the years 2001 and 2002, were analyzed to identify the risk factors for mortality and length of hospitalization.
Results: Males comprised 62.4% of the hospitalized burn patients. The mortality rate was 3.2% (n=18) and among them 55.6% were women. Fifty percent of the fatality cases were over 48 years old, with statistically significant correlation of mortality rate and age. Most of the fatality cases (66.7%) had burns with total burn surface area (TBSA) larger than 40%. The multiple logistic regression model showed that leukocyte count on admission, TBSA, and age are the most important predictors of mortality. Smoke inhalation was not found to be an independent risk factor.
Conclusions: Using a statistical model for estimating the mortality rate, this study found that white blood cell count at admission, TBSA, and age were the most significant predictors of mortality.

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KEY WORDS: burns, total body surface area (TBSA), mortality, risk factors, prediction

Burn injuries impose a serious load on public health around the world. They are extremely common, with as much as 1% of the world population being affected [1]. Burns have a devastating effect as they require long hospitalization, may result in serious physical as well as psychological sequelae, and may require multidisciplinary treatment to prevent morbidity and mortality. Burn injury severity can be characterized by several parameters – total body surface area, the area of the burn, the depth of the burn (superficial, partial-superficial, partial-deep, full-skin thickness), the specific location of the burn, and whether the patient suffered from smoke inhalation. The mortality from burns has declined significantly in the last few decades but is still high in patients with extensive burns [2]. Research has shown that mortality rates are reduced in patients who received early surgical treatment [3,4]. Research has also shown a difference in the mortality rates of different groups – such as a higher mortality rate for women [5,6] and an increase in mortality with age [7] – and in the percentage and depth of the burn [3,8]. Ryan et al. [9] built a model for mortality from burns and showed that the three main prognostic factors are age over 60, TBSA > 40%, and smoke inhalation. It was concluded from this model that if none of these factors are present the risk for death is 0.3%, if one factor it is 3%, two factors 33%, and three factors > 90%. Newer models have added other prognostic factors such as gender, prior medical history/premorbidities, and the type of treatment [10-12]. Burn victims tend to suffer from severe burn-related complications such as hypoxemia, hypotension and myocardial dysfunction, and research has shown that due to these complications burn patients tend to be hospitalized for long periods. A recent study has shown that for every percent of burn area a patient will be hospitalized for 1.5 days on average [10].

Due to our unique heterogeneous population and its different cultural habits, we wished to explore whether there are specific mortality and morbidity factors that differentiate this population from other burn patients. We believe that by defining the specific risk factors for morbidity and mortality we can decrease morbidity and mortality rates as well as shorten hospitalization time. Specific mortality and morbidity risk factors were identified in several studies [13,14], but to our knowledge this has not been done in Israel.

PATIENTS AND METHODS

This work was an epidemiological retrospective study based on data gathered from patients' files. The study population comprised burn patients who were admitted to the Soroka University Medical Center in the years 2001–2002. Soroka is the only medical center in the Negev and thus serves the entire population of the Negev; we believe the study population truly represents the population of the region.

Data were collected from patients' files, including information gathered at admission in the emergency department until the end of hospitalization. Data included epidemiological characteristics (age, gender, origin, socioeconomic status), clinical characteristics (cause of the burn, smoke inhalation, treatments, nutrition, hospitalization duration), burn complications (infections, intubation, recurrent hospitalizations, contractures, mortality), and cause of death.

We investigated the causes for mortality including gender, age (grouped into ages 1–20, 21–26, 27–34, 35–48, and 48+) and burn area (0–2%, 2–4%, 5–9%, 10–19%, 20–40%, and 40+%).

STATISTICAL ANALYSIS

Data were stored and analyzed using SPSS 12.0 for Windows. Data were analyzed using parametric tests (*t*-test and ANOVA) for normally distributed variables, and aparametric tests (Mann-Whitney and chi-square) in non-quantitative variables or variables with an abnormal distribution. A logistic regression was built to identify mortality risk factors. Odds ratios and confidence intervals were assumed with 95%. $P < 0.05$ was considered significant.

Sample size was influenced by the fact that there are not enough studies on the subject and that a large variety exists in the reported mortality rates between these studies. Thus we assumed that the mortality rate in patients with severe burns is 10% ($\pi = 10\%$)]15], the assumed error E = 5%, and $\alpha = 0.01$, leading us to the following sample size calculation:

$\pi\ (100-\pi)/E^{2}2$ * n= $\Sigma\zeta(1-\alpha/2)$

$n = 2.33^{2} *9*(100-9)/25 = 5.43*819/25 = 178.88$

Thus, it was assumed that 180 patients would give us a large enough sample size. In fact, we included all burn patients in the years 2001–2002, i.e., 558 patients.

RESULTS

Of the 558 patients surveyed, 210 were women (37.6%). We categorized age into five groups: 0–20, 21–26, 27–34, 35–48, and 48+ years old. The mean age of the patients who died was 45.2, which is much higher than the mean age of burn patients, 15.4 years. On evaluating mortality rates in the different age groups we found a significant difference ($P < 0.01$) [Figure 1]. We grouped all patients in the age group 21–48; we also observed a significant difference in mortality rates ($P < 0.01$) and noted that half the patients who died were in this age group.

The severity of the burn as measured by TBSA is depicted in Figure 2. Eighteen of our patients (3.2%) died during their hospitalization; of them 10 were women (55.6%). A chi-square test showed no significant difference in mortality

Figure 1. Mortality by age group **[A]** and TBSA **[B]**

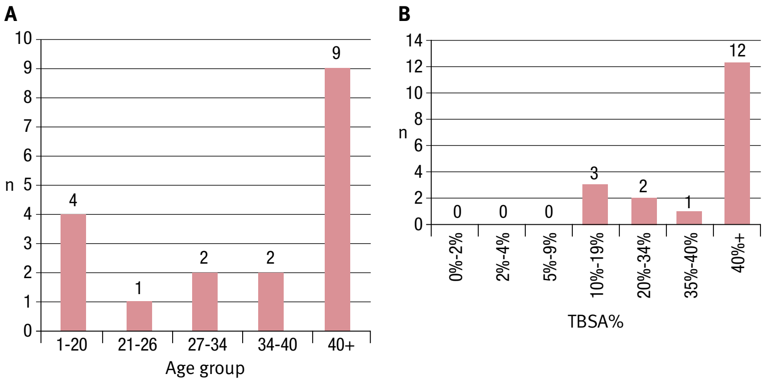
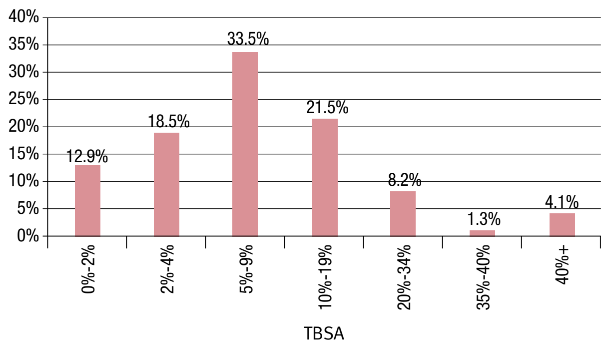


Figure 2. Frequency of burn severity



rates between men and women ($P = 0.112$). It is important to note that among the patients who died from their burns, the mean TBSA was 62%. We did find three cases of death with a lower TBSA (12–15%), which could be ascribed to the old age of these patients or to their severe background illnesses.

When comparing mortality rates in the different TBSA groups, we found that a third of the fatalities occurred in patients with TBSA > 40%, and that most of the patients who died had TBSA more than 40% (52.2%). A comparison of patients with large burn area (> 40%) to those with lower TBSA showed a significant difference ($P < 0.01$) [Figure 1].

When comparing hospitalization duration in men (10.32) and women (13.74), we found a significant difference ($P = 0.014$). When comparing hospitalization stay in the different age groups, we found a significant difference: $P = 0.014$, $F(4,364)=3.171$, but post hoc tests could not find the source of the difference. A comparison of hospitalization stay between patients with different burn percentages demonstrated a significant difference: $P < 0.01$, $F(5, 358) = 22.641$, and post hoc tests showed that the source of this difference was between the patients with a high level of burn (> 20%) [Table 1].

We tried to build a regression model to predict mortality by using the following variables: white blood cell count at admission, TBSA, and age – all of which were significant

Table 1. ANOVA and post hoc analysis of hospitalization duration in accordance with TBSA

Burn percentage	In comparison to	*P*
+40%	< 2% 2–4% 5–9% 10–19%	< 0.001 < 0.001 < 0.001 < 0.001
20–40%	< 2% 2–4% 5–9% 10–19%	< 0.001 < 0.001 < 0.001 0.044
10–19%	< 2% 2–4%	0.041 0.043

Table 2A. Logistic regression model for the prediction of death from burns

	OR	95% CI	*P*
WBC	1.20	1.013–1.273	0.029
TBSA	1.162	1.030–1.312	0.015
AGE	1.135	1.013–1.273	0.029

Table 2B. Logistic regression model for the prediction of death from burns including smoke inhalation

			95% CI for OR		
	df	Sig.	OR	Lower	Upper
TBSA	1	0.000	1.129	1.064	1.199
Age	1	0.000	1.097	1.042	1.154
Gender	1	0.730	1.354	0.242	7.567
Ethnicity	1	0.915	0.894	0.114	7.038
Smoke inhalation	1	0.383	2.302	0.354	14.967

CI = confidence interval, OR = odds ratio, TBSA = total body surface area, WBC = white blood cells

as predictors. The most influential was WBC at admission, then TBSA, and last was age [Table 2A]. The model also adjusted for other variables that were entered. We tried to see if smoke inhalation was an independent risk factor for death, but in this model it was not [Table 2B].

DISCUSSION

Reviewing our data we found, as in other studies [9], that age is a significant risk factor for death from burns, and it is widely acknowledged today that age older than 60 is a significant risk factor [15–17]. The current study has shown that 50% of deaths occurred in patients older than 48, and a significant difference in mortality rates was found in the different age groups ($P < 0.01$).

Another known risk factor for death from burns is the size of the burn: % TBSA. Anlatici and co-workers [3,18] found that the TBSA in people who did not die from burns was 22.4% on average, compared to 48.8% in those who died ($P < 0.01$). In the current study 67% of deaths occurred in patients with TBSA > 40% ($P < 0.01$).

The question of gender as a risk factor for death among burn patients is more controversial. George and collaborators [13] found that women are more at risk, which has been shown in other studies as well [6]. The current study did not find similar differences and gender was not found to be a risk factor, as seen in other studies as well [9,11]. However, we did find a difference between men and women in hospitalization duration ($P = 0.014$), with longer stay in women. This was also shown in other studies [19,20], which led us to believe that female burn patients are more at risk, if not for mortality then for morbidity. Some investigators, such as Kerby et al. [21] and Gregory et al. [22], speculated that there are differences in male and female immunomodulation factors, such as interleukin-6, which might explain this difference in morbidity. Age is also considered a risk factor for longer hospitalization [9,23], as shown in the current study. We noted that patients with elevated TBSA (> 20%) were hospitalized for significantly longer durations.

Ryan et al. [9] tried to create a prediction model for death from burns, but their model did not consider gender as a factor. Newer studies have tried alternative prediction models. O'Keefe and team [6] used prediction factors such as TBSA, smoke inhalation, age, and gender. Sharma et al. [11] found that age, gender, burn cause, and TBSA are the significant risk factors for death from burns. Similar to these studies, we tried to build a predictive model to evaluate the risk for dying from burns by using a logistic regression model and found that the significant factors for prediction are age, burn % TBSA, and leukocyte level on admission. From a survey of similar models we found that leukocyte level as a prognostic factor was not mentioned, although it is well known that burns have a significant inflammatory component [23]. This could be attributed to the fact that inflammation follows tissue damage caused by the burn, and if this inflammatory response is intense this could lead to multiple organ failure and even death. This inflammatory response is short lived and lasts only a few days, hence the importance of WBC on admission. One may postulate that a marker for the inflammatory response could help us in treating patients; it is well known that leukocyte level is strongly correlated with the severity of the inflammatory response, as are other inflammatory markers such as erythrocyte sedimentation rate and C-reactive protein. Other studies have shown that leukocyte level has an important prognostic value in illnesses like ischemic heart disease and stroke [24] and it is worthwhile considering when predicting burn severity. On the other hand, we might explain the elevated leukocyte level as due to an infection that accompanies the burn; further research would thus be warranted to determine if and at what level leukocytes can be considered a risk factor. What part of the differential WBC is more important? And would an addition of other inflammation markers contribute to the prognostic value of leukocyte level at admission?

WBC level is a simple and inexpensive test that is performed routinely on admission. It is surprising that a literature review has not shown the usefulness of WBC level as a prognostic factor in burn patients. Although our finding needs further validation it is worth considering when admitting new burn patients as it might help to quantify the extent of inflammation and the risk of dying.

There are some discrepancies between our findings and other studies; for example, our female patients were not more prone to mortality. We believe this is due to the low mortality rate and small number in our study (18 in all) and thus feel there is a need to continue to gather data and expand the sample size. Another explanation may arise from the population age stratification: in our study the majority of patients were younger than 20 years old. This might have lowered the mortality rate in our sample compared to other studies. We note that in older patients [25] the mortality rate is higher. Our study population is specific in nature, mainly due to the fact that a large proportion is underprivileged and has a lower socioeconomic background. Thus, other populations should be studied, such as in the center of Israel where the socioeconomic backgrounds are higher. Another difference between the current study and prior research is the issue of smoke inhalation, which was not found to be an independent risk factor in the regression analysis. We found the same in the univariate analysis where this variable was not significant. We attribute this to the small number of patients who suffered from smoke inhalation, and our sample size was thus underpowered to seek this specific goal.

The current study has a number of limitations. First, this was a retrospective study and therefore is subject to all the problems inherent in that type of study. Second, since we did not include information on the type of treatment (surgical or non-surgical) or on postoperative complications, our speculations cannot answer questions about the different treatment regimens, which play an important role in mortality rate [18].

CONCLUSIONS

The current study found that age and the severity of burn wound as depicted by % TBSA are risk factors for death from burns. Gender was not found to be a risk factor for mortality, although gender and TBSA were found to be risk factors for prolonged hospitalization. Age, on the other hand, was not a risk factor for prolonged hospitalization. Using logistic regression models, we found that leukocyte count on admission, % TBSA, and age are significant predictors for death. There is a need for further studies to determine whether leukocyte count on admission is indeed a prognostic factor for mortality, and if so, this can serve as an objective tool to quantify burn severity and the risk of death from burns.

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