VANDERBILT UNIVERSITY
MEDICAL CENTER

Guideline: Pediatric Burn Inhalation Injury

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I. Purpose

This protocol is intended to provide recommendations of treatment for pediatric patients with inhalation injuries with or without facial burns. All patients with confirmed or suspected inhalation injuries will be admitted to the PICU.

II. Population and Injury Characteristics

This protocol applies to the pediatric patients with burn injuries seen in Monroe Carell Jr. Children's Hospital at Vanderbilt (Monroe Carell) that sustain burn inhalation injuries.

III. 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:

a. Supraglottic burn injury which is caused by the direct damage to the upper airway and can result in swelling, mucosal sloughing, and bronchospasm.
b. 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.
c. Systemic poisoning which includes carbon monoxide poisoning and cyanide poisoning.

IV. 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 enclosedspaces 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 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 always 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.

V. 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) is 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	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 evaluated 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 oxygen delivery is impaired, rather than oxygen uptake or carrying capacity. Cyanide labs are not routinely ordered because 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 NOT be treated 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] Patients symptomatic of cyanide toxicity with acidosis may be treated with hydroxocobalamin following approval by the attending Burn Surgeon.

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 relies 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 12 hours of injury is the gold standard diagnostic test for diagnosis of inhalation injury.[3,4] If possible, this exam should be coordinated with the burn surgeon.

d. Bronchoscopic injury severity scoring. The Abbreviated Injury Score (AIS) correlates with degree of hypoxia experienced in the first 72 hours after injury.[5]

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

VI. Interventions

a. Recommended labs
   i. Arterial blood gas (ABG) or venous blood gas (VBG) with lactate, methemoglobin, and carboxyhemoglobin
   ii. Standard burn admission labs

b. Tests
   i. Baseline chest radiograph
   ii. Bronchoscopy within 12 hours of injury
   iii. Spontaneous breathing and awakening trials per unit protocols
   iv. Assessment for cuff leak by RT every shift

c. Consults

   The following are consults that should be placed in addition to the standard orders for a pediatric patient undergoing resuscitation (i.e. ≥15% TBSA burn)
   i. Pulmonology
   ii. Speech language pathology

VII. Treatment

a. Medications
   i. **Cyanokit:** Although evidence in pediatric populations remains limited, some studies suggest an increased risk of acute kidney injury (AKI) without clear benefits in outcomes with Cyanokit use. Due to the high metabolic rate in pediatric patients, those with significant cyanide toxicity tend to develop symptoms rapidly within minutes; therefore, Cyanokit should be considered for patients who exhibit clinical symptoms within 2-3 hours of exposure. In contrast, for patients who remain asymptomatic several hours post-injury, Cyanokit can be considered when acidosis is significant, persists despite adequate fluid resuscitation and other contributing factors have been ruled out.
      i. Criteria:
         1. Enclosed-space fire

         AND

         2. Clinical manifestations within a 2-3 hours post-injury
            a. CNS: headache, confusion, vertigo, loss of consciousness, seizure
            b. CV: dysrhythmias, cyanosis
            c. GI: vomiting, abdominal pain
            d. Flushing (''cherry-red" color) separate from burns

         OR

            e. Acidosis unresponsive to fluid resuscitation
      ii. Pediatric Dose: 70mg/kg with max of 5 grams

      NOTE: Cyanokit will turn the urine a dark pink/magenta and will cause the wound exudate to develop a pink hue.
   ii. Inhalation injury “burn cocktail.” Administer q4hrs* for 72 hours post-injury, or until extubated – whichever occurs first. Do not start on patients that are not intubated.[6] Albuterol within the burn cocktail has been shown to reduce the length of mechanical ventilation in patients with inhalation injury.[9]

Inhalation Injury Protocol for Intubated Patients (AKA “Burn Cocktail”)	
****Alternate treatments every 2 hours***	
Q4hr	Albuterol 2.5mg/3mL (0.083%)(nebulized) *followed by* 3mL 20% N-acetylcysteine (nebulized)

Administer albuterol administered 5 minutes prior to N-acetylcysteine. The ventilator expiratory filter should be changed at least every 24 hours (ideally, every shift) to prevent clogging with the burn cocktail. Platelet counts need to be monitored and heparin treatment held for a platelet count <50.[16,17]

b. Humidified oxygen should be administered
c. Inhaled Nitric Oxide (iNO) has been shown to improve oxygenation without affecting outcomes and remains at the discretion of the PICU provider.[6]

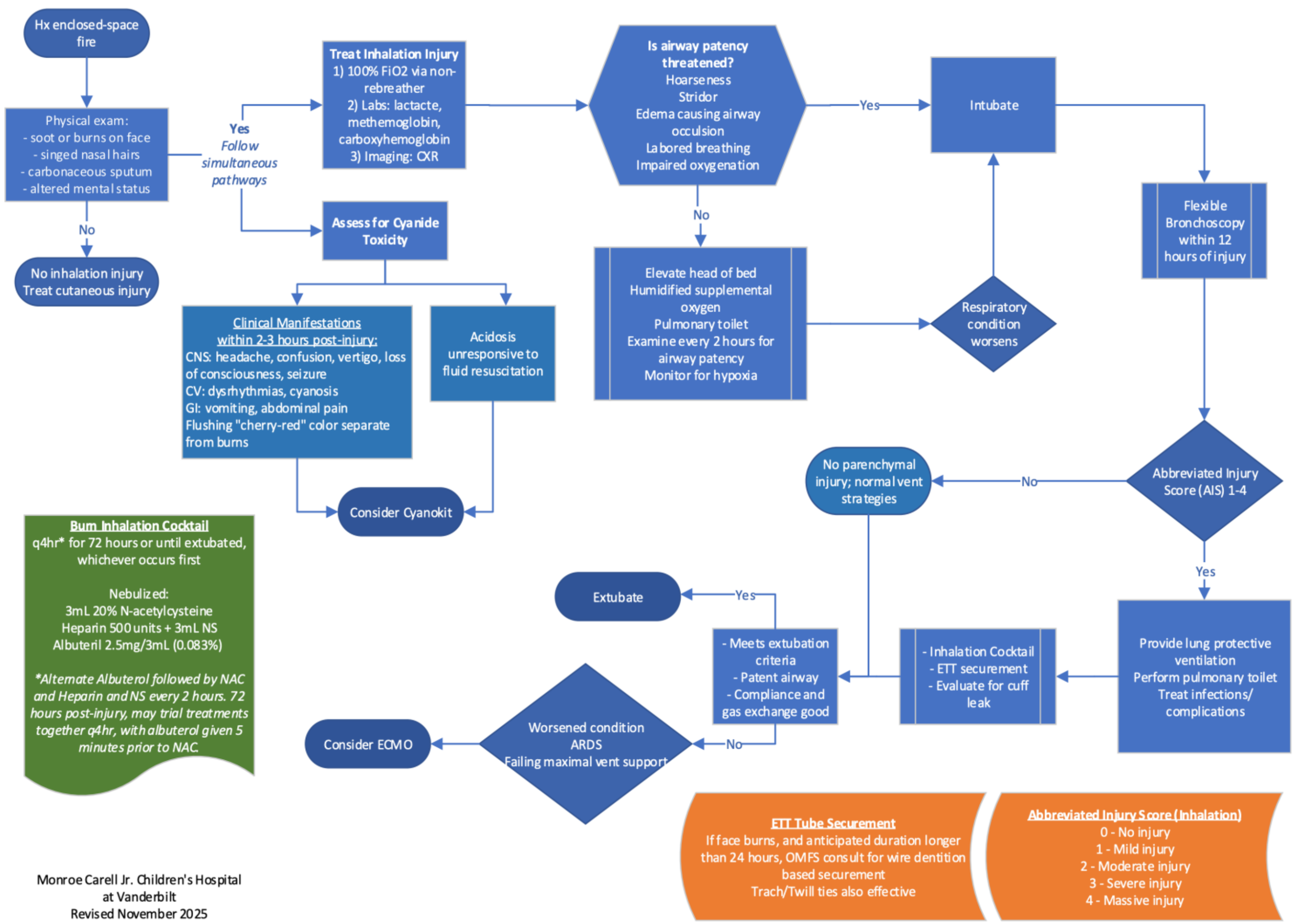
d. Consults
   i. Speech Language Pathology (PLP)

VIII. 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 inhalation injuries: Delayed mucosal sloughing and risk of hypoxemia for up to 72 hours post injury in patients with a bronchoscopy graded 2 or greater injury.
b. Endotracheal Tube Securement: For patients with inhalational or significant burn injury with facial burns, standard endotracheal tube securement cannot be achieved using adhesive tapes. In these settings, if a patient with facial and peri-oral burns has an ETT and it is expected that the patient will require intubation for longer than 24 hours, the patient will need a more stable, oral, or nasal securement.
   i. Patients with adequate or molar dentition, Oral and Maxillofacial Surgery (OMFS) will provide initial support for ETT securement (molar wiring or arch bar 8) with ENT backup if OFMS is unavailable. In patients without adequate dentition for securement (< 18 months or 9 to 12 years of age) or in patients who are expected to be intubated > 1 week with expected high sedation demands, Anesthesia (Airway Team) is available to discuss the possibility of converting an endotracheal ETT to a nasotracheal ETT.
   ii. Decisions for longer term securement should be made in conjunction between the subspecialties team to discuss risk/benefit and safety of the procedures during standard daytime hours. **In patients who do not meet criteria for ETT securement by Oral and Maxillofacial Surgery, trach ties (twill ties) may be used for ETT securement.**
c. 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 oscillatory ventilation. No specific ventilator strategy has been shown to confer a mortality benefit in this patient population.[9] The ventilator management strategy is under the purview of the PICU attending.
d. Fluid Management: In patients with severe, cutaneous thermal injury (≥15% TBSA), **the addition of an inhalation injury predicts an increased fluid requirement.**[10,11] This is important to note but does not change the initial resuscitation rate.
e. 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.[12] **However, emerging data suggests that ECMO can be a successful strategy in the management of patients with severe burns and ARDS and that outcomes are no different than standard indications for pediatric ECMO**.[13-15] In patients that have refractory hypoxia or hypercarbia, ECMO should be considered in a discussion between the PICU and burn surgery attendings.

Appendix I: Algorithms

Pediatric Inhalation Injury
Clinical Practice Guideline



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