Inhalation injury

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Case description

Mr B. is a 46-year-old man who is brought to your emergency department one night after being rescued from a fire in his apartment complex. He thinks he might have briefly lost consciousness while he was trapped in a smoke-filled room before firefighters were able to free him. He is fully awake and breathing comfortably upon arrival. Measurement of his vital signs reveals the following: heart rate of 85 beats/min, blood pressure of 124/76 mm Hg, respiratory rate of 20 breaths/min, oxygen saturation of 100% on room air, temperature of 36.8°C, and a glucose level of 6.5 mmol/L. A brief examination reveals only superficial burns to his face and neck. He says that he feels fine now and he wants to return home. How would you manage Mr B.? Is there anything concerning about Mr B.'s story?

Inhalation injury after a fire is a very serious condition, with very high rates of morbidity and mortality. Inhalation injury complicates 20% of burns, particularly facial burns, leads to respiratory failure in 70% of patients, and is fatal in 30% of cases.[1] It accounts for more than 80% of all fire-related mortality, with carbon monoxide (CO) being responsible for most deaths.[1]

Inhalation injury encompasses 3 different types of insult to respiratory function. Thermal injury to supraglottic structures results in edema and can rapidly lead to upper airway obstruction in the initial hours after exposure.[2,3] Chemical injury develops over the first 36 hours when small particles contained in smoke travel to the alveoli and trigger inflammatory reactions that lead to bronchospasm and impaired gas exchange in the distal airways.[3] Finally, systemic oxygenation is impaired by toxic gases released in most fires, specifically CO and cyanide.[3]

While advances in burn care have resulted in substantial improvements in the management of cutaneous burns, the same cannot be said for inhalation injury. Some of the reasons for this are the lack of clear diagnostic criteria and the absence of specific disease-modifying treatments.[1] That is why a high level of clinical suspicion and aggressive supportive care remain the mainstays of management.

Initial assessment

The initial assessment of inhalation injury begins with the rapid evaluation and stabilization of the airway, breathing, and circulation. In a burn patient, this means ensuring a patent airway, administering 100% oxygen by mask, and starting intravenous fluids as indicated by the patient's circulatory status.[2]

Once that is complete, a brief history should be obtained from the patient or any witnesses. Details of the exposure, including the type and location of the fire, the duration of smoke exposure, any loss of consciousness, and the condition of any other victims, can provide information about potential inhalation injury.[3,4]

A targeted physical examination should evaluate for any signs suggestive of inhalation injury, such as face and neck burns, singed nasal hairs, carbonaceous sputum, soot in the upper airways, voice changes, or wheezing.[3,4] It is important to note that the absence of these signs does not rule out inhalation injury.[2] Additionally, the patient should be fully exposed, and the extent and depth of any cutaneous burns should be noted.

To intubate or not to intubate?

The decision of when to definitely secure the patient's airway is among the most challenging in managing inhalation injury. While any sign of airway compromise during the primary assessment (eg, stridor, respiratory distress, hypoventilation, or decreased mental status) clearly necessitates intubation, even patients who are well initially can rapidly deteriorate.[4] Furthermore, as airway edema worsens, intubation becomes technically more difficult. However, there is no reliable indicator of which patients will go on to need intubation, and intubation is neither without harm to patients nor practical for every burn victim.[2] A reasonable approach is to consider prophylactic intubation for patients with evidence of serious cutaneous burns, soot in the oropharynx, or deep burns to the face, neck, or oropharynx, and to closely observe those without such signs for 24 hours while maintaining a low threshold for intervention.[4] It is important to properly secure the endotracheal tube, particularly during transfer, as loss of the airway could be catastrophic.[1]

Further management

There is very little available in terms of specific therapies for inhalation injury, so treatment continues to focus on supportive care. Regardless of the patient's oxygen saturation on pulse oximetry, 100% supplemental oxygen should be administered owing to potential CO exposure. Additionally, if there is any sign of bronchospasm, inhaled β-agonists can be helpful.[3]

Fluid replacement can be difficult to manage in patients with inhalation injury. While it has been

shown that inhalation injury in the context of severe cutaneous burns greatly increases fluid requirements, aggressive fluid replacement in isolated inhalation injury can be harmful by worsening airway edema and obstruction in the initial hours, and increasing the risk of developing adult respiratory distress syndrome.[2] Optimal rehydration requires frequent reassessment with adjustments as indicated by the patient's status.

Efforts to expand the therapeutic arsenal have largely been directed at interrupting the inflammatory and coagulation cascades in the distal airways.[1] The most promising results were seen with nebulized anticoagulants, such as heparin; however, there is not yet enough evidence to recommend them as standard treatment.[1] Other treatment strategies being studied include modulating pulmonary blood flow or using surfactants and anti-inflammatory agents.[1] Notably, antibiotics and corticosteroids are not effective in the treatment of inhalation injury.[2,4]

Investigations

While inhalation injury remains largely a clinical diagnosis, there are several studies that can provide valuable information. Measurement of arterial blood gas is necessary for a true assessment of oxygen saturation, as pulse oximetry is inaccurate in the context of CO poisoning.[5] Blood gas testing with co-oximetry can also demonstrate the presence of carboxyhemoglobin or lactic acidosis.[5] Imaging is rarely helpful acutely, as findings of a chest x-ray scan will usually be unremarkable.[4] If available, bronchoscopy can be used to help diagnose and determine the severity of inhalation injury. Different bronchoscopic grading systems exist, which might offer prognostic information; however, none can reliably predict which patients will develop respiratory failure, and the absence of findings on bronchoscopic investigation cannot rule out inhalation injury.[3]

Systemic poisoning

In addition to direct pulmonary injury in inhalation injury, patients are also at risk of hypoxemia from CO and cyanide inhalation, particularly if the fire occurred in an enclosed space.

Carbon monoxide is formed by the incomplete combustion of hydrocarbons and binds to hemoglobin with 200 times more affinity than oxygen. This causes an effective anemic state by decreasing the oxygen-carrying capacity of hemoglobin and shifting the oxygen dissociation curve to the left.[5] Symptoms of CO poisoning, such as headache, nausea, malaise, dyspnea, and decreased level of consciousness, can be nonspecific.[5] Therefore, it should be presumed to be present in the context of inhalation injury unless ruled out by a normal carboxyhemoglobin level (< 3% in non-smokers; < 10% in smokers).[3] Supplemental 100% oxygen will accelerate CO clearance and is the treatment of choice. Hyperbaric oxygen treatment is thought to clear the CO more quickly, but whether it improves outcomes is controversial.[5] Owing to the difficulty of managing critically ill patients in a hyperbaric chamber, it is not universally recommended, but you can discuss this with your local hyperbaric medicine centre.[5]

Cyanide is produced by the combustion of various synthetic materials often found in house fires. It causes hypoxemia by blocking the electron transport chain in the mitochondria and inducing anaerobic metabolism.[1] Symptoms of cyanide poisoning (eg, restlessness, dyspnea, headache, and dizziness) can be very nonspecific, but toxicity should be suspected in any patient with a history of exposure and depressed level of consciousness or respiration.[6-8] Cyanide levels are rarely available in the acute setting, but a lactate level greater than 10 mmol/L is highly predictive of poisoning.[6-8] Hydroxocobalamin has replaced the combination of amyl nitrite and sodium thiosulfate as the antidote of choice and should be considered in severe cases.[9] Discussion with your local poison centre is recommended.

What next?

After the primary evaluation and treatment, the next step will depend on the patient's condition and your centre's capabilities. Patients with minimal exposure, a physical examination with normal findings, and no evidence of CO or cyanide poisoning can likely be discharged home with instructions to return if any symptoms develop.[1,2] Patients with severe inhalation injury requiring intubation or with other concerning burns should be transferred to a burn centre intensive care unit as early as possible after stabilization. Long-term concerns for these patients include pneumonia, atelectasis, and acute respiratory distress syndrome.[4] Patients who are well but in whom inhalation injury is suspected represent a more difficult decision, and should be managed in consultation with your local burn centre.[2]

Back to Mr B.

Because the fire was in an enclosed space, he lost consciousness, and there were burns to his face, Mr B. was kept in the emergency department for investigation and monitoring. Further examination did not reveal any burns or soot in the oropharynx and blood tests showed no sign of CO or cyanide poisoning. He remained asymptomatic and was discharged home 24 hours later.

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Competing interests
None declared

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BOTTOM LINE

- Inhalation injury should be suspected in the context of smoke inhalation and with any of the following: closed-space fire, loss of consciousness, burns to the face or neck, changes in voice, respiratory symptoms, soot in the mouth or airway, or singed nasal hairs.
- Early intubation should be considered, as airway compromise can develop rapidly.
- Management is mainly supportive, with emphasis on supplemental oxygen, bronchodilators, and appropriate fluid resuscitation.
- Carbon monoxide and cyanide poisoning should be anticipated and treated with oxygen and cyanocobalamin, respectively, when present.

POINTS SAILLANTS

- Il y a lieu de soupçonner une blessure due à l'inhalation dans le contexte d'une inhalation de fumée et dans l'une ou l'autre des circonstances suivantes: incendie dans un espace clos, perte de conscience, brûlures au visage ou au cou, changements dans la voix, symptômes respiratoires, suie dans la bouche ou les voies aériennes, ou poils du nez roussis.
- Il faut envisager une intubation sans délai, car une détérioration des voies aériennes peut se développer rapidement.
- La prise en charge est principalement une approche de soutien, en insistant sur un supplément d'oxygène, des bronchodilatateurs et une réanimation liquidienne appropriée.
- Il faut anticiper un empoisonnement au monoxyde de carbone et au cyanure, et la traiter, le cas échéant, avec de l'oxygène et de la cyanocobalamine respectivement.

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