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EPIDEMIOLOGY AND OUTCOME OF INHALATION INJURY DUE TO FLAME BURN INJURIES IN IRAN

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ABSTRACT

Introduction: smoke inhalation injury has significant morbidity and mortality. Inhalation injury increase fluid resuscitation requirements, incidence of pulmonary complications and overall mortality of thermal injury. The purpose of this study is to survey the epidemiology, risk factors, outcome and treatment cost of inhalation injury. Methods: The burn registry program data of our country were analyzed during two years for inhalation injury. Those who had only flame burn or explosion were selected. All of data regarding emergency department admission , treatments before reaching to hospital, Demographic data, pregnancy, types of treatments , respiratory care treatments , frequency of intubation and ICU admission , Length of stay in ICU, length of stay in hospital , complications , infection ,total parentral nutrition(TPN), Albumin infusion ,cost of treatment , outcome and mortality rates were gathered in a special designed questionnaire. Pearson chi square was used for analysis of descriptive statistics and ANOVA and Independent-samples T test for analysis of numeric statistics. Results: 1721 burn patients were admitted to hospital in a 2 year period. 719 patients were flame burn victims and 381(52.9%) of them were diagnosed with inhalation injury of whom 12.5% were admitted in intensive care unit (ICU) and 17% died. We found correlation between cardiovascular disorders, diabetes mellitus, chronic obstructive pulmonary disorders, asthma, pregnancy, psychotic disorders, age and total burned surface area with the outcome of the patients. Also there was a significant correlation between intubation, total parenteral nutrition and the outcome. There were correlation between closed space injury, smoke inhalation, face burn, drug abuse (inhalation abuse) and inhalation injury. Mortality was higher among patients with inhalation injury. The ventilator support days was significantly higher in patients with inhalation injury. The average cost of treatment for inhalation injury patients was 545 $ (19,000,000 Rials) per one day of intensive care, where one day of treatment of other burn patients was 155 $ (5,400.000 Rials).The difference was highly significant ($p<0.001$). Conclusion: in burn patients with inhalation injuries the mortality can increase up to 11% more (from 6% to 17%). TBSA, age, ventilator support, TPN had high influence on outcome of our patients. And diabetes mellitus, pregnancy and cardiovascular disorders could influence the final outcome.

KEYWORDS: Burns; inhalation injury; Flame burn; Mortality; Parenteral nutrition; Pediatric.

INTRODUCTION

In the United States, 40000 patients are admitted at hospitals because of burn injuries each year.[1] Approximately 6-20% of fire victims have a concurrent inhalation injury, which is mostly a chemical insult.[2, 3] Acutely, those with an inhalation injury have more pronounced arterial hypotension and require more extensive fluid resuscitation, and the diffuse epithelial sloughing, bronchorrhea, and plugging of sub-segmental bronchi characteristic of inhalation injury can result in linear atelectasia , and sub-segment pneumonia rates of 20-50%.[4-8] Moreover, the combination of pulmonary and dermal injury may double a patient's mortality.[8] In a model to estimate burn-related mortality, SII (smoke inhalation injury), together with age>60 years and >40% TBSA burned, is an independent factor for mortality. In the presence of only one of those factors the burn mortality rate is 3%, increasing to 33% and 90%, respectively when two and all of those factors are present[9] So , SII can be classified into three types: 1) upper airway thermal injury involving the mouth , oropharynx and larynx, 2) lower airway and

parenchymal injury caused by chemicals and particulate matter originating from smoke; and 3) metabolic asphyxiation , whereby certain smoke constituents interfere with tissue O2 delivery, tissue O2 consumption , or both. The immediate management of SII victims should focus primarily on the ABCDE of trauma.[10] During last 40 years, there were slower progress for improvement in management of inhalation injury. Burned cutaneous tissue may be excised and replaced with skin grafts, but injured pulmonary tissue must merely be supported and protected from secondary injury. The critically ill burn patients have multiple mechanisms in addition to smoke inhalation that may contribute to lung injury such as sepsis, Ventilator-Induced Lung Injury (VILI) or systemic inflammation in response to burns.[11-13] Thus inhalation injury has a significant effect on burn patient outcome but is difficult to separate from the contribution of other mechanisms which also affect the lungs.[14-16] In recent decades, there has been a dramatic decline in the mortality due to large burns. In contrast, despite considerable advances in our knowledge of the pathophysiology of inhalation injury, there are few therapeutic options, and patient care is mainly supportive. Recently several studies have suggested a decrease in the mortality associated with inhalation injury, these changes would result from overall improvement in care and not so much from interventions aimed specifically at inhalation injury. It is neccessary that a well-organized, complex approach to respiratory management of burn care be utilized so that improvement in result can be made, and the morbidity and mortality associated with inhalation injury can be reduced. The goal of this study was to assess epidemiology, premorbid conditions and their effect on the outcome in flame burn patients with inhalation injury. We also evaluated the cost of treatment.

MATERIALS AND METHODS

The data of our burn registry program admission in two years (from March 2009 to March 2011) was used as our source. During two years 1721 patients were admitted. Of them 719 were flame burn injuries which were included in this study .The following data were obtained: age, gender, place of burn, site of injury in the body, extent of burns, presence of inhalation injury, history of previous medical condition, pregnancy, admission to an intensive care unit (ICU), and ICU related mortality, length of hospital stay (LOS), length of stay in ICU, treatment outcome, treatment cost, and cause of death. And the mortality rate was calculated from data.

Inhalation injury was defined and diagnosed on the basis of history (presence in closed space), physical findings, arterial blood gas monitoring, serial chest radiography, and serial fiberoptic bronchoscopy in some of symptomatic cases and diagnosed by senior physician, usually during first 3 days of burn injury and most of all in the first 24 hours.

Indications for intubation and ventilator support were: PO2 <60, PCo2>50, Respiratory rate >40/min, Po2/FIO2<250, Severe respiratory distress.

All of above variables and data were collected in a pre-coded format from patients' medical records and formed the data of our burn registry program.

Data were collected by a special questionnaire (pre-coded format with all of the above variables) and analyzed using Statistical Package for Social Sciences (SPSS, version 20) and values are presented as a number (%) for categorical variables, and as mean +/- SD for quantitative parameter. P value less than 0.05 was considered significant. Pearson chi square was used for analysis of descriptive statistics and ANOVA and Independent-samples T test for analysis of numeric statistics. Multiple logistic regression was used for the correlation of variables with outcome.

RESULTS

A total of 1721 patients were hospitalized during 2 years from and of them 719(41.7%) were flame burn and/or explosion victims. 381(52.9%) of them were diagnosed with inhalation injury and 48(12.5%) of them were intubated and ICU admitted**.**

Base line characteristics and the clinical course of the patients are shown in table 1.The mean+/- SD of age was 32.5 +/- 9.5 years, and the mean +/- SD of TBSA was mean 31+/- 17 %. The logistic regression of cases is shown in Table 2.

Table 1- Demographic and clinical course of the patients

Demographic data	With inhalation injury	Without inhalation injury	*p* Value
Age (mean in years) +/_ SD	32.5 +/_ 9.5	28.1 +/_ 10	0.002 *
male/female	275/106 (72.5%)	195/143 (57.7%)	0.001 *
TBSA(mean %) +/_ SD	31 +/_ 17%	23.2 +/_ 13.9%	<0.001 *
Facial burns	335 87.9%	96 28.4%	<0.001 *
Closed space	329 86.4%	139 41.1%	<0.001 *
Smoke inhalation (percent of those with closed space burn)	307 93.3%	0	<0.001 *
Ventilator support (mean in days)	3.4 +/_ 1.7	2 +/_ 1.2	0.041 *
ICU (mean in days)	5.6 +/_ 2.9	5.9 +/_ 3	0.81

Length of stay(mean +/_ SD in days)	15.4 +/_7.1	13.8 +/_ 8.3	0.12
Mortality	65 17%	15 6.1%	0.02 *
Average of total Cost($)	8175 +/_ 1150	2300 +/_ 445	0.001 *
Mean of cost per one day +/_ SD	545 $ +/_ 85	155 $ +/_ 30	0.001 *
Drug abuse	203 53.3%	142 42%	0.001 *
Intubation	48	20	<0.001 *

- = Significant

Table 2: The results of logistic regression in our patients

Variable	Adjusted Odds Ratio	P value
Age	25.19 (2.32-273.66)	p=0.008
female sex	2.16(1.28-5.34)	p=0.05
TBSA	10.07(2.34-43.39)	p=0.002
closed space burn	2.38 (1.22-4.65)	p=0.011
smoke inhalation	12.43 (5.98-25.85)	p<0.0001
drug abuse	15.21 (6.02-38.44)	p<0.0001
Mortality rate	6.92(1.72-27.75)	p=0.006

Table3-Pre-morbid conditions of the burn patients with inhalation injury

Medical condition	Patients	Percent
Chronic obstructive pulmonary disease	36	9.4
Hypertension	14	3.7
Diabetes mellitus	16	4.2
Chronic renal failure	4	1
Immunodeficiency	2	0.5
Sensory motor disorder	2	0.5
Pregnancy	10	3.1
Coronary artery disease	22	5.7
Thyroid disease	6	1.6
Psychotic disorder	24	6.3
Epilepsy	1	0.3
Mental retardation	2	0.5
Drug abuser	203	53.3

Although, the length of hospital stay are longer in patients with inhalation injury (15.4 +7.1 versus 13.8 +/- 8.3 days in patients without inhalation injury), the difference with other patients was not statistically significant and some of other patients also needed ICU admission due to some other causes. But those with inhalation injury required more days with ventilator support.

In 52 patients (13.6%) of inhalation injuries were occurred in open spaces.

Then we excluded the patients without inhalation injury and analyzed 381 patients with inhalation injury. The premorbid conditions of the patients are summarized in table 3.

203 patients (53.3%) were drug abusers .there is a significant correlation between drug abuse and inhalation injury (p<0.001).

Among all 719 patients with flame injuries, 93% were cigarette smoker (358 patients (93.9%) of inhalation injury group were smokers and 311 (92%) of others were smokers.) and we did not find any correlation between cigarette smoking and inhalation injury.

Regarding treatment for skin wounds, Wound closure was achieved either temporarily by wound dressing and/or using skin substitutes or permanently with split thickness auto grafts or flaps. Among patients with inhalation injury a total of 206 patients underwent skin graft and 4 patients needed flap repair for their wound coverage. And 6 patients underwent limb amputation.

We analyzed premorbid conditions, diabetes mellitus, pregnancy and cardiovascular disorders could influence the final outcome. When we analyzed therapeutic modalities we could find a significant correlation of TPN and intubation with the mortality of the patients.

In inhalation injury group, 143 (37.5%) patients received TPN.

The mortality rate in the group of patients with TPN treatment was 23.8% while mortality in the rest of patients who did not receive TPN was 6.2%.

Albumin infusion decreased mortality rate from 66.7% to 62.5% although it was not statistically significant (p=0.17).

The overall mortality rate of our patients with flame burn injury was 11.9%. Patients in our study with an inhalation injury of any kind had a mortality of 17% as compared to only 6.9% for those without it.

The average cost of treatment for inhalation injury patients was 545 $ (19,000,000 Rials) per one day of intensive care, where one day of treatment of other burn patients was 155 $ (5,400.000 Rials), the difference was highly significant($p<0.001$). The average cost of total treatment for Inhalation injury patients was 8175 $ and average for other patients was 2300$, this difference was also statistically significant ($p<0.001$).

DISCUSSION

It is well known that patients suffering smoke inhalation injury in addition to dermal injury have poorer outcomes than those with skin burns.[17-19] The study of human burn victims not only reaffirms the effects of smoke inhalation on burn patient outcomes, but also demonstrate that the severity of inhalation injury may play a role in the overall pulmonary inflammatory response.[20] The pathology of the upper and lower respiratory tract lesion is due to the formation of edema, mucosal casts, and copious secretions.[21] focal areas of congestion and edema and areas of collapse, atelectesia and pneumonia are seen, which are the results of compensatory emphysema.[22] As a result, pulmonary compliance decreases, which can go to less than 50%.In severe injuries, physiologic shunt leading to profound hypoxemia and acute microvascular injury with increased transvascular fluid flux produces a clinical picture of ARDS. Furthermore, in burn patients, multiple mechanisms, besides inhalation injury, may contribute to ALI(acute lung injury) (e.g., sepsis, ventilator-induced injury, or SIRS).[19] In the clinical setting, diagnosis of inhalation injury is usually a subjective decision based on a combination of history and physical examinations, and is confirmed by diagnostic studies (e'g': ABGs, fiberoptic bronchoscopy, Xenon scanning, carboxyhemoglobin level, estimation of extravascular lung water by thermal and dye dilution).[19, 22] Defining the diagnostic criteria for inhalation injuries is complicated due to the extreme heterogeneity of clinical presentation as evaluated by the criteria above. Another difficulty is encountered when one attempts to distinguish between exposure to inhaled irritants and inhalation injury.[23] Bronchoscopy of the airway is still the gold standard to detect a pathognomonic mucosal hyperemia and sloughing.[19, 21, 22] Chest radiographs after third day may show signs of diffuse atlectasis, pulmonary edema or bronchopneumonia. However, during the initial period, the degree of injury is usually underestimated based on the chest X-ray, as the injury is mainly confined to the airways.[24]

The base of diagnosis of inhalation injury in our country is history of injury in a closed space, physical findings(if any), ABGs and in some patients bronchoscopy.

Patients in our study with an inhalation injury had a mortality of 17% as compared to only 6.9% for those without it, which is also similar but less than findings reported by Shirani et al in 1987, this issue indicates an improvement in therapeutic strategies at present time in our centers.[25] We also showed that inhalation injury in addition to burns increased mortality by approximately 11% (or 3 folds, from 6% to 17%).Mlcak et al found a 40% increase in mortality rate in severely burned patients with pneumonia, but if the pneumonia occurred in patients with inhalation injury the mortality rate went up to 60%.[26] It means that pneumonia increase mortality of inhalation injury by approximately 20%.

The overall mortality rate of our patients with flame burn injury was 11.9%.Lionello et al analyzed the risk of death in severely burned patients in the period 1972-2000. He found that the mortality rate among patients with inhalation injury was four times higher than patients without inhalation injury. This issue goes with our findings, we found 3 fold increase in mortality of our patients with inhalation injury. He established that the main cause of death was the occurrence of infectious complications in the airways.[27] In another meta-analysis on prognostic factors in burn injury with smoke inhalation reveals that overall mortality increased dramatically with inhalation injury (26.7% versus13.9%). Extent of burn size and age were also predictive of mortality. Another study included a predictive model of outcome with cutaneous injury plus smoke inhalation. In a review of 110 patients, the percent of Total Body Surface Area (TBSA), age and PaO2/FiO2 ratio were mortality predictors.[11-13]

37.5% of patients received TPN and their mortality was 23.8% in comparison to only 6.2% in those who did not receive TPN .It may be due to worse general condition of the patients who received TPN. Or in other words, more critical patients need TPN support. It is also a ground for further research in this topic.

OF 381 patients with inhalation injury, 42 patients were under 15 years. In children with flame burn the mortality was 11.9% .Mortality increased up to 13% in patients with inhalation injury. The number of children with inhalation injury is small, so the data may not be conclusive.

But, in another study performed in our center, evaluating pediatric burn injuries, (6.9%) had inhalation injury. Among the patients with inhalation injury, 18 patients (30%) expired; however, of patients without inhalation injury (810 patients), 71 patients (8.7%) expired. The difference was significant ($p < 0.0001$).The overall mortality rate in pediatric age group was 10.6%.[28, 29, 30] We find some differences in the mortality rate and rate of

inhalation injury in these studies which is due to our study population. In this study only flame burn injuries were included, however, in the previous study all burn victims under the age of 15 were included and as we know scald burns are the major cause of burn in pediatric population.

In our patients, 86.4% of inhalation injuries occurred in closed space and there is a significant correlation between closed space injuries and inhalation injuries .However 13.6%of inhalation injuries occurred outside in open spaces it goes with other references which reported about 12% inhalation injuries happen in open space.[12,18;21]

Our study showed that Albumin infusion decreased mortality rate from 66.7% to 62.5% although it is not statistically significant (p=0.17) This issue has to be evaluated further in other study and pathophysiology of it is not clear. One of the explanations is that The critically ill patients need more TPN support, more Albumin infusion and more time (days) for ventilatory support. Typically these patients have worse mortality rates and worse outcome. Although it is not proved yet.
We found a great correlation between drug abuse specially inhaled forms and inhalation injuries .This finding needs further evaluation to explore the pathophysiology of that for therapeutic interventions. Another interesting finding was the correlation between comorbidities such as diabetes, cardiovascular disorders and the outcome. There was a correlation between pregnancy and mortality too. This can be due to big belly in pregnant women which can predispose them to flame burn injuries while cooking in front of a gas stove (open flame). .Pregnancy and big belly also prevents proper respiratory care and complete respiratory recovery.

Against the background of the current literature, there has been a remarkable increase in our knowledge regarding the pathogenesis of smoke inhalation injury during the last decades. It seems that there is a need for prospective studies that enable standardization of monitoring.

CONCLUSION

TBSA, age and needs for ventilator support had worse influence on outcome of our patients.

Pregnancy with big belly, diabetes and cardiovascular disorders had negative influence on outcome.

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COMPETING INTEREST

"The authors declare that they have no competing interests."

AUTHORS CONTRIBUTION

HK, AM, MM, participated in the design of the study, performing the study and draft the manuscript and revisions.

MV performed the statistical analysis and draft the manuscript.

“All authors read and approved the final manuscript.”

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