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Predicting Mortality among Acute Burn Patients Using BOBI Score vs. FLAMES Score

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Abstract**—**Thermal injuries remain a global health problem and a common issue encountered in forensic pathology. They are a devastating cause of morbidity and mortality in children and adults especially in developing countries, causing permanent disfigurement, scarring and grievous hurt. Burns have always been a matter of legal concern in cases of suicidal burns, self-inflicted burns for false accusation and homicidal attempts. Assessment of burn injuries as well as rating permanent disabilities and disfigurement following thermal injuries for the benefit of compensation claims represents a challenging problem. This necessitates the development of reliable scoring systems to yield an expected likelihood of permanent disability or fatal outcome following burn injuries. The study was designed to identify the risk factors of mortality in acute burn patients and to evaluate the applicability of FLAMES (Fatality by Longevity, APACHE II score, Measured Extent of burn, and Sex) and BOBI (Belgian Outcome in Burn Injury) model scores in predicting the outcome. The study was conducted on 100 adult patients with acute burn injuries admitted to the Burn Unit of Alexandria Main University Hospital, Egypt from October 2014 to October 2015. Victims were examined after obtaining informed consent and the data were collected in specially designed sheets including demographic data, burn details and any associated inhalation injury. Each burn patient was assessed using both BOBI and FLAMES scoring systems. The results of the study show the mean age of patients was 35.54±12.32 years. Males outnumbered females (55% and 45%, respectively). Most patients were accidently burnt (95%), whereas suicidal burns accounted for the remaining 5%. Flame burn was recorded in 82% of cases. As well, 8% of patients sustained more than 60% of total burn surface area (TBSA) burns, 19% of patients needed mechanical ventilation, and 19% of burnt patients died either from wound sepsis, multi-organ failure or pulmonary embolism. The mean length of hospital stay was 24.91±25.08 days. The mean BOBI score was 1.07±1.27 and that of the FLAMES score was -4.76±2.92. The FLAMES score demonstrated an area under the receiver operating characteristic (ROC) curve of 0.95 which was significantly higher than that of the BOBI score (0.883). A statistically significant association was revealed between both predictive models and the outcome. The study concluded that both scoring systems were beneficial in predicting [1]mortality in acutely burnt patients. However, the FLAMES score could be applied with a higher level of accuracy.

Keywords**—**BOBI, Burns, FLAMES, scoring systems, outcome.

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I. Introduction

THERMAL injuries remain one of the most challenging health problems throughout the world, especially in low and middle-income countries [1], [2]. Globally, burns and fires account for more than 300,000 deaths annually, according to the World Health Organization (WHO) 2014 fact sheet [3]. Burn injuries can be caused by contact with dry heat (flame or hot metal), hot liquid or steam (scalds). Burns also include any damage to the skin from radiant heat, radioactivity, electricity or corrosive substances, as well as respiratory damage resulting from smoke inhalation [4].

Burns are the most devastating of all injuries with outcomes ranging from physical impairment, permanent disfigurement and scarring to debilitating long-term effects, such as emotional and mental consequences [5].

From a medico-legal perspective, thermal injuries present complex questions and issues. Burns on living persons often have considerable medicolegal significance, especially in vulnerable populations such as children and elderly victims of physical abuse or neglect. If burns caused or led to death (accidental, suicidal or homicidal attempts), a thorough forensic investigation and a postmortem autopsy are mandatory [6].

Medicolegal experts are frequently called upon by the courts to throw light on the different aspects of burnt victims, like the circumstances of work-related burns, deliberate self-burning and complex situations of burn injuries (false declarations and malicious prosecution) [7].

Nowadays, the implementation of scoring systems to give a valid outcome measure amongst burn patients has received increasing acceptance. Scoring allows objective and complex assessment of a patient's health condition and facilitates the diagnostic and therapeutic process. It helps in understanding the relative influence of different prognostic variables. It will be possible to determine priorities based on empiric data and health concepts, and hence a better assessment of the medical care provided [8].

Evaluation of morbidity and factors leading to mortality following burn injuries is highly critical, especially when dealing with legal claims raised in cases of assaults, as well as malpractice suits. The burn survivors usually suffer from both physical impairment and emotional impact (post-traumatic stress disorders, depression, psychological stigma and rejection) [9], [10].

Within the context of burn injury assessment, several different scoring systems have been developed. They are particularly important as they guide the appropriate therapeutic approach. The BOBI scoring system is a recent

addition to the severity scores. It attempts to increase the predictive value by subdividing patients according to age and percentage of TBSA [11]. The FLAMES score may contribute to triage and management decisions, evaluation of new diagnostic and treatment modalities, and comparisons of burn populations. Furthermore, the FLAMES score might help in easing the communication of health professionals with relevant parties regarding therapeutic decisions based on the estimated mortality risk of burn patient groups [12].

The study was therefore designed to identify the risk factors of mortality in acute burn patients and to evaluate the applicability of BOBI and FLAMES model scores in predicting the outcome.

II. Subjects and Methods

A. Study Design

A prospective study was carried out on 100 adult patients with acute burn injuries admitted to the Burn Unit at Alexandria Main University Hospital within one year from October 2014 to October 2015.

The research proposal was approved by the Ethics Committee of Alexandria Main University Hospital and informed consent was obtained from the studied patients before participation.

Exclusion Criteria:

- Discharged patients before obtaining their complete data.
- Delayed transfer and/ or delayed admission to the Burn Unit more than 24 hours after the burn incident.
- Patients admitted for reconstructive post-burn surgery or with different diagnosis other than acute burn injury.

The following data were collected in a specially-designed sheet as regards:

- Demographic data (age and sex)
- Circumstances of burn (accidental, homicidal or suicidal)
- Place of burn incident (home, workplace or outdoors)
- Type of burn (flame, scalds, chemical, electrical or radiation)
- Anatomical site of burn
- Degree of burn (partial thickness or full thickness)
- %TBSA estimated by Lund & Browder Chart.
- Any associated inhalation burn injury.

Predicting mortality for each patient using:

- The BOBI score [11].
- The FLAMES score [12].

Duration of hospital stay:

- Outcome
- Causes of death

B. Statistical Analysis

The data obtained were analyzed with a Statistical Analyses Package for Social Sciences Software (SPSS) **(**Armonk, NY: IBM Corp**)** version 20.

Qualitative data were described using number and percentage. Quantitative data were described using range (minimum and maximum), mean, standard deviation and median. The significance of the obtained results was judged at the 5% level.

For categorical variables, comparisons between two different groups were made using chi-squared test. A Mann Whitney U test was applied to see the difference in quantitative data between the two groups. A Fisher's test (Monte Carlo) was used for the correction of the Chi-square when more than 20% of the cells have an expected count of less than 5. A Kruskal Wallis test was used for abnormally quantitative variables to compare between more than two studied groups.

Univariate and multivariate analyses were performed. A ROC curve was generated by plotting sensitivity on the Y-axis versus specificity on the X-axis at different cutoff values. The area under ROC denotes the diagnostic performance of the prognostic models. The area more than 50% gives acceptable performance and the area about 100% is the best performance. The ROC curve allows a comparison of performance between the two models.

A decision criterion of 0.5 was set as the cutoff value; at a value >0.5 patients were predicted to die, whereas patients with a calculated PD <0.5 were predicted to survive (probability of death=50%).

III. Result

The age and sex distribution of the studied burn patients is displayed in Table I.

Fig. 1 demonstrates the circumstances of burns; 95% of the burns were accidental. Forty percent of the suicidal burn injuries occurred in the age group of 20 to 30 years. The accidental burns were more likely to occur among males (56.8%), while females accounted for 43.2%. On the other hand, burns due to suicidal attempts occurred more among females than among males (80% and 20%, respectively), albeit no statistically-significant relation was detected. No assault burn cases were reported.

50% of the burns occurred in the workplace, whereas 47% took place at home. All suicidal attempts of burns occurred at home, with a statistically significant association detected between the place of burn and its circumstances (χ^2=5.935 and ^{EF} p=0.020).

Flame burns due to kerosene, butane or petrol ignition accounted for 82% of the cases, scalds 8% (hot liquids, such as boiling water or oil), chemical burns (6%) and electrical burns 4%.

The majority of the burn cases (97.8%) among females occurred at home, and 94.5% of the cases of burns among males took place at the work place (χ^2=84.688 and p<0.001).

All electrical burns occurred in males. Flame burns among males accounted for 54.9%. A great percentage of scalds occurred in females (87.5%). Most chemical burns (83.3%) were encountered among males. There was a statistically significant relation between the type of burn and sex (χ^2=10.410 and ^{MC} p=0.009).

All burn injuries due to suicidal attempts were flame burns. Most accidentally, burnt patients (81.1%) also had flame burns followed by scalds (8.4%), chemical burns (6.3%) and lastly

electrical burns (4.2%).

Most burnt patients (90%) in the current study had burns in more than one site. Extremities (83%), face (73%), chest (41%) and hands (30%) were the most commonly burned. The extremities were the most common sites to be involved in all types of burn (83%), as shown in Fig. 2. Facial burn injuries were the most common among scald burns (87.5%). The extremities, chest and back, were equally affected by chemical burns (50%). Involvement of the extremities and face was the highest and equally distributed among all electrical burns (75%).

Partial thickness burns were observed in 90% of the cases, full thickness in 9% and only 1% of the patients suffered from superficial burn injury.

The %TBSA ranged from 4% up to 100% with a mean of 35.54 ±12.32%. Sixty-seven percent of the patients had a %TBSA less than 30%, 25% had a %TBSA of 30% to 60% and only 8% of patients had burns covering more than 60% TBSA. A statistically significant relation was recorded between the circumstances of the burn and the %TBSA (χ^2=25.743 and ^{MC} p<0.001). The highest percentage of patients (62.5%) with %TBSA more than 60% was due to suicidal attempts.

One patient (aged 18 years) suffered from inhalational burn injury, caused by a flame burn affecting the face. It was diagnosed by the presence of signs of inflammation in lower airways (bronchoscopy evidence of inflammatory changes in lower respiratory tract and the presence of soot in the tracheal aspirate).

The days of hospital stay ranged from one day up to 160 days with a mean of 24.91±25.08 days. The lowest mean of duration of hospital stay (12.75± 5.31 days) was encountered in scald burn patients and the highest mean (40.0± 22.38 days) was recorded in the cases of chemical burns. The lowest mean of duration of hospital stay (7.38± 5.80 days) was noticed in burn patients with a %TBSA more than 60 % and the highest mean (32.84± 38.69 days) was recorded in patients with burns involving 30-60% TBSA. A statistically significant association was detected between the duration of hospital stay and the percentage of TBSA (H=10.095 and ^{KW}p= 0.006).

Nineteen percent of the cases needed mechanical ventilation, with a duration of hospital stay ranging from one to 53 days (mean of 27.91± 26.32 days). Sixteen percent of patients suffering from burns had undergone grafting, with a mean duration of hospital stay of 46.12± 14.49 days.

A. Burn Specific Scoring Systems

1. BOBI Score and FLAMES Score

The present study showed that BOBI score in the burnt patients ranged from 0 to 7 with a mean of 1.07± 1.27.

The FLAMES score ranged from -8.19 to 8.63 with a mean of -4.76± 2.92.

Table II demonstrates the distribution of the burnt cases by the burn specific scoring systems and age. A significant association was detected between the BOBI score and age of the patients. No significant relation was recorded between the mean BOBI score among males (1.02± 1.28) and female patients (1.13± 1.27).

TABLE I
AGE AND SEX DISTRIBUTION OF THE STUDIED CASES

	Number	%
Age		
<20	8	8
20-	26	26
30-	32	32
40-	16	16
50-	12	12
60-	6	6
Min-Max	18.0 – 67.0	
Mean ± SD	35.54 ± 12.32	
Median	33.0	
Sex		
Male	55	55
Female	45	45

Min: Minimum, Max: Maximum, SD: Standard deviation

The mean of the FLAMES score among females (-3.87± 3.07) was higher than that among males (-5.48± 2.60), with a statistically significant association (Mann-Whitney test (MN) = 3.645 and p<0.001).

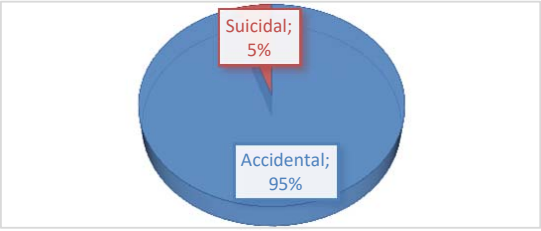

Fig. 1 Distribution of the burn patients according to the circumstances of burn

No significant differences were recorded between the specific burn scores and the type of burn

Table III demonstrates the significant relation between both burn scoring systems and the %TBSA.

A statistically significant association was reported between BOBI and FLAMES scores and the need of patients for mechanical ventilation (Mann-Whitney test = 5.482, p<0.001 and MN= 6.111, p<0.001, respectively).

As regards to the outcome, 81% of the burnt patients survived and showed either complete recovery or suffered from complications. The complications were psychological (post-traumatic stress disorders, phobic anxiety or depression), associated medical conditions (sensory loss and hyperpigmentation), hypertrophic scars and functional limitations of burn scars with resultant contractures.

No significant relation was noted between the outcome and the age of patients, however about one third of the patients above 60 years died from burn injuries. Mortality among females was (57.9%), while among males, it reached 42.1%.

Regarding the percentage TBSA, a significant relation was recorded between the outcome and percentage TBSA.

The most common causes of death were burn wound sepsis (84.2%), multiple organ failure (10.5%), pulmonary embolism and cerebrovascular stroke (5.3% each).

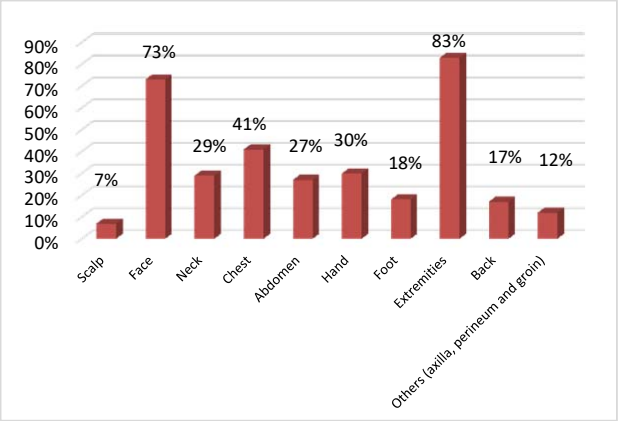

Fig. 2 Distribution of the patients according to the anatomical site of burn

Table IV illustrates the relation between the outcome and both the BOBI and FLAMES scores (a univariate analysis). A statistically significant association was detected between the outcome and both of the BOBI and FLAMES scores, where (MN=5.482 and p<0.001 and MN=6.111 and p<0.001, respectively). By applying the multivariate analysis, the FLAMES score maintained a statistical significance (0.019*) for predicting death (95% confidence interval =1.120 to 3.639). On the other hand, the BOBI score was insignificant (p=0.674, 95% CI=0.166 to 3.193).

The FLAMES score demonstrated an area under the ROC curve of 0.95 which was significantly higher than that of the BOBI score (0.883) Fig. 3 and Table V.

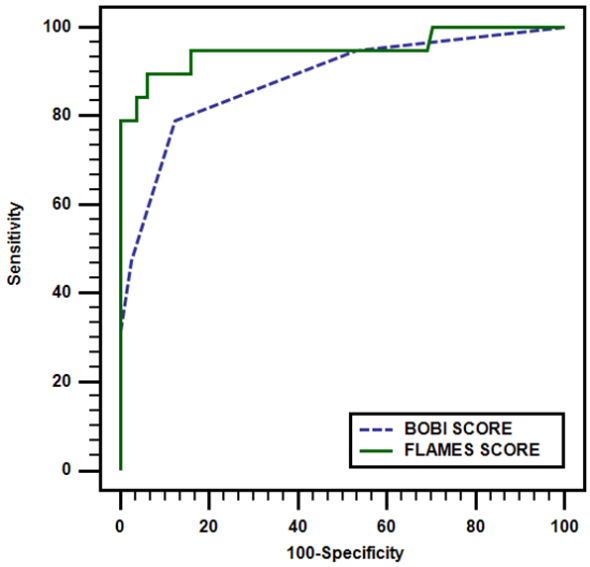

Fig. 3 The ROC curve for BOBI score and the FLAMES score

TABLE II
DISTRIBUTION OF THE PATIENTS ACCORDING TO BOBI, FLAMES SCORES AND AGE

	Age						H	p
	<20 (n=8)	20 - (n=26)	30- (n=32)	40- (n=16)	50- (n=12)	60- (n=6)		
BOBI score								
Min. – Max.	0.0 – 7.0	0.0 – 4.0	0.0 – 3.0	0.0 – 4.0	1.0 – 2.0	1.0 – 5.0		
Mean ± SD.	1.75±2.31	0.92±1.26	0.69±0.86	1.0±1.15	1.33±0.49	2.50±1.76	13.478*	0.019*
Median	1.50	0.50	0.0	1.0	1.0	2.0		
FLAMES score								
Min. – Max.	0.02 – 99.30	0.03 – 74.89	0.01 – 86.24	0.09 – 99.98	0.16 – 8.60	0.58 – 94.60	11.014	0.051
Mean ± SD.	12.78±34.96	8.37±21.01	8.11±20.28	12.49±31.72	1.17±2.37	27.64±41.19		
Median	0.28	0.26	0.28	0.66	0.36	2.88		

H, p: H and p values for Kruskal Wallis test. *p value is significant when p ≤ 0.05.

TABLE III
DISTRIBUTION OF THE PATIENTS ACCORDING TO BOBI, FLAMES SCORES AND THE PERCENTAGE TOTAL BURN SURFACE AREA (%TBSA)

	TBSA%			H	p
	<30 (n=67)	30% – 60% (n=25)	>60 (n=8)		
BOBI score					
Min. – Max.	0.0 – 3.0	1.0 – 4.0	2.0 – 7.0		
Mean ± SD.	0.49 ± 0.66	1.68 ± 0.80	4.0 ± 1.51	51.231*	<0.001*
Median	0.0	2.0	4.0		
FLAMES score					
Min. – Max.	0.01 – 5.60	0.10 – 64.0	58.0 – 99.98		
Mean ± SD.	0.52 ± 0.92	10.59 ± 19.49	82.43 ± 16.73	42.148*	<0.001*
Median	0.25	1.18	86.62		

H, p: H and p values for Kruskal Wallis test. * p value is significant when p ≤ 0.05.

TABLE IV
DISTRIBUTION OF BURN PATIENTS ACCORDING TO BOBI, FLAMES SCORES AND THE OUTCOME

	Outcome		MW	p
	Survived (n=81)	Non-Survived (n=19)		
BOBI score				
Min. – Max.	0.0 – 3.0	0.0 – 7.0	5.482*	<0.001*
Mean ± SD.	0.68 ± 0.76	2.74 ± 1.66		
FLAMES score				
Min. – Max.	-8.19– -2.82	-6.42– -8.63	6.111*	<0.001*
Mean ± SD.	-5.86 ± 1.17	-0.08± 3.47		

MWp: p value for Mann-Whitney test. *: Statistically significant at $p \leq 0.05$

TABLE V
SENSITIVITY, SPECIFICITY, POSITIVE, NEGATIVE PREDICTIVE VALUES AND ACCURACY AT CUTOFF VALUES FOR THE BOBI SCORE AND FLAMES SCORE AMONG THE STUDIED PATIENTS

	AUC	P	95% CI (L - U)	Cutoff	Sensitivity	Specificity	PPV	NPV	Accuracy	Z	p
BOBI	0.883*	<0.001*	0.802 – 0.938	>1	79.0	87.7	60.0	94.7	86.0	2.846*	0.004*
FLAMES	0.950*	<0.001*	0.887 – 0.983	>50%	57.9	100	100	91.0	92.0		

AUC: Area Under Curve. CI: Confidence Interval. L: Lower limit, U: Upper limit. PPV: Positive Predictive Value. NPV: Negative Predictive Value. χ^2, p: χ^2 and p values for Chi square test. MWp: p value for Mann Whitney test.

IV. DISCUSSION

Despite the major evolution in medical care and the new promising advancements in plastic and reconstructive surgeries, thermal injuries remain a devastating health problem worldwide and patients suffering from severe burns still experience substantial risk of mortality [13], [14].

Age, sex, the percentage of the body surface involved, the depth of the burns and the presence of inhalation burn, have all been recognized as critical risk factors for the prediction of mortality from thermal injuries [15], [16].

The highest percentage of patients in the current study was in the age group of 20 years to less than 40 years (58%), as this sector is generally active and consequently more vulnerable to danger at home and work places. This coincides with the results reported in Iran 2013 [17].

Aside from age, sex appears to be an independent predictor of mortality in burn patients. The relatively high percentage of females in this study, approaching half of the cases with increased incidence of burns at home, mostly scalds can be explained by the fact that females are more engaged in kitchen work and household activities throughout the day. Similar results were reported by Makhdoom et al. in Pakistan [18].

More than half of the burn incidents in the current study took place in work places, mostly in males, who are more exposed to work dangers. These injuries could be aggravated by the inappropriate operation of equipment or handling of chemicals and failure to use effective individual protection, in addition to the non-compliance of an employee to safety regulations and/ or a lack of safety education. All electrical burns occurred exclusively in males as handling of electrical equipment and devices is much more common among males [19].

Regarding the circumstances, the small number of suicidal burns reported in the current study could be mainly attributed to the occurrence of unreported cases; as some families deny the possibility of suicidal attempts because of the stigma attached to the circumstances. More than one third of the suicidal burns occurred in patients in their third decades that could be attributed to an expression of anger and depression from repeated exposure and the inability to cope with stressful work situations. Also, family disharmony, domestic violence, interpersonal and marital conflicts are among the most important motives for self-inflicted burns, especially among females [20], [21].

The accidental burns were more encountered among males than among females, while, in suicidal cases, females exceeded males. Similar results were reported by Sukhai et al., and this might be attributed to the fact that females are more likely to develop psychological troubles [22].

All suicidal attempts occurred indoors, as it is less likely to undertake suicidal attempts in public. Similar results were recorded by Taghaddosinejad et al. in his research in Iran [23].

No burns due to criminal assaults were reported in the present study, as burn victims usually deny the truth for fear of legal punishment if the assailant is the domestic partner or a family member.

The most encountered burns in this work were flame and scalds in accordance with previous studies in various countries [24]-[26].

Kerosene and liquefied petroleum derivatives ignition accounted for a great percentage of cases, as they are easily-accessible, cheap and frequently used for domestic purposes [27]. One of the most popular ways for committing suicide or just threatening somebody is by soaking clothes in kerosene and setting fire to them [28].

Regarding the duration of hospital stay, the relatively short duration in the current study may be attributed to the presence of experienced plastic surgeons, who performed early wound coverage and proper surgical interventions assisted by a qualified nursing staff. On the other hand, the seriousness of the injury and the early mortality were crucial elements in shortening the length of the hospital stay.

The high mortality recorded in elderly patients (aged above 60 years) could be explained by the premorbid condition and

altered immunological and inflammatory reactions caused by aging, which add additional risk [29].

Mortality among females was higher than that among males. This might be due to the fact that females had a higher incidence of self-inflicted burn injuries as well as a higher mean of %TBSA affected, reduced muscle bulk in comparison with men as well as the resultant decrease in protein and tissue dehydration [30].

The %TBSA is an important prognostic variable for mortality after burn injury; the more the %TBSA, the poorer the outcome. In developing countries, survival of patients with burns involving more than 40% of the body surface area is unlikely. This is in agreement with the results reported by Sharma et al. in Kuwait [25] and Virendra et al. in India [31].

Medical teams dealing with burnt patients, either in pre-hospital care, triage or Intensive Care Burn Units, are more subject to face confusing medicolegal issues concerning burns [32]. The prediction of the outcome (survival or mortality) is a matter of concern for the treating physician for appropriate decision making. Over the past few years, numerous composite models (burn specific and nonspecific) were developed to predict mortality from thermal injury. Some of these systems are either outdated and fail to take into consideration improvements in clinical settings or complex and consequently difficult to apply [8]. Hence, in the present study, it is necessary to assess whether a specific burn score really provides a more precise prediction than a generalized score among acute burn patients, or not.

In the current study, the area under the curve (AUC) demonstrated by the BOBI score was 0.883 (95% confidence interval: 0.802-0.938), that was slightly lower than that reported by Brusselaers et al. (95% confidence interval: 0.89-0.98 and AUC: 0.94) [33].

The sensitivity of the BOBI score was 79% and the specificity was 87.7%, which were higher than those reported by Smith et al. in South Africa [34].

The FLAMES score showed a sensitivity of 57.9% and a specificity of 100%. The AUC was 0.950. These figures were close to those reported by Gomez et al. [12].

Although the APACHE II is a non-burn-specific measure, when combined with age, sex and the extent of burn, a good predictive model, i.e. FLAMES score, is developed. However, one of the points of criticism of the FLAMES score is that it depends on the early assessment (first day) of clinical parameters, while a few days later, major alterations in the physiological and metabolic functions may supervene. A contradictory opinion is that the first day is the most appropriate to perform the test and a little or even negligible change in the score is recorded [35]. An additional negative drawback regarding the FLAMES score is that the depth of burn injury (partial or full thickness) is based on the physician's estimation and experience, which are sometimes subjective and misleading. Moreover, in the course of treatment of thermal injury, partial thickness burns may spontaneously convert into full thickness ones [36].

The FLAMES score predicted mortality with a higher positive predictive value (100%) than that recorded by the BOBI score (60%) and the accuracy provided by FLAMES was slightly higher than that of BOBI's (92% and 86%, respectively). Although the univariate analysis recorded statistical significance for both scores, at the multivariate analysis, only FLAMES maintained a statistical significance ($p=0.019^{*}$) in the prediction of mortality among burnt patients. Nevertheless, the BOBI score, similar to the FLAMES score, showed statistically significant relations with most of the patient variables, including the outcome together with being a simple bed side score that is faster to calculate. Including inhalation injury as a main variable also gives this score a privilege to apply among burn patients with an acceptable level of accuracy.

V. Conclusions

In conclusion, the study highlighted the need to implement new scoring systems for burn injuries assessment and showed that both FLAMES and BOBI scores have been successful in estimating the outcome of burn patients. Nevertheless, the accuracy yielded by FLAMES was higher than that of the BOBI score.

There is a need to adapt effective, predictive, as well as internationally-validated scoring models for adult burn patients. Moreover, a multicenter study is advised for a better evaluation of the scoring models.

The present study had several limitations. First, it was a single, Burn-Unit study, based on a specific patient population with their health team providers in that hospital. Second, the research was conducted on a small sample size; a larger sample has the benefit of providing more detailed information. Lastly, the burn scoring systems were not applied on children with burn injuries, as the current study included only adult patients.

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