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Determinants of Mortality and the Lethal Area 50 Index (LA50) in Burn Patients Admitted to a Large Burn Center; A Single Center Experience

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ABSTRACT

Objectives: To investigate the determinants of mortality and the lethal area 50 (LA50) in large series of Iranian burn patients admitted to a single burn center.
Methods: This cross-sectional study was conducted in Shahid Motahari burn center of Tehran, Iran during a 1-year period from 2011 to 2012. We included all the burn patients who were admitted to our center during the study period. Those with incomplete medical records and those referred to other centers were excluded from the study. The medical records of the included patients were reviewed and the demographic, clinical, laboratory and outcome measures were recorded. The mortality rate was recorded and the determinants of LA50 were analyzed in a univariate and stepwise multivariate model.
Result: Overall we included a total number of 1200 subjects with mean age of 30.8±18 years. There were 907 (75.6%) men and 293 (24.4%) women among the patients. The total LA50 was 55.5% (95% CI: 52.98%-58.3 %). There was a significant difference between age group >61 years and two 11-20 and 21-30 groups regarding LA50. The advanced age (p<0.001), female gender (p=0.002), inhalational injury (p<0.001) and burn extension determined by TBSA% (p<0.001) were significantly associated with mortality. In addition, male gender (p=0.087), flame (p=0.156), scald (p=0.088) and chemical injuries (p=0.071) were not associated with mortality.
Conclusion: The LA50 determine din our study is still much lower than that reported in developed countries, as a result, the quality of medical care is lower. Female gender, age, inhalational injury and extension of burn determined by TBSA% were found to be the independent risk factors of mortality in burn patients in our series.

Keywords: Prognosis; Lethal area 50 (LA50) index; Burn; Mortality.

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Introduction

Burns and their sequelae are among the most devastating injuries being associated with high mortality and morbidity and thus is a considered a public health problem especially in developing countries [1]. In the US, about 450,000 patients annually receive medical treatment for burn injuries and 40,000 hospitalizations and 3,400 deaths per year has been reported [2]. In the Middle East, the incidence of burns requiring hospital admissions has been reported from 112 to 518 per 100,000 per year. In Iran, about 100,000 to 150,000 burn patients seek medical attention annually, with about 6% of them admitted to burn hospitals. Mortality of burn patients in Iran has been reported to be 10% [3]. The mortality of the burn patients depends on the center in which the patient is admitted and treated. In developed countries, about 1% of patients in Emergency Departments are admitted due to burns [1, 2].

Lethal Area 50 (LA50) index (which is defined as the burn size lethal to 50% of patients) reflects quality of resuscitation process and medical burn care [4, 5]. It has been used as an indicator of quality of burn care. So it can be compared between different time periods to estimate how quality of medical care has been changed. It can be compared between various centers too. In the 1940s, LA50 in the United States has been reported as 40% [6], and increased to approximately 60% in the 1970s [7]. Between 1991-1993 in 28 burn centers the LA50 for young adults was 81% total body surface area (TBSA) [8] and currently is about 90% [7]. LA 50 for developing countries is lower than this [9]. On the other hand, previous clinical and experimental studies have shown that burn size (TBSA), age, inhalation injury and premorbid conditions are among the most important risk factors for mortality and morbidity in burn injured patients [10, 11]. Several epidemiological studies have addressed the LA50 in different centers worldwide. But data regarding this issue from Iranian centers is scarce. In addition, the determinants of mortality and morbidity in burn patients is yet to be identified. Thus, we conducted the current study in order to calculate the LA50 in burn patients admitted to a large burn center in Iran and also to determine the prognostic factors in these patients.

Materials and Methods

Study Population

This was a cross-sectional study being conducted during a 1-year period from January 2011 to January 2012 in Shahid Motahari burn center affiliated with Iran University of Medical Sciences, Tehran, Iran. The study protocol was confirmed by the institutional review board (IRB) and medical ethics committee of Iran University of Medical Sciences. as this was a retrospective review of the medical charts, no informed written consents were required. We included all the patients who were consecutively admitted to our center during the study period were included. We excluded those whose medical charts lacked essential information and those who were transferred to other center for further care.

Study Protocol

The medical charts of the patients were reviewed and the data was recorded in data gathering forms. The demographic information (age, gender), cause of burn (scald, flame, chemical, electrical, radiation), etiology of burn (suicidal or accidental), delay between injury and admission, presence of inhalation injury, bum size (TBSA), comorbidities, length of hospital stay and outcome (patient has survived to discharge or died) were recorded. Cause of the burn was determined regarding the history. The size of burn injured area was reported as percentage of TBSA, based on the area of second and third degree burns, and was estimated according to the Lund and Browder chart [12]. The burn depth was determined by clinical criteria [12]. Inhalation injury was diagnosed by the presence of facial burns, singed nasal vibrissae, stridor, soot in the mouth, carbonaceous sputum and a history of closed space injury. In most cases, deterioration of PO_2 in serial arterial blood gas tests and bronchoscopic findings of airway edema, inflammation and mucosal necrosis.

Statistical Analysis

All the data were entered into an online database and the extracts were analyzed using statistical package for social sciences (SPSS Inc., Chicago, Illinois, USA) version 21.0. Data are presented as mean±SD and proportions as appropriate. Calculation and analysis of LA50 was performed by Probit analysis. We conducted a multiple logistic regression model analysis and a univariate stepwise analysis to identify the mortality risk factors. Crude and adjusted odds ratios (OR) with 95% confidence intervals (CI) were reported. A 2-sided *p*-value of less than 0.05 was considered statistically significant.

Results

Overall we included a total number of 1200 subjects with burns admitted to our center during the study period. The mean age of the patients was 30.8±18 (ranging from 1 to 88) years. There were 907 (75.6%) men and 293 (24.4%) women among the patients. The highest rate of burns was in 21-30 years (27.5%). The most common cause of burn injury was flame (58.8%). The demographic, clinical and outcome measures of the patients with burn admitted to our center during the study period is summarized in Table 1. As demonstrated the overall mortality rate was 186 (15.5%).

Total LA50 was 55.5% (95% CI: 52.98%-58.3 %) (According to Probit analysis of relation of percentage of burn size and mortality) (Figure 1). LA50 in

Table 1. The baseline characteristics of 1200 burn patients admitted to our center during the study period.

Variable	Value
Age (years)	30.84±18.86
Gender	
Men (%)	907 (75.6%)
Women (%)	293 (24.4%)
Ethnicity	
Iranian (%)	1095 (91.3%)
Foreigner (%)	105 (8.8%)
Marital status (%)	
Married (%)	603 (50.3%)
Single (%)	557 (46.4%)
Divorce (%)	25 (2.1%)
Widow (%)	15 (1.3%)
Literacy	
Illiterate (%)	327 (27.3%)
Only writing and reading (%)	431 (35.9%)
Diploma (%)	328 (27.3%)
Academic (%)	81 (6.8%)
Unknown (%)	33 (2.8%)
Cause of burn	
Accidental (%)	1073 (89.4%)
Suicide (%)	61 (5.1%)
Homicide (%)	15 (1.3%)
Unknown (%)	51 (4.3%)
Type of burn	
Flame (%)	705 (58.8%)
Scald (%)	260 (21.7%)
Electrical (%)	132 (11.0%)
Contact (%)	43 (3.6%)
Tar (%)	25 (2.1%)
Chemical (%)	24 (2.0%)
Other (%)	11 (0.9%)
Smoking (%)	296 (29.8%)
Opium addiction (%)	253 (21.1%)
Inhalation injury (%)	250 (20.8%)
Treatments	
Debridement (%)	725 (60.4%)
Escharotomy (%)	119 (9.9%)
Fasciotomy (%)	47 (3.9%)
Early grafting (%)	158 (13.2%)
Amputation (%)	50 (4.2%)
Outcome	
Release from hospital (%)	160 (13.3%)
Complete recovery (%)	356 (29.7%)
Partial recovery (%)	498 (41.5%)
Mortality (%)	186 (15.5%)
Total body surface area (%)	27.46±23.61
ICU stay (days)	7.57±7.89
Hospital stay (days)	12.50±10.80

age groups of patients is demonstrated in Table 2. According to our findings there is a significant difference between age group >61 years and two 11-20 and 21-30 groups (Table 2). Overall, there was a 20.8% rate of inhalation injury and there was significant difference in LA50 between patients with inhalation injury and those without. Overall 61.5% of patients had arrived to our center before 24 hours after injury and the rest more after 24 hours. There was no significant difference in these two categories. LA50 in men is more than women, but this difference was not statistically significant (Table 2).

We ran a stepwise univariate analysis and a multivariate logistic regression model analysis in order to determine the risk factors of mortality in our series. As demonstrated in Table 3, the advanced age, female gender, inhalational injury and burn extension determined by TBSA% were significantly associated with mortality. In addition, male gender, flame, scald and chemical injuries were not associated with mortality. The results of crude and adjusted OR calculation is summarized in Table 3.

Discussion

In the current study we tried to investigate the LA50

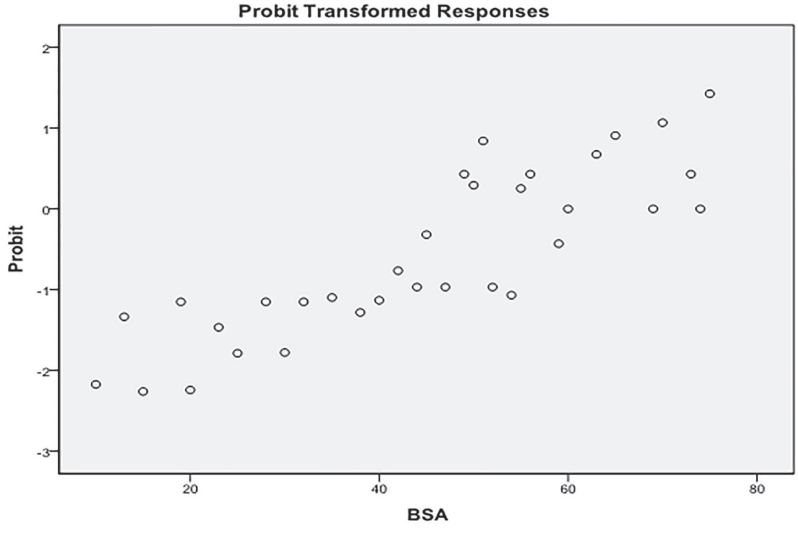

Fig. 1. Dot plot chart demonstrating the Probit survival analysis for 1200 burn patients admitted to our center during the study period. Probability of survival is plotted against burn size expressed as total body surface area (TBSA%). This plot is used for calculation of lethal area 50 (LA50).

Table 2. The lethal area 50 (LA50) in 1200 burn patients admitted to our center during the study period according to various variables.

	Point LA50 (TBSA%)	Lower Limit	Upper Limit
Age Group(Years)			
≤10	57.9	49.5	79.8
11-20	59.1	51.9	71.9
21-30	57.3	52.1	64.8
31-40	54.5	50.3	59.3
41-50	55.2	49.9	60.1
51-60	51.3	44.4	58.9
>60	45.3	39.1	51.8
Gender			
Men	56.5	46.6	59.7
Women	51.9	46.6	59.1
Time interval			
<24 hours	55	52.1	58.4
≥24 hours	56.5	51	64.2
Inhalational injury			
Yes	49.5	45.6	53.2
No	59.7	55.3	56.3

Table 3. The determinants of mortality in a series of 1200 burn patients admitted to our center during the study period based on the multivariate logistic regression model.

	Crude OR (CI[a] 95%)	*p*-value	Adjusted OR[b] (CI 95%)	*p*-value
Age	1.22 (0.523-1.886)	<0.001	1.31 (0.487-1.906)	<0.001
Male gender	0.96 (–0.081-1.077)	0.087	1.05 (–0.021-1.271)	0.192
Female gender	1.85 (0.752-2.321)	0.002	1.99 (0.523-2.601)	0.001
Inhalation injury	2.07 (1.032-2.901)	<0.001	2.11 (1.280-2.883)	<0.001
TBSA[c]	1.74 (0.998-2.207)	<0.001	1.69 (1.051-2.023)	<0.001
Flame	0.55 (–0.074-0.993)	0.156	0.56 (–0.036-1.011)	0.068
Scald	0.71 (–0.980-1.581)	0.088	0.93 (–0.801-1.354)	0.055
Chemical	0.98 (–0.022-1.146)	0.071	0.86 (–0.018-1.055)	0.078

[a]CI: Confidence interval; [b]OR: Odds ratio; [c]TBSA: Total body surface area

and the determinants of mortality in a large series of burn patients admitted to an Iranian referral center. We demonstrated that the LA50 was 55.5%. In 2009, a retrospective study was performed in this center (Motahari Hospital), medical records from HIS and patients profile were evaluated (10,194 patients was included) and annual LA50. Over 10 Iranian calendar years ended on March 2009 (March 1999-March 2009) were calculated by Probit analysis. The study demonstrated that LA50 and mortality rate had improved over these years. This difference was statistically significant (p<0.001). Annual LA50 in March 2008-March 2009 was 57.14%. Our result (LA50=55.5%) in comparison to this study shows LA50 and survival rate of burn patients has decreased over 2 years although this difference is not significant; however, it shows that our progression in burn care has been ceased at least (Figure 2).

In comparison to developed countries, we have a long distance to go. As previously mentioned, between 1991 and 1993 in 28 burn centers in the US the LA50 for young adults was 81% total body surface area (TBSA) [8, 13] In the United Kingdom from 2000 to 2008, the LA50 were 100% (95% confidence intervals, 85.5-100%) in the 0 to 14 cohort ,76.4% (CI, 69.1-83.8%) in the 15 to 44 cohort, 58.6% (CI, 50.8-66.5%) in the 45 to 64 cohort, and 30.8% (CI, 24.7-36.9%) in the >65 cohort(13). In 1999, a mortality of 3.5% and LA50 of 90% has been reported in Spain [14]. In 2004, a report from the USA stated that an LA10 of 73% in burn patients fell to 50% if they had inhalation injury [15]. In a report from Kuwait, LA50 was 76.5% for adults and 41.8% for the elderly, similar to reports from the UK [16]. LA50 was 39% in a report from Africa, which is much lower than our result. In the Czech Republic, it was reported that LA50 was 55% and that it decreased with age [17].

This study demonstrates that LA50 in patients of age group >61 years old are less than patients in 11-30 year groups. It is consistent with previous studies. Burns in elderly bring more serious injuries than in the general population and they have a higher mortality rate. According to in 1997 in the US LA50 for the young adult exceed 80% TBSA, whereas for patients aged 60 to 70 years was approximately 43% of TBSA and for older than 70 years, it was approximately 25% of TBSA and 13.1% for those 80 [18, 19]. This means that children can better withstand the trauma of an equal-sized burn, and that their probability of survival is higher for the same percentage of TBSA burned.

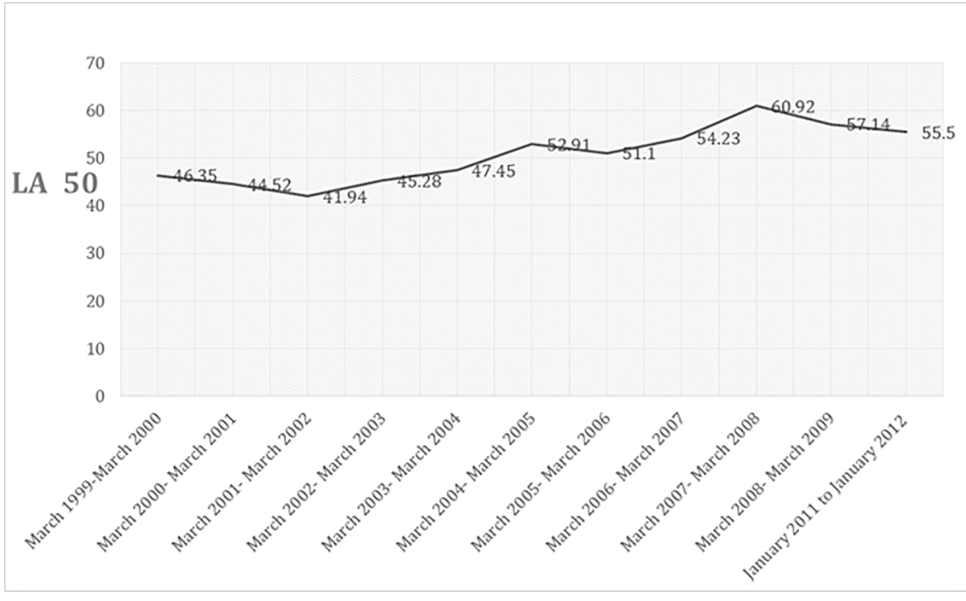

Fig. 2. The trend changes of lethal annual 50 (LA50) over a 10-year period in our center compared to the results of the current study demonstrating improvement in quality of care.

In another study in 2011 by Fazeli and colleague in Imam Khomeini Hospital (main educational tertiary referral hospital in Kermanshah, Iran) in 540 burn patients they found probability of death was 25.8%. Lethal area fifty percent (LA50) was 50.82 (CI 95%: 47.76 - 54.48) [20].

Physical and physiologic differences(decreased physiologic reserve), medical comorbidities (such as COPD and CAD, CRF) more prevalent in this age group [10], decreased wound healing potential (19;21;22) which are made the outcome poor. Infections are more common and their response to infections is impaired. When systemic sepsis occurred prognosis is extremely poor [21]. Pre-existing protein energy malnutrition is commonly present in the elderly burn population and that significantly increases morbidity and mortality rate [19]. One of the common causes of mortality in elderly burn patients is hypovolemic shock [19].

There was significant difference in LA50 between patients with inhalation injury and those without. Inhalation injury, results in severe lung-induced morbidity and mortality. Respiratory failure is the most common cause of mortality in burn centers [22-26]. Common components of smoke are Carbon dioxide , Hydrogen cyanide, Oxygen radicals, Acrolein, Aldehydes, Ammonia, Sulfur dioxide, Hydrogen chloride, Aromatic hydrocarbons [27-29]. Carbon monoxide is a by-product of combustion that its toxicity is one of the main causes of mortality in fires. It's rapidly transported across the alveolar membrane and binds with the hemoglobin in place of oxygen. The result is impairment in oxygen delivery to tissues [30, 31]. Direct-heat injury caused by the inhalation of air heated to a temperature 150◦C or higher ordinarily results in burns to the face, oropharynx, and upper airway (above the vocal cords) [32-34]. Upper-airways edema occurs after smoke inhalation and its progression can lead to obstruction. Burn patients with a combination of inhalation injury and a major body burn have the greatest risk of pneumonia, with a rate exceeding 50% [30]. There are systemic responses to a smoke inhalation injury [35].

Some studies have shown the difference between men and women in mortality following to burn injury that could not be explained by differences in age, race, TBSA burn and inhalation injury [36, 37]. mortality rate in female patients is more than men up to the age of 60 years [36, 38]. Difference in immune response between two sexes after thermal injury [38, 39]and etiology and/or type of burn [40] have been presented as explains for this difference .In this study LA50 in male patients is more than female patients, but this differences is not statistically significant.

In conclusion, the point estimates LA50 and survival rate of burn patients decreased over 2 years ago. Although this difference is not significant but it shows that our progression in burn care has been ceased at least. LA50 is still much lower than those in developed countries, as a result, the medical care quality is low in comparison to developed countries. The female gender, age, inhalational injury and the extension of the burn determined by TBSA% is associated with mortality in burn patients. It seems that more educational and preventive programs are needed in our country and in countries like the USA in order to achieve a better outcome for burn patients.

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Conflicts of Interest: None declared.

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