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A novel mathematical model to predict prognosis of burnt patients based on logistic regression and support vector machine

Yinghui Huang [a,b,c], Lei Zhang [d], Guan Lian [a], Rixing Zhan [a], Rufu Xu [e], Yan Huang [c], Biswadev Mitra [f], Jun Wu [a,*], Gaoxing Luo [a,*]

[a] Institute of Burn Research, Southwest Hospital, Third Military Medical University, Chongqing, China
[b] Institute of Combined Injury, State Key Laboratory of Trauma, Burns and Combined Injury, Chongqing Engineering Research Center for Nanomedicine, College of Preventive Medicine, Third Military Medical University, Chongqing, China
[c] Department of Biochemistry and Molecular Biology, Third Military Medical University, Chongqing, China
[d] College of Communication Engineering, Chongqing University, Chongqing 400044, China
[e] The Department of Epidemiology, Third Military Medical University, Chongqing, China
[f] Trauma Service Center, Alfred Hospital, 55 Commercial Road, Melbourne, VIC 3004, Australia

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A B S T R A C T

Objective: To develop a mathematical model of predicting mortality based on the admission characteristics of 6220 burn cases.
Methods: Data on all the burn patients presenting to Institute of Burn Research, Southwest Hospital, Third Military Medical University from January of 1999 to December of 2008 were extracted from the departmental registry. The distributions of burn cases were scattered by principal component analysis. Univariate associations with mortality were identified and independent associations were derived from multivariate logistic regression analysis. Using variables independently and significantly associated with mortality, a mathematical model to predict mortality was developed using the support vector machine (SVM) model. The predicting ability of this model was evaluated and verified.
Results: The overall mortality in this study was 1.8%. Univariate associations with mortality were identified and independent associations were derived from multivariate logistic regression analysis. Variables at admission independently associated with mortality were gender, age, total burn area, full thickness burn area, inhalation injury, shock, period before admission and others. The sensitivity and specificity of logistic model were 99.75% and 85.84% respectively, with an area under the receiver operating curve of 0.989 (95% CI: 0.979–1.000; $p < 0.01$). The model correctly classified 99.50% of cases. The subsequently developed support vector machine (SVM) model correctly classified nearly 100% of test cases, which

* Corresponding authors. Tel.: +86 2368754173.
E-mail addresses: ikkyhuang@163.com (Y. Huang), leizhang@cqu.edu.cn (L. Zhang), lianguan@126.com (G. Lian), zhanrx@sina.com (R. Zhan), xrf@tmmu.edu.cn (R. Xu), huangy@163.com (Y. Huang), biswadev.mitra@monash.edu (B. Mitra), junwupro@cta.cq.cn (J. Wu), logxw@hotmail.com (G. Luo).

Abbreviations: SVM, support vector machine; TBA, total burn area; ROC, receiver operating characteristic; PCA, principal component analysis.

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could not only predict adult group but also pediatric group, with pretty high robustness (92%–100%).

Conclusion: A mathematical model based on logistic regression and SVM could be used to predict the survival prognosis according to the admission characteristics.

1. Introduction

Predicting death risk of burnt patients is one of the useful ways to reduce the mortality. Burn parameters quantized from patients provide useful information for evaluating patients' status. Comprehensive analysis of these parameters would help clinicians assess the prognosis of burn patients and guide therapy. However, predicting survival among victims of major burns trauma remains challenging.

Various injury and physiological variables may impact on mortality post burns, such as age, total burn area (TBA), depth of burn injury, presence of inhalation injury, the sites involved. Previous studies had tried to explore stable models to predict the risk of death after burn injury. However, most of them only focused on the effect of a single factor on mortality or were limited by small numbers of cases, not to mention classifying adult group and pediatric group respectively [1]. Currently, there are few practical, stable models that can predict mortality post burns injury accurately. In addition to the high mortality, major burns injury is associated with substantial morbidity and accurate prediction may enable effectiveness and palliation [2–4].

The aims of this study were to retrospectively analyze data on burns patients to develop a mathematical model of predicting mortality based on admission characteristics.

2. Methods

2.1. Clinical data collection and primary analysis

This study was approved by the ethics committee of Southwest Hospital (No.2108A0248). Data on all the burn patients presenting to Institute of Burn Research, Southwest Hospital, Third Military Medical University from January of 1999 to December of 2008 were extracted from the departmental registry. Clinical data included patient outcomes and 11 possible risk factors for mortality, including gender, age, cause, total burn area (TBA), full-thickness area, shock, inhalation injury, hours before hospitalized, combined injury and primordial condition. After the model was constructed, the accuracy, robustness and other features were determined. After the model was constructed, the accuracy, robustness and other features were determined. The evaluation of burn area and depth was based on the rule of nine and three degree four classifications. All evaluation was conducted by experienced burns surgeons in the institute. Shock status was evaluated at admission. Inhalation injury was diagnosed by bronchofibroscope and classified according to the involved range in airway when patient was suspected to have suffered inhalation injury at admission. Patients without acute burn injury, such as those for plastics or cosmetic surgery and the cases with missing data were excluded. The pediatric age group was defined by age ≤14 years.

2.2. Assignment of the collected clinical factors of the valid burn patients

All the collected factors possible to impact mortality were assigned. The final outcome of patient was assigned as Y, gender as X1, age as X2, cause of burn injury as X3, TBA as X4, full thickness area as X5, shock as X6, inhalation injury as X7, hours before hospitalization after burn injury as X8, involved sites as X9, combined injury as X10, premorbid condition as X11. The detail assignments of variates were shown as in Table 1 in supplementary.

For the causes of burn injury varied too much, subvariation [5] was introduced in the analysis and model building as presented in Table 2 in supplementary.

2.3. Building a multi-factor logistic regression predictive model

All variables showing statistical correlation with mortality were entered into a logistic regression model [6] to determine independent associations with mortality. This model was developed using a stepwise selection procedure and a

Table 1 – Verification of the constructed predictive model based on multifactor logistic regression.

Observed			Predicted		
			Y		Percentage Correct
			Survivors	Non_survivors	
Step 11	Y	survivors	6092	15	99.75
		non_survivors	16	97	85.84
	Overall Percentage				99.50