INHALATION INJURY AS A PROGNOSTIC FACTOR FOR MORTALITY IN BURN PATIENTS

El-Helbawy R.H.,* Ghareeb F.M.2

Menoufiya University, Egypt
Chest Department1
Plastic Surgery Department2

SUMMARY. Inhalation injury greatly increases the incidence of respiratory failure and acute respiratory distress syndrome. It is also the cause of most early deaths in burn victims. The aim of this research is to study the incidence, early diagnosis, complications, and management of inhalation injury and to discuss the relationship between inhalation injury and death in burn patients. The study included 130 burn patients (61 male and 69 female) with inhalation injury admitted to Menoufiya University Hospital Burn Center & Chest Department (Egypt) from January 2008 to January 2010. It was found that the presence of inhalation injury, increasing burn size, and advancing age were all associated with increased mortality (p < 0.01). The incidence of inhalation injury was 46.3% (the 130 patients came from a total number of 281 burn victims). The overall mortality rate among patients with inhalation injury was 41.5% (54/130) compared with 7.2% (11/151) among patients without inhalation injury. These statistics clearly indicate that inhalation injury was an important factor for predicting burn patient mortality. Approximately 80% of fire-related deaths are due not to the airway burn injury itself but to the inhalation of toxic products, especially carbon monoxide and hydrogen cyanide gases. Inhalation injury is generally caused by thermal burns, and is mostly confined to the upper airways. Major airway, pulmonary, and systemic complications occur after inhalation injury, and this increases the incidence of mortality among burn patients.

Keywords: inhalation injury, mortality

Introduction

Inhalation injury is an acute respiratory tract insult caused by steam or toxic inhalants such as fumes, gases, and mists. Inhalation injury may occur without cutaneous burn injury, though the two injuries usually occur together. Despite increasing clinical interest in the problem of inhalation injury over the last few decades, the pathophysiology of inhalation injury remains poorly understood and there have been few improvements in treatment. Inhalation injury continues to be one of the most serious associated injuries complicating the care of thermally injured patients. Prevention or early diagnosis and treatment of associated life-threatening complications are necessary to decrease its associated morbidity and mortality: airway injury is present in up to one-third of patients with major burns, and the risk of concurrent pulmonary damage is directly related to the extent of the body surface area burned.

Inhalation injury greatly increases the incidence of respiratory failure and acute respiratory distress syndrome. It is also the cause of most early deaths in burn victims. The mortality rate following smoke inhalation ranges from 45 to 78%.1 Shirani et al. estimated that the burn-related death rate is 20% higher in patients with combined inhalation injury and cutaneous burns than in those with cutaneous burns alone.3

Smoke inhalation remains a serious and life-threatening problem. The heat generated during combustion can cause significant thermal injury to the upper airways. Particulate matter produced during combustion (soot) can mechanically clog and irritate the airways, causing reflex bronchoconstriction. The noxious asphyxiant gases released during thermal decomposition include carbon monoxide and hydrogen cyanide. Other by-products produced by the combustion of furniture and cotton (aldehydes) or rubber and plastics (chlorine gas, ammonia, hydrocarbons, various acids, ketones) also cause injury.4

Aim of the work

The aim of our research was to study the incidence, early diagnosis, complications, and management of inhalation injury and to discuss the relationship between inhalation injury and death in burn patients.

* Corresponding author: Dr Rana El-Helbawy, Menoufiya University Hospital, Menoufiya, Egypt. Tel.: 0020105268496; E-mail: megahedmaa@yahoo.com
Patients and methods

This study includes all burn patients with inhalation injury admitted to Menoufiya Burn Unit, Plastic Surgery Department and Chest Department from January 2008 to January 2010. Each patient was subjected to the following procedures:

1. History taking
The patient’s name, age, sex, and past history of illness, chronic diseases or congenital diseases were recorded. Age is a valuable factor in forming a prognosis, such as in the case of very young or very old patients, in whom the prognosis is poor. The patients’ sex is important as females are more exposed to burns. Chronic diseases such as diabetes mellitus, ischaemic heart disease, or bronchial asthma can increase the mortality rate if associated with burns.

2. General examination
We measured vital signs at the time of admission (blood pressure, pulse rate, temperature) - blood pressure and pulse rate in order to know the degree of hypovolaemia and as a base line for the progress of fluid intake (whether enough or insufficient) and the level of consciousness to determine the degree of hypoxaemia.

3. Evaluation and assessment of inhalation injury
We suspect smoke inhalation injury in anyone who was trapped in a confined space or who lost consciousness during a fire, especially in the presence of large quantities of heavy smoke. Clinical manifestations vary among victims, depending on their susceptibility to injury and degree of exposure. Injury may be limited to the upper airways (e.g. nasopharyngeal irritation, hoarseness, stridor, cough) or may extend distally with tracheobronchial and alveolar destruction (e.g. dyspnoea, chest discomfort, haemoptysis). Inhalation injury is likely in the presence of facial and upper cervical burns, singed eyebrows and nasal vibrissae, bronchial breath sounds, wheezing, rales, cyanosis, and carbonaceous sputum (Figs. 1, 2, 3, 4).

We assessed the extent of the burns and the degree of hypoxaemia in patients presenting with inhalation injury. Patients at low risk of injury and with no clinical symptoms can usually be observed for 4-12 h and then discharged, with close follow-up and instructions to return if symptomatic.

a. Investigations
In all patients admitted to our Department with clinically suspected inhalation injury, arterial blood gas analysis was a fundamental diagnostic test that was performed serially. Arterial hypoxaemia and reduced oxyhaemoglobin saturation (SaO2) accompany smoke inhalation, and the presence of hypoxaemia is therefore an indicator of inhalation injury, until it is proved otherwise. Initial measurement of PaO2 is thus an insensitive indicator.

It was found that the onset of hypoxaemia could be delayed as much as 48 h in spite of the absence of clinical or X-ray findings of inhalation injury.

b. Chest X-ray
We performed serial chest X-rays in patients with suspected inhalation injury. Chest X-rays taken on the day of injury were unreliable as a means of determining pulmonary injury by smoke inhalation. However, we performed them on admission because they serve as a baseline for subsequent radiographs.

The chest X-rays were used in the follow-up of pa-
tients for the detection of atelectasis and more or less extensive peribronchial cuffing or oedema.

In our Department we performed X-rays for the detection of complications of several therapeutic interventions (e.g. endotracheal intubation, intravenous catheterization, and central venous line replacement).

c. Respiratory function tests

We used respiratory function tests as a bedside procedure for the early detection and quantitation of inhalation injury. These tests demonstrate the presence of airway obstruction.

d. Fiberoptic bronchoscopy

Fiberoptic bronchoscopy provides direct information about the entire respiratory system. In addition to its diagnostic functions, bronchoscopy has important therapeutic and investigative applications and is used to determine the severity of inhalation injury. The following grading was used:

- Grade I: no laryngeal oedema
- Grade II: minimal laryngeal oedema and erythema
- Grade III: slight tracheal mucosal oedema and erythema
- Grade IV: moderate tracheal mucosal oedema and erythema
- Grade V: severe tracheal oedema and erythema

4. First aid and early management

This started when burn patients with inhalation injury came to our emergency room, where we performed first aid as follows:

a. Airways: we ensured patent airways.

b. Breathing: we checked for upper airway compromise, difficult breathing, stridor, and cough. We administered 100% oxygen because of the possibility of carbon monoxide inhalation in fires.

c. Circulation: patients were admitted to our burns unit according to our admission policy. When a patient arrives in the burns unit, there are two main problems. The first is severe pain, which may lead to neurogenic shock, and the second is fluid loss, which may lead to hypovolaemic shock.

The patient starts his journey of treatment from the dressing-room, where the dressing-room doctors and nurse start dressing him. We put the patient on a trolley in order to place him in a water container for the removal of dead skin and aspiration of bullae. We then paint the patient with Dermazine (silver sulphadiazine). During dressing, a venous line (cannula) is inserted in the patient and fluid therapy is started with 500 cc Ringer’s acetate; we also give the patient an analgesic. The patient is then weighed and the burn percentage is estimated for the purposes of fluid therapy with the Evans formula: 2 cc × body weight (kg) × burn percentage. If the burn more than 20% in children or more than 25% in adults, a urine catheter is inserted to record urine output, which must be 1 cc/kg body weight/h for adequate perfusion and fluid resuscitation.

In major burns, i.e. over 50% total body surface area (TBSA), we insert a central venous line (Swan-Ganz catheter) for continuous measurement of central venous pressure. We assess the patient for the presence of inhalation injury; if the patient is suspected of having inhalation injury a 100% oxygen mask is applied, followed by nebulized heparin.

5. Definitive treatment:

a. Fluid resuscitation

Fluid resuscitation: our unit follows the Evans formula...
la (2 cc/kg/% burn lactated Ringer’s) and the patient is
given a maintenance dose as 5% glucose. All fluids should
be warm to avoid hypothermia.

b. Dressing

Dressing of the patient was performed twice daily by
the open method with micronized silver sulphadiazine in
a hydrophilic base (Dermazine) after hydrotherapy.

c. Medical treatment

Any patient with suspected inhalation injury received
humidified oxygen. We used high-oxygen flow rates and
a tight-sealed non-rebreathing-type face mask, which fa-
cilitated delivery of high levels of supplemental oxygen,
thus helping to reverse the oxygenation defect created by
ventilation-perfusion mismatch. The inhaled oxygen also
helped in the displacement of CO from haemoglobin, de-
creasing the half-life of carboxyhaemoglobin from 4-6 h
in room air to 40-60 min in 100% FiO₂. It is recommended
that oxygen therapy should be continued until acidosis is
corrected, the carboxyhaemoglobin levels have fallen be-
low 15%, and the neurological symptoms have ceased,
which typically takes several hours.

We use the nebulized Farcolin bronchodilator because
it relaxes bronchial smooth muscle by action on β₂ re-
ceptors, with little effect on cardiac muscle contractility.
We give the following dose: adults (nebulizer), dilute 0.5
ml (2.5 mg) 0.5% inhalation solution in 1-2.5 ml saline
every 6 h and according to the patient’s symptoms; pa-
diatric <5 yr (nebulizer): dilute 0.25-0.5 ml (1.25-2.5 mg)
0.5% inhalation solution in 1-2.5 ml saline every 6 h and
according to the patient’s symptoms.

We use bronchodilators with special care in cases of
hyperthyroidism, diabetes mellitus, and cardiovascular dis-
orders; the adverse effects include tachycardia, palpitations,
tremor, insomnia, nervousness, nausea, and headache.

We add heparin to the nebulizer, and this plays an im-
portant role in breaking the cast and debris formed as a
result of inhalation injury.

Corticosteroids like Decardon and Solioctrif are added to
the medications because of their important role as
anti-inflammatory elements.

6. Surgical intervention

In the circumferentially burned chest we performed an
escharotomy to prevent restriction of chest expansion dur-
ing respiration. This was done by means of two lateral in-
cisions in the chest and a mid-line incision in the chest
wall and two parallel incisions.

Tracheostomy was performed in patients with severe
inhalation injury and airway obstruction in whom intuba-
tion was difficult.

Results

This study considered 130 burn patients (61 male, 69
female with inhalation injury admitted to Menoufiya Uni-
versity Hospital Burn Center and Chest Department from
January 2008 to January 2010 (Tables I, II, III).

Discussion

Over the past 20 years, there has been remarkable im-
provement in the chances of survival of patients treated in
burn centres. A simple, accurate system for objectively es-
timating the probability of death would be useful in coun-
selling patients and making medical decisions. This re-
markable success can be attributed to a number of ther-
apeutic developments, including vigorous fluid resusci-
tation, the early excision of burn wounds, advances in criti-
cal care and nutrition, powerful topical and systemic anti-
biotics, and the evolution of specialized, multidisciplinary
burn centres. It is over two decades since the first paper
on inhalation injury was published.1 In an article published
the following year it was reported that inhalation injury
was an important factory - and possibly the primary fac-
tor - responsible for mortality in thermally injured patients.6
Although that may still be true today, many new things
have been learned that have reduced the morbidity and
mortality of burn patients who have sustained a concomi-
tant inhalation injury.7 While some studies have reported
that little progress has been made in reducing mortality as-
associated with inhalation injury,8 others have noted signif-
ificant progress,9 with improved techniques for ventilating
patients, more aggressive fluid therapy, and better tech-
niques for trachea bronchial toilet. Better understanding of
the pathophysiology caused by cutaneous burns and smoke
to the lung will lead to even further advances in the treat-
ment of such lesions.10

The most commonly used predictors of mortality in
burns are age, burn size, and inhalation injury. In the past,
burns in over 80% TBSA that were mostly full-thickness
were often considered fatal, especially in children and the
elderly. In the past 15 years, advances in burn treatment
have increased the survival rates of patients treated in spe-
cialized burns centres, while the following are significant
predictors of increased mortality: larger burn size, the pre-
sence of inhalation injury, delayed intravenous access, low-
er admission haematocrit, lower base deficit on admission,
higher serum osmolarity on arrival in hospital, sepsis, ne-
cessity of inotropic support, platelet count < 20,000, and
ventilator dependency during the hospital course. It has
been found that the patients most likely to die are the very
young, those with limited donor sites, those who have in-
halation injury, those with delayed resuscitation, and those
with burn-associated sepsis or multi-organ failure.11

We conducted a review of all 130 burned patients with
inhalation injury admitted from 2008 to 2010 to Menoufiya
Burn Center, General Surgery Department, in Menoufiya
University Hospital (Egypt).
Our study found that the presence of inhalation injury, increased burn size, and advanced age were all associated with increased mortality \( (p < 0.01) \). The incidence of inhalation injury in our study was 46.3\% (130 patients out of 281 were identified as having inhalation injury). Overall mortality in patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.

A study performed in Tokyo, Japan, to evaluate the impact of inhalation injury on burn patient mortality showed that between 1984 and 2002, of the 5560 patients admitted to 13 burn facilities of the Tokyo Burn Unit Association, 1690 patients (30.4\%) had experienced inhalation injury. The overall in-hospital mortality rate of patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.

A study performed in Tokyo, Japan, to evaluate the impact of inhalation injury on burn patient mortality showed that between 1984 and 2002, of the 5560 patients admitted to 13 burn facilities of the Tokyo Burn Unit Association, 1690 patients (30.4\%) had experienced inhalation injury. The overall in-hospital mortality rate of patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.

A study performed in Tokyo, Japan, to evaluate the impact of inhalation injury on burn patient mortality showed that between 1984 and 2002, of the 5560 patients admitted to 13 burn facilities of the Tokyo Burn Unit Association, 1690 patients (30.4\%) had experienced inhalation injury. The overall in-hospital mortality rate of patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.

A study performed in Tokyo, Japan, to evaluate the impact of inhalation injury on burn patient mortality showed that between 1984 and 2002, of the 5560 patients admitted to 13 burn facilities of the Tokyo Burn Unit Association, 1690 patients (30.4\%) had experienced inhalation injury. The overall in-hospital mortality rate of patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.

A study performed in Tokyo, Japan, to evaluate the impact of inhalation injury on burn patient mortality showed that between 1984 and 2002, of the 5560 patients admitted to 13 burn facilities of the Tokyo Burn Unit Association, 1690 patients (30.4\%) had experienced inhalation injury. The overall in-hospital mortality rate of patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.

A study performed in Tokyo, Japan, to evaluate the impact of inhalation injury on burn patient mortality showed that between 1984 and 2002, of the 5560 patients admitted to 13 burn facilities of the Tokyo Burn Unit Association, 1690 patients (30.4\%) had experienced inhalation injury. The overall in-hospital mortality rate of patients with inhalation injury was 41.5\% (54 out of 130) compared with 7.2\% (11 out of 151) for those without inhalation injury. These statistical data clearly indicate that inhalation injury is an important factor in burn patient mortality prediction.
in the burns centre at Gulhane Military Medical Academy in Turkey from 1 January 1986 to 31 December 1995 found that 134 of them presented inhalation injury, of whom 82% died. Our study found that 83.1% of burn patients with inhalation injury died. Three risk factors for death were identified: age over 60 years, more than 40% TBSA burned, and inhalation injury. The mortality formula they developed predicts 0.3%, 3%, 33%, or approximately 90% mortality, depending on whether zero, one, two, or three risk factors are present. The results of the prospective test of the formula were similar. A large increase in the proportion of patients who chose not to be resuscitated complicated comparisons of mortality over time.15

In another study the outcome of 1385 patients admitted to a burns unit over a 20-yr period was evaluated in relation to the presence of three major risk factors for death: age 60 years or over, total burned surface area 40% or more, and the presence of inhalation injury. Mortality was respectively 9.9%, 48.0%, and 90.5%, and it was found that nearly all the patients who died had at least one risk factor present. In the presence of three risk factors the prognosis following burns was particularly compromised.16

Our study found an overall burn patient mortality of 23.13% (65 out of 281).

In a study of all patients admitted to the Burns Unit in Alexandria Menoufiya University Hospital, Egypt, over a 1-year period (1999), the mortality rate was 33%.17

A retrospective analysis of 435 consecutive admissions to a regional burns unit in Saudia Arabia, over an 8-year period, found a case fatality rate 7.4%.18

The above-mentioned retrospective study analysing 5264 patients treated at Gulhane Military Medical Academy found an overall in-patient mortality rate of 18.2%.19

An analysis of mortality rates and related factors in Spanish burn centres, based on 710 patients treated between 1985 and 1988, found an overall mortality rate of 6.6%.20

The marked difference in mortality rate between this centre and our own burns centre is due to the fact that the average burn size was 14% TBSA in the Spanish centre. Between 20 February 1987 and 13 July 1990, 844 patients were admitted to the Grady Memorial Hospital Burn Unit. The mortality rate was 8.5%.21 Half of the burns covered less than 10% TBSA, which explains the low mortality compared with that of our centre.

Any measure of outcome in a group of burn patients is useless and misleading unless the severity of injury is standardized. For many years, it was accepted that the extent of burn and the age of the patient were the two most important determinants of mortality probability in burn patients. It is now recognized that smoke inhalation is an important risk factor that must be included in the computation of mortality probability.

Inhalation injury greatly increases the incidence of respiratory failure and acute respiratory distress syndrome. It is also the cause of most early deaths in burn victims. The mortality rate following smoke inhalation ranges from 45% to 78%.22

Conclusions

Approximately 80% of fire-related deaths are due not to the burn injury to the airway but to inhalation of toxic products, especially carbon monoxide and hydrogen cyanide gases. Inhalation injury is generally caused by thermal burns, mostly confined to the upper airways. Major airway, pulmonary, and systemic complications occur with inhalation injury, which increases the incidence burn patient mortality.

Early detection and management of inhalation-related injury are absolutely essential. We therefore make the following recommendations:

1. Administer 100% humidified oxygen by facemask to burn patients with inhalation injury, once they have been admitted.
2. Burn patients with inhalation injury require more fluid than those with cutaneous burn alone; urine output and central venous pressure should be monitored to assess urine output.
3. Encourage central feeding as soon as possible.
4. Chest physiotherapy and postural drainage are essential to clear airways of cellular debris and soot.
5. Encourage extubated patient with inhalation injury to cough and breathe deeply; if intubated, use gentle suction to remove mucous, debris, and sloughed epithelium.
facteur important pour prédire la mortalité chez les patients brûlés. Environ 80% des décès liés au feu sont dus non pas à la simple brûlure des voies aériennes mais à l’inhalation des produits toxiques, et en particulier des gaz du monoxyde de carbone et d’acide cyanhydrique. Les lésions par inhalation, provoquées dans la majorité des cas par les brûlures thermiques et normalement limitées aux voies respiratoires supérieures, peuvent avoir des complications majeures aux voies aériennes, comme aussi après les complications pulmonaires et systémiques, et elles provoquent un incrément de la mortalité des patients brûlés.

Mots-clés: lésions par inhalation, mortalité

BIBLIOGRAPHY


This paper was accepted on 31 March 2011.