Predictive models for mortality and length of hospital stay in an Egyptian burns centre

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نماذج للتكُّهن بالوفيات ومدة الإقامة بالمستشفى في مركز مصري لمعالجة الحروق

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خلاصة: كان هدف الدراسة رسم صورة إحصائية للمتوفين والناجين من الوفاة بين ضحايا الحروق، وتكوين نماذج للتكهن بالوفيات ومدة البقاء بالمستشفى. وشملت الدراسة جميع المرضى الذين أُدخلوا في وحدة الحروق بالمستشفى الرئيسي لجامعة الإسكندرية خلال سنة كاملة. ووجد أنه من بين 533 حالة كان متوسط مدة البقاء بالمستشفى 15.5 ± 21.6 يوماً. وكان معدل الوفيات 33%. وكانت المساحة الكلية لمنطقة الحرق، والحروق الاستنشاقية، والعمر، والجنس، وعمق الحروق ودرجاتها، هي عوامل التكهن المستقلة، ذات الدلالة الإحصائية، للوفاة، في تحليل التحيُّف اللوجستي المتعدد العوامل. أما عوامل التكهن المستقلة ذات الدلالة الإحصائية والمتعلقة بطول مدة البقاء بالمستشفى فكانت احتراق الملابس والمساحة الكلية للمنطقة المنحرقة والجنس ودرجة الحرق وعمقه والحروق الاستنشاقية.

ABSTRACT Our aim was to obtain a statistical profile of survivors and deaths among burn victims and to develop predictive models for mortality and length of hospital stay. All patients admitted to the Burns Unit of Alexandria Main University Hospital over a 1-year period were included. Of 533 cases , mean length of hospital stay was 15.5 ± 21.6 days and the mortality rate was 33%. Total surface area burnt, inhalation burns, age, sex, depth and degree of burn wounds were the significant independent predictors of mortality in multiple logistic regression analysis. The significant independent predictors of the length of hospital stay were clothing ignition, total surface area burnt, sex, degree and depth of burn and inhalation burns.

Modèlee prédictife pour la mortalité et la durée du séjour hospitalier dans un centre des brûlés égyptien

RESUME Le but de notre étude était d'obtenir un profil statistique relatif aux survivants et aux décès parmi les victimes de brûlures et d'élaborer des modèles prédictifs pour la mortalité et la durée du séjour hospitalier. Tous les patients admis au Centre des brûlés de l'Hôpital universitaire principal d'Alexandrie sur une période d'un an ont été inclus dans l'étude. Pour 533 cas, la durée moyenne du séjour hospitalier était de 15,5 ± 21,6 jours et le taux de mortalité s'élevait à 33%. La surface totale brûlée, les brûlures par inhalation, l'âge, le sexe, la profondeur et le degré des blessures par brûlures étaient les prédicteurs indépendants significatifs pour la mortalité dans l'analyse de régression logistique multiple. Les prédicteurs indépendants significatifs pour la durée du séjour hospitalier étaient l'ignition des vêtements, la surface totale brûlée, le sexe, le degré et la profondeur des brûlures et les brûlures par inhalation.

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Introduction

Burn injuries are an extremely stressful experience for victims and their families. Patients with extensive burns frequently die, and for those with less severe injuries, physical recovery is slow and painful [*1*]. Mortality is the most important, most readily quantified and most oft-studied outcome among burn patients [*2*]. On admission, the patient and/or the patient's family often ask questions about chances of survival. Clinicians frequently are unable to provide an accurate assessment of outcomes because of a lack of statistical data. When available, such data can guide clinicians in the management of their patients and help to provide better quality information to the patient and the patient's family [*3*].

Statistical multivariate regression analysis can explain a significant amount of the variation in the patient factors studied. Through multivariate regression, confounding factors can be controlled for, and the contribution of individual variables evaluated. Multivariate regression yields a predictive equation that indicates how values of the independent or predictor variables may be weighted and summed to obtain the best possible prediction of the dependent or predicted variables [*3*]. Mortality predictive models [*4*] have many important applications, including:

- calculation of an admission severity score to aid in patient management;
- assistance in patient and family counselling;
- identification for audit of those patients whose fate differs substantially from that predicted;
- use as a standard for evaluation of new therapies;
- targeting of distinct risk factors for improvements in therapy.

Length of hospital stay is an important measure of morbidity. There is a clinical impression that the length of stay is positively correlated with total length of time off work and the post-burn complications requiring physiotherapy, occupational therapy and surgical intervention [*3*]. One direct use of a morbidity index is the estimation of the distribution of scarce resources for burns treatment [*4*]. The predictive model for the length of hospital stay can potentially be used to assist in patient and family counselling, as a standard for evaluating new therapies and to estimate the distribution of resources for burns treatment, including burns bed needs.

Models from one institution should not be used to forecast outcomes in another burns unit. Significant variations between patient treatment protocols may exist and mortality experience may differ significantly. Individual burns units need to develop their own models for analysis and cross comparison. The present study was carried out to obtain a statistical profile of survivors and deaths, and to develop predictive statistical models for burns mortality and length of hospital stay in an Egyptian burns unit.

Patients and methods

All cases admitted to the Alexandria Main University Hospital Burns Unit throughout the 1-year period, January–December 1997, were included in the study. Data collection was carried out by questionnaire-interview with patients, using a pre-planned, specially designed questionnaire. Data collected on admission and updated on discharge included:

- Registration data (name, age, sex, address);
- socioeconomic data (marital status, crowding index, education, occupation, family income);

- injury data (place and agent of burn, first-aid measure used, patient's and attendant's reaction, cause of delay, if any, in obtaining medical attention);
- chronological data (date and time of injury, length of hospital stay, discharge destination);
- clinical data (site affected, total surface area burnt (TSAB), degree, depth and severity of the burn wound and complications, if any).

Statistical analysis

Information regarding each patient was transferred to code sheets and the data were analysed using *SPSS* version 6 software. The relationship between mortality and patient profile was studied using multivariate logistic regression analysis. The model for prediction of probability of dealth was expressed by the formula:

$$\left(1+e^{-[\beta_0+\sum\beta_i\chi_i]}\right)^{-1}$$

where χ_i are the patient factors; β_0 is a constant; and β_i are the respective coefficients of the patient factors.

The factors used in the development of this model included age and sex of the patient, agent and intent of burn injury, occurrence of clothing ignition, TSAB, degree and depth of the burn wound, and the occurrence of inhalation burns. These factors were individually correlated significantly with outcome (survived or died), using the appropriate test of significance (chi-squared test for nominal and ordinal factors and Student *t*-test for quantitative continuous variables).

The relationship between survived patients' profiles and length of hospital stay was studied using multivariate linear regression analysis. The linear regression analysis model for prediction of length of hospital stay was expressed in the formula:

$$\delta = a_0 + \sum\beta_i\chi_i$$

where χ_i are the patient factors; a_0 is the intercept at the y axis; and β_i are the respective coefficients of the patient factors.

Only the survived patients (n = 357) were included in the model for prediction of length of hospital stay using linear analysis. The factors used to develop the morbidity predictive model were the same factors used for the mortality model. These factors were also individually correlated significantly with the length of hospital stay using the independent samples Student *t*-test or ANOVA and the Spearman rank correlation coefficient for continuous factors. The coding of categorical variables used to develop the models was as follows: sex: 0 male, 1 female; inhalation burns: 0 did not occur, 1 occurred; clothing ignition: 0 did not occur, 1 occurred; and depth: 0 superficial, 1 deep.

Results

There were 533 burn patients in the study, ranging in age from 6 months to 81 years [mean age (SD) = 22.95 (16.71) years]. There was an almost equal distribution of cases by sex (M:F = 1:1.004). However, when stratified by age, more females were found in the age groups < 5 years, 10–30 years and 40–60 years. The majority of cases (91.4%) occurred at home — mostly in the kitchen (57.0%) and commonly during cooking (63.5%). Occupational and street burns represented 4.7% and 3.9% of the total respectively. Flame was the most common agent responsible for burn occurrence (66.8%), followed by scalds (26.3%). Electrical and chemical burns represented 3.9% and 3.0% respectively. Ignition of clothes was reported in 83% of flame burns cases, mostly among females. Inhalation burns occurred among

8.6% of cases. The case fatality rate was 33%. Table 1 shows the difference between survivors and those who died with regard to age, sex, TSAB and agent. The length of hospital stay ranged from 0.2 to 138 days [mean length (SD) = 16.2 (19.5) days]. For survivors, the mean length of hospital stay was 51.5 (21.7) days, while that for those who died it was 5.3 (5.1) days.

Table 1 **Distribution of factors affecting condition on admittance among survivors and those who died**

Variable	Survived		Died		χ^2	*P*
	No.	%	No.	%		
Age group (years)						
< 10	108	82.4	23	17.6	35.6	0.0000
10–20	74	61.7	46	38.3		
21–40	145	68.7	66	31.3		
> 40	30	40.1	41	59.9		
Sex						
Male	218	82.0	48	18.0	53.8	0.0000
Female	139	52.1	128	47.9		
TSAB (%)						
20	321	95.3	16	4.7	359.7	0.0000
40	33	35.5	60	64.5		
100	3	2.9	100	79.1		
Agent						
Flame	192	53.9	164	6.1	82.5	0.0000
Non-flame	165	93.2	12	6.8		
Depth						
Superficial	194	99.5	1	0.5	147.5	0.0000
Deep	162	48.2	175	51.8		
Degree						
1st and 2nd	27	96.4	1	3.6	214.8	0.0000
2nd	228	96.6	8	3.4		
3rd	6	85.7	1	14.3		
2nd and 3rd	96	36.6	166	63.4		
Complication						
No inhalation	357	67.9	119	32.1	14.3	0.0002
Inhalation	0	0	7	100.0		
Clothing ignition						
No	217	91.2	21	8.8	113.8	0.0000
Yes	140	47.5	155	52.5		
Intent						
Unintentional	337	71.0	138	29.0	31.1	0.0000
Intentional	20	34.5	38	65.5		

TSAB = total surface area burnt.

Mortality predictive model

By applying logistic regression analysis using forward stepwise selection based on the probability of likelihood ratio statistics, it was shown that of nine factors, only five were significantly different between survivors and those who died. These were: TSAB, occurrence of inhalation burns, depth of burn wound, degree of the burn wound and age of the burn patient. Thus, probability of death =

$$\left(1+e^{[-9.089+2.8x_1-2.54x_2+2.69x_3-1.34x_4-1.98x_5]}\right)^{-1}$$

where x_1, x_2, x_3, x_3, x_4 and x_5 represent respectively: TSAB, occurrence of inhalation burns, depth of burn wound, degree of burn wound and age of the burn patient.

Length of hospital stay predictive model

The significant predictors of length of hospital stay were: TSAB, degree of burn wound, depth of burn wound, occurrence of clothing ignition, sex and occurrence of inhalation burns. This model explained 44.5% of the variability in the dependent variable where $r^2 = 0.444$.

Length of hospital stay in days = –17.81 + 6.89(occurrence of inhalation burn) + 7.74(depth) + 4.31(sex) + 0.365(TSAB) + 1.95(degree) + 5.27(clothing ignition).

Discussion

An accurate, objective estimate of the probability of death provides clinicians with an explicit basis for clinical decisions. It also helps them understand the relative contributions of specific prognostic criteria and reduces reliance on clinical intuition. In addition, the estimates can be useful to patients and to others making financial decisions about their care [5]. In our study, the case fatality rate was 33%. Higher case fa-

Table 2 **Reported predictive variables for burns' mortality from eight international studies (1979–98)**

Study	Year	Significant independent factors	Reference
Ryan et al.	1998	Age, TSAB, inhalation injury	[6]
Raff, Germann, Barthold	1996	Age, TSAB, inhalation burns, FTB, sex	[7]
Vico, Papillon	1992	TSAB, age, sex, inhalation injury	[8]
Benitio-Ruiz et al.	1991	TSAB. age. FTB. inhalation injury. associated medical conditions	[9]
Shirani, Pruitt Jr, Mason Jr	1986	TSAB, age, age^2, age^3, inhalation injury, pneumonia	[10]
Roi et al.	1983	PTB, FTB, PTB × FTB, FTB^2, PTB × FTB2x, age, age^2, age^3, perineum involved, sex, interval between injury and admission	[11]
Curreri et al.	1980	TSAB, age, age^2	[12]
Zawacki et al.	1979	Age, TSAB, FTB, prior bronchopulmonary disease, PaO_2, airway oedema	[13]

TSAB = total surface area burnt.
FTB = full thickness burns.
PTB = partial thickness burns.

tality was observed in the older age groups, females, those with a greater TSAB, deep wounds and mixed 2nd and 3rd degree burns. Similar independent variables have been reported as contributors to mortality in other studies [*6–13*], as shown in Table 2. It is suggested that the variability of these results probably indicates differences between treatment protocols that influence ultimate mortality [*14*]. The accuracy of the present model was 95.5%, which is comparable to the models of Bowser et al. [*14*], Scott-Conner et al. [*15*], Wong and Ngim [*3*], and Stern and Waisbren [*16*].

Estimation of the length of hospital stay is important for financial reasons. Early, accurate estimates facilitate better financial planning for both the patients and their families. Few studies discuss the prediction of length of hospital stay for survivors. In the present study, TSAB, degree and depth of the burn wound, sex, occurrence of clothing ignition and inhalation burn significantly affected length of stay. These finding are in agreement with others [*17–20*]. This may be explained by increased tendency for infection, delayed healing and the need for surgical procedures such as grafting, which was observed in patients with larger TSAB, deeper burns with higher degree of burn and if inhalation burns occurred.

Conclusion and recommendations

Multivariate models for predicting mortality and length of hospital stay were developed. In the mortality prediction model, the shared significant independent variables were TSAB, degree and depth of the burn wound, occurrence of inhalation burns and age of the burn patient, while sex and occurrence of clothing ignition were additional independent variables in the length of hospital stay prediction model. These models have to be tested against a future set of patients. With confirmation, they will aid in patient management, clinical audit and patient and family counselling. They will serve as baseline standards for the evaluation of new therapies and assist in the allocation of resources and identification of the at-risk population, all of which will contribute to improvements in therapy.

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