

## SMOKE INHALATION INJURY

The definition of smoke inhalation injury involves damage to the respiratory system as a result of breathing in harmful vapors, gases and particulate matter. The effects of smoke inhalation may be manifested as thermal injury, chemical injury or systemic toxicity (or a combination).

The number of fire victims and fire-related deaths has been reported as steadily increasing. The mortality rates from smoke inhalation injury over the years have shown no significant improvement. The US Fire Administration has reported 1.3 million fires in 2019 resulting in 3,704 deaths and over 17,000 injuries.

Smoke inhalation primarily affects the respiratory system with the type of respiratory injury being influenced primarily by the magnitude of exposure, as well as the types and properties of the toxic gases that are inhaled. Smoke is actually a product of combustion comprised as solids, liquid particles and gases. The incomplete combustion of carbon produces carbon monoxide and nitrogen-containing toxic materials, such as hydrogen cyanide and ammonia. Up to 150 toxic compounds have been identified in smoke. Smoke inhalation injury can occur from fires from various sources, including residential, vehicle and wildfires.

The three mechanisms of injury as a result of smoke inhalation injury include heat, inhalation of particulate matter and asphyxiation, as well as systemic toxicity. Burns of the upper airway are common, though thermal burns below the vocal cords are rare. Smoke containing super-heated steam causes swelling of the upper airway and occasional sudden death. Symptoms include shortness of breath, hoarseness and respiratory stridor (abnormal sounds produced by breathing due to a narrowed airway). Damage to the airway may not be apparent until the swelling is sufficient to cause an obstructed airway.

The inhalation of noxious chemicals result in an increase in secretions and fluid that may occlude the airways, as well as increasing the permeability of blood vessels, leading to a phenomenon known as pulmonary edema. The ability of the lungs to oxygenate the blood thus becomes compromised. Systemic toxicity involving several organ systems may occur secondary to the products of combustion in fire. Carbon monoxide is the most common substance causing systemic toxicity following smoke inhalation and may cause organ damage secondary to tissue hypoxia (low oxygen levels in the tissues).

A wide variety of synthetic materials currently used in buildings (such as insulation, furniture, carpeting and decorative items) increase the potential for severe health impacts from the inhalation of those products of combustion during building fires. This phenomenon has resulted in a higher degree of toxicity than was seen in the past, resulting in more severe inhalational injury and clinical outcomes.

Following thermal injury, further lung injury may be activated by the toxins in gases and particle components in smoke, perpetuating lung inflammation. The inflammatory process becomes self-

perpetuating, leading to significant systemic abnormalities that may injure other organs, potentially leading to multisystem organ failure.

Due to the progressive nature of thermal and inflammatory injury to the respiratory system, early intubation (introduction of a breathing tube into the airway) is often indicated. Failure to control airway swelling may result in airway obstruction and sudden death. Severe inflammation and airway injury may persist indefinitely, leading to long-term adverse effects on lung function. These abnormalities may persist indefinitely and result in abnormalities in pulmonary function testing that may be manifested as airway obstruction and/or restriction.