VANDERBILT UNIVERSITY MEDICAL CENTER

Guideline: Adult Inhalation Injury

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Content Experts
Robel Beyene, MD Jessica Schucht, MD

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I. Population

This protocol is intended to provide recommendations of treatment for adult burn patients with inhalation injuries.

II. Definitions

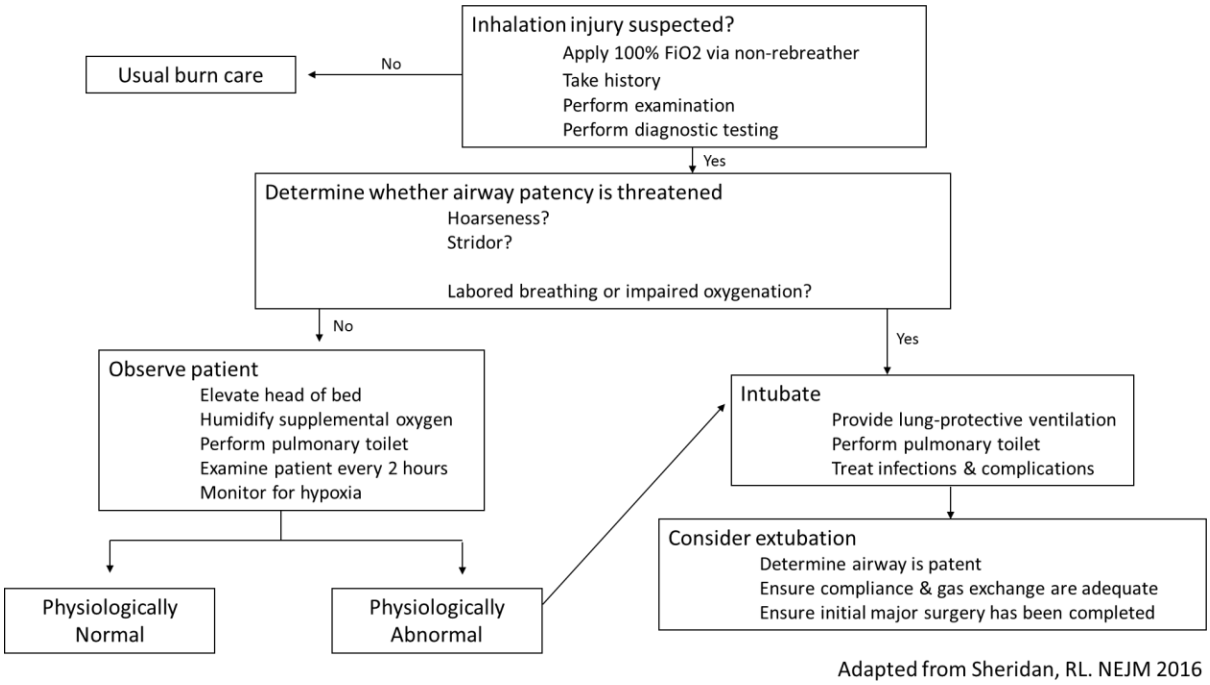
Inhalation injury refers to three separate injuries that occur when a patient is exposed to a fire in an enclosed space and inhales hot air and chemicals and incomplete products of combustion:

- Supraglottic burn injury which is caused by the direct damage to the upper airway and can result in swelling, mucosal sloughing, and bronchospasm.
- Subglottic burn injury is lower respiratory tract injury resulting from inhalation of chemicals and incomplete products of combustion that causes intense inflammatory responses and can lead to bronchospasm, vasospasm, bronchorrhea, and bronchial exudate and cast formation resulting in endoluminal obstruction.
- Systemic poisoning which includes carbon monoxide poisoning and cyanide poisoning.

III. Assessment

All burn patients should be assessed for inhalation injury. It is important to know the circumstances of the burn injury – enclosed vs non-enclosed. Patients trapped in enclosed spaces such as house fires and car fires with prolonged extrication are at greatest risk for inhalation injury.

a. Patients should be examined for physical signs suggestive of smoke inhalation – soot in mouth/nose/larynx, hoarseness, stridor, facial burns, singed nasal hairs or carbonaceous sputum. Note: Not all patients present with the classic signs and symptoms of inhalation injury, and presence or absence of these factors are not a reliable indicator of presence or severity of inhalation injury. The algorithm below provides guidance for early management of the airway in fire related inhalation injury.[1]
b. Patients should also be assessed for systemic poisoning when appropriate. A blood carboxyhemoglobin level should be obtained as soon as possible. We are not currently using the external monitor (finger probe) as it has not been validated in our center. Cyanide levels are not helpful due to the delay in getting the lab result back.



Adapted from Sheridan, RL. NEJM 2016

IV. Diagnosis

a. Carbon Monoxide (CO) poisoning. CO poisoning should be suspected in any patient who was in an enclosed space fire. The half-life of carboxyhemoglobin (COhb) in approximately one hour at an FiO2 of 100%.[2] Pulse oximetry is unreliable in CO poisoning as the elevated COHb level will falsely elevate the SaO2 measurements.

COHb Level	Symptoms
0-5	Normal
15-20	Headache, Confusion
20-40	Disorientation, Fatigue, Nausea, Visual changes
40-60	Hallucination, Combativeness, Coma, Shock
60 or above	Cardiopulmonary arrest

b. Cyanide poisoning. Hydrogen Cyanide is released with the products of combustion of synthetic polymers (couches, car seats, mattresses, etc.) and is absorbed by inhalation. Cyanide poisoning should be suspected in a patient who was in an enclosed space fire (e.g. home, car, trailer). Hydrogen cyanide interferes with oxygen transfer in the mitochondrial cytochrome oxidase system which results in tissue anoxia. Pulse oximetry is unreliable in patients with cyanide poisoning because the issue is with oxygen delivery not with oxygen uptake or carrying capacity. Cyanide labs are not routinely ordered. The lab is performed externally and takes several days to result. If cyanide poisoning is

suspected, the patient should be treated supportively and monitored for acidosis that is not resolving as expected with adequate resuscitation. **Cyanide toxicity should <u>NOT be treated</u> empirically in patients who have been in an enclosed space fire or have confirmed or suspected inhalation injury due to the increased risk of AKI and no large-scale human trial evidence of survival benefit.**[3]

c. Lower respiratory tract injury. The diagnosis of inhalation injury should be suspected based upon clinical findings in the setting of prolonged smoke exposure (i.e. history of being in an enclosed space fire), but definitive diagnosis relied upon direct examination of the airways. Once the airway is secured and the patient is hemodynamically normal, the diagnosis should be confirmed with flexible bronchoscopy. **Flexible bronchoscopy done within 24 hours** of injury is the gold standard diagnostic test for diagnosis of inhalation injury.[4,5,6] Need for BAL determined by intensivist on a case by case basis.
d. We do not intubate for the sole purpose of performing a diagnostic bronchoscopy or BAL.

Bronchoscopic injury severity scoring. The Abbreviated Injury Score (AIS) correlates with degree of hypoxia experienced in the first 72 hours after injury.[7]

Grade	Class		Description
0	No injury		Absence of carbonaceous deposits, erythema, edema, bronchorrhea or obstruction
1	Mild injury		Minor or patchy areas of erythema, carbonaceous deposits in proximal or distal bronchi
2	Moderate injury		Moderate degree of erythema, carbonaceous deposits, bronchorrhea, or bronchial obstruction
3	Severe injury		Severe inflammation with friability, copious carbonaceous deposits, bronchorrhea or obstruction
4	Massive injury		Evidence of mucosal sloughing, necrosis, endoluminal obliteration

V. Interventions

a. Recommended labs:
   i. Arterial blood gas (ABG) with lactate, methemoglobin, and carboxyhemoglobin
   ii. Standard burn admission labs
b. Tests:
   i. Baseline chest radiograph
   ii. Bronchoscopy within 24hrs of injury
   iii. Spontaneous breathing and awakening trials per unit protocols
   iv. Assessment for cuff leak by RT

VI. Treatments

a. Resuscitation:
   i. All confirmed intubated smoke inhalation patients should undergo a formal burn resuscitation (see burn resuscitation guideline).
b. Medications
   i. Cyanokit (hydroxocobalamin) should not be routinely administered given the increased risk of AKI and lack of consistent evidence supporting improved outcomes.[3] If cyanide poisoning is suspected **and** the patient has an acidosis that is not responsive to usual resuscitation the attending Burn Surgeon should be notified and prompt discussion regarding administration. If it was given prehospital, it should NOT be given again. Adult dose is 5 grams. NOTE: Cyanokit will turn the urine a dark pink/magenta and will cause the wound exudate to develop a pink hue. Note: Significant, transient hypertension is a known side-effect of Cyanokit.
   ii. Inhalation injury "burn cocktail." Administer q4hrs for 7 days or until extubated.[8] The use of nebulized medications in non-intubated patients remains understudied without evidence for or against use and benefit, the addition of the inhalation cocktail may be at the discretion of the Burn Attending.[6]

Inhalation Injury Protocol for Intubated Patients (aka "burn cocktail")	
Q4hr	3mL 20% N-acetylcysteine (nebulized)
Q4hr	Heparin 5000 units + 3mL of NS (nebulized)
Q4hr	Albuterol 2.5mg/3mL (0.083%) (nebulized)

   iii. Albuterol, combined with the burn cocktail has been shown to reduce the length of mechanical ventilation in patients with inhalation injury.[9]
      - The ventilator expiratory filter should be changed at least q24 hours (ideally, q shift) to prevent clogging with the burn cocktail.
   iv. Humidified oxygen should be administered.
   v. Inhaled Nitric Oxide (iNO) has been shown to improve oxygenation without affecting outcomes and remains at the discretion of the BICU provider.[6]

VII. Considerations

a. Extubation Criteria: Patients often appear to meet extubation criteria during the first 24 hours. Strong consideration should be given to the following when discussing extubation of patients with inhalation injuries: delayed mucosal sloughing and risk of hypoxemia for up to 72 hours post injury in patients with a bronchoscopic graded 2 or greater injury.
    i. In patients with proven inhalation injury, there is data to suggest that there are higher rates of failed extubation if done in the first 48h. Those who are able to extubate within 48h, are likely those who did not need intubation initially.[10]
    ii. >33% extubation failure in 48 hours, in inhalation injury patient, **irrespective of severity.** Primarily due to poor pulmonary toilet.[11]

b. Ventilator Settings: All efforts should be made to prevent further pulmonary trauma. This may be conventional ventilator strategies with lung-protective settings (e.g., low tidal volume) or alternative ventilator strategies such as VDR.No specific ventilator strategy has been shown to confer a mortality benefit in this patient population. [6,12] The ventilator management strategy is under the purview of the BICU attending.

c. Fluid Management: In patients with severe, cutaneous thermal injury (≥20% TBSA), the addition of an inhalation injury predicts an increased fluid requirement.[13,14] This is important to note but does not change the initial resuscitation rate.

d. ECMO: The role of ECMO in burn patients remains unclear. Retrospective data indicates that the survival for burn patients requiring ECMO is low and that the cohort of burn patients with the highest survival is those with isolated inhalation injury or small burns with inhalation injury or ARDS.[15] However, emerging data suggests that ECMO can be a successful strategy in the management of patients with severe burns and ARDS.[16,17] In patients that have refractory hypoxia or hypercarbia, ECMO should be considered in a discussion between the BICU and burn surgery attendings.

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