BURN INHALATION INJURY TREATMENT

SUMMARY

In patients with suspected inhalation injury, initial assessment should be performed to identify the need for intubation followed by bronchoscopy to determine the severity of the inhalation injury. When injury is present, burn inhalation treatment including aerosolized heparin, N-acetylcysteine, and albuterol should be initiated and continued for 7 days post-inhalation injury.

RECOMMENDATIONS

- **Level 1**
  - **None**
- **Level 2**
  - **None**
- **Level 3**
  - **In patients with suspected inhalational injuries, bronchoscopy should be performed within 24 hours of admission.**
  - **The use of aerosolized heparin, N-acetylcysteine, and albuterol has been shown to significantly improve survival in burn inhalation injuries.**
  - **Hydroxycobalamin (Cyanokit®) should be considered in burn injuries sustained in an enclosed space with suspected cyanide toxicity and one or more of the following criteria:**
    - **Hypotension without clear etiology**
    - **Altered mental status or seizure**
    - **Cardiopulmonary arrest**
  - **If patients have received hydroxycobalamin, do not administer ascorbic acid therapy as patients are at a higher risk for calcium oxalate nephropathy.**

INTRODUCTION

Inhalation injury can be caused from both thermal and chemical exposure. Thermal injury is typically isolated to the upper airway due to reflex closure of the larynx, but can lead to significant swelling and airway obstruction (1). Intubation should be performed in patients with respiratory distress or concern for airway edema, as swelling can worsen during fluid resuscitation. Chemical injuries, however, can occur throughout the respiratory tract, leading to damage of epithelial and capillary endothelial cells (1). Patients may also develop damaged mucociliary transport with an inability to clear secretions and bacteria (1).

LITERATURE REVIEW

Inhalation injury has been shown to significantly affect morbidity and mortality rates in burn patients. Various studies have been performed to analyze the extent of injury and effect on patient prognosis. A retrospective review performed by the U.S. Army Institute of Surgical Research evaluated 1058 patients presenting

EVIDENCE DEFINITIONS

- **Class I:** Prospective randomized controlled trial.
- **Class II:** Prospective clinical study or retrospective analysis of reliable data. Includes observational, cohort, prevalence, or case control studies.
- **Class III:** Retrospective study. Includes database or registry reviews, large series of case reports, expert opinion.
- **Technology assessment:** A technology study which does not lend itself to classification in the above-mentioned format. Devices are evaluated in terms of their accuracy, reliability, therapeutic potential, or cost effectiveness.

LEVEL OF RECOMMENDATION DEFINITIONS

- **Level 1:** Convincingly justifiable based on available scientific information alone. Usually based on Class I data or strong Class II evidence if randomized testing is inappropriate. Conversely, low quality or contradictory Class I data may be insufficient to support a Level I recommendation.
- **Level 2:** Reasonably justifiable based on available scientific evidence and strongly supported by expert opinion. Usually supported by Class II data or a preponderance of Class III evidence.
- **Level 3:** Supported by available data, but scientific evidence is lacking. Generally supported by Class III data. Useful for educational purposes and in guiding future clinical research.

between 1980 and 1984 of which 373 were documented to have inhalation injuries (2). They found that inhalation injury led to a mortality of 20% and that this increased to 60% in patients with both inhalation injury and pneumonia (2). Failure to properly address these injuries can therefore lead to poor outcome for the patient.

A retrospective review of charts from the National Burn Repository was performed in 2009 to determine the importance of bronchoscopy in evaluating patients with burn inhalation injury (3). Patients with 30-59% total body surface area (TBSA) burn and inhalation injury that underwent bronchoscopy had a decreased duration of mechanical ventilation as well as intensive care unit (ICU) stay compared to patients who did not have bronchoscopy. Additionally, patients who had one or more bronchoscopic procedures had an 18% reduction in mortality. Endorf et al. analyzed 80 patients with suspected inhalational injuries that underwent bronchoscopy within 24 hours of admission and grouped patients according to a grading system (Figure 1) (4). Higher grades of injury were associated with poorer survival rates.

Figure 1: INHALATION GRADING SYSTEM (4)

GRADE	CLASS	DESCRIPTION
0	No Injury	Absence of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction
1	Mild Injury	Minor or patchy areas of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction
2	Moderate Injury	Moderate degree of carbonaceous deposits, erythema, edema, bronchorrhea, or obstruction
3	Severe Injury	Severe inflammation with friability, copious carbonaceous deposits, bronchorrhea or obstruction
4	Massive Injury	Evidence of extensive mucosal sloughing tissue necrosis, endoluminal obstruction

McIntire et al. retrospectively analyzed 72 patients with burn inhalation injury of which half were treated with 10,000 units of nebulized heparin in conjunction with a mucolytic and N-acetylcysteine every 4 hours for 7 days (5). Treatment patients were matched with historical control patients based upon percent TBSA and age. The experimental group showed a significant decrease in duration of mechanical ventilation and increase in ventilator-free days.

Miller studied 30 patients with documented burn inhalation injury (6). An experimental patient group received nebulized heparin, N-acetylcysteine, and albuterol while a control group received ventilator support and albuterol alone. The experimental group showed significant improvement in lung injury severity scores, respiratory resistance, compliance measurements, and hypoxia scores compared to the control patients.

Improved survival is thought to be due to inhibition of clot formation by heparin, mucolysis from N-acetylcysteine, and bronchodilation from albuterol administration (6,7).

INITIAL EVALUATION

Upon arrival to a trauma/burn center, patients with burn injuries should be screened for inhalation injury. Physical examination should include evaluation for signs of respiratory distress, stridor, voice changes, nasal/oral soot, singed facial hair, significant facial burns, and edema. In suspected inhalation injury, patients should be placed on 100% oxygen by a non-rebreather mask and, if indicated, intubated for airway protection. If burn inhalation is suspected, bronchoscopy should be performed upon admission and the degree of injury should be noted using the inhalation injury grading system (Figure 1).

CARBON MONOXIDE POISONING

Upon initial evaluation of inhalation injuries, a co-oximetry arterial blood gas (ABG) with carboxyhemoglobin measurement should be performed to evaluate for elevated carbon monoxide levels. The affinity of carbon monoxide for hemoglobin is 200 times greater than for oxygen, reducing oxygen delivery to tissues (1). Patients with carbon monoxide poisoning will present with symptoms of poor oxygenation (headache, dizziness, nausea, altered mental status), but normal pulse oximetry. Treatment for carbon monoxide poisoning is mainly supportive with administration of 100% oxygen by non-rebreather mask to reduce the degree of carboxyhemoglobin and promote excretion of carbon monoxide. Hyperbaric oxygen therapy, although rarely necessary, can be utilized in cases of severe carbon monoxide poisoning and has been shown to reduce the risk of long-term cognitive complications (8).

CYANIDE TOXICITY

Cyanide toxicity results from inhibition of the cytochrome oxidase system (1). Smoke from house fires can place patients at risk for exposure to cyanide, produced from fumes of a variety of household items. In cases of suspected cyanide toxicity, the use of intravenous hydroxycobalamin (Cyanokit®) is indicated. Treatment should be initiated based on clinical suspicion for suspected cyanide exposure as well as additional symptoms, such as hypotension (unrelated to another cause), altered mental status, seizure, respiratory or cardiac arrest (9).

The starting dose of hydroxycobalamin for adults is 5 grams administered by IV infusion over 15 minutes. A second dose of 5 grams IV may be administered depending upon the response and clinical severity of the poisoning (9). Acute renal failure with acute tubular necrosis, renal impairment, and calcium oxalate crystals are potential side effects of hydroxycobalamin (9). Therefore, if patients have received hydroxycobalamin, do not administer ascorbic acid infusions or low dose ascorbic acid, as patients are at a higher risk for calcium oxalate nephropathy (9,10).

TREATMENT

Burn inhalation treatments should be implemented in patients with documented inhalational injuries. Various studies have been performed to evaluate treatment regimens. The use of aerosolized heparin, N-acetylcysteine, and albuterol have been shown to significantly improve survival.

Our American Burn Association-verified burn center recommends the following burn injury inhalation protocol be administered:

- N-acetylcysteine (20% aerosolized solution) - 3 ml
- Heparin aerosolized solution (10,000 unit(s)/mL) - 1 ml
- Albuterol sulfate aerosolized solution (2.5 mg/0.5 mL) - 0.5 ml

All three medications are mixed together by respiratory therapy and administered by inhalation treatment every four hours for the first seven days post-inhalation injury. This inhalation protocol continues even after extubation in patients that initially required mechanical ventilation.

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