

Ammonia Toxicity: Integrating Environmental Health, Radiology, Nursing, and Respiratory Therapy

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Abstract

Ammonia is a highly toxic, colorless gas with a pungent odor, widely used in industrial, agricultural, and household settings. It is naturally produced in the human body but becomes harmful when external exposure exceeds safe limits. Ammonia exposure occurs through inhalation, ingestion, or direct contact, leading to respiratory, gastrointestinal, dermal, and ocular injuries. Despite its widespread use, systemic toxicity from external exposure is rare, but localized damage can be severe and life-threatening. This article aims to provide a comprehensive overview of ammonia toxicity, focusing on its pathophysiology, epidemiology, clinical presentation, diagnostic evaluation, management, and prevention. It emphasizes the roles of environmental health, nursing, and radiology in mitigating risks and improving patient outcomes. The review synthesizes evidence from case studies, systematic reviews, and clinical guidelines to outline the mechanisms of ammonia toxicity, its clinical manifestations, and interdisciplinary management strategies. Key areas include toxicokinetics, histopathology, diagnostic techniques, and treatment protocols. Ammonia exposure primarily causes localized damage, with inhalation leading to respiratory distress, ingestion causing gastrointestinal burns, and dermal/ocular contact resulting in chemical burns. Severe exposure can lead to chronic lung disease, esophageal strictures, or vision loss. Diagnostic tools include imaging, endoscopy, and laboratory tests, while management focuses on decontamination, supportive care, and early specialist intervention. Preventive measures, such as proper ventilation and protective equipment, are critical in reducing exposure risks. Ammonia toxicity requires a multidisciplinary approach involving environmental health, nursing, radiology, and other specialties. Early recognition, prompt treatment, and preventive strategies are essential to minimize morbidity and improve outcomes. Public education and safety regulations play a vital role in reducing exposure incidents.

Keywords: *Ammonia Toxicity, Environmental Health, Respiratory Therapy, Radiology, Nursing, Interdisciplinary Care, Prevention, Management.*

Introduction

Ammonia is a colorless irritant gas with a pungent odor, readily soluble in water to generate ammonium ions [1]. It is a natural by-product in the human body, serving as an intermediate in several metabolic reactions, primarily those involving amino acid synthesis [2]. Additionally, ammonia is produced in the human gut due to the enzymatic actions of bacteria [3]. Despite its physiological role, ammonia is highly toxic and must be rapidly metabolized into urea in the liver through the urea cycle and subsequently excreted by the kidneys [4][5]. In healthy adults, blood ammonia levels typically range from 15 to 45 micrograms/dL

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[6]. However, ammonia toxicity occurs when the concentration of ammonia in the blood exceeds the liver's capacity to eliminate it, which can result from overproduction, as seen in congenital hyperammonemia, or under-elimination, as observed in liver cirrhosis [7][8]. This discussion focuses on the various ways the human body is exposed to external sources of ammonia and the mechanisms through which it exerts its toxic effects. Injury from ammonia commonly occurs through three primary routes: inhalation, ingestion, and direct contact. Inhalation of anhydrous ammonia gas or vapors from liquid ammonia is a significant exposure pathway, often leading to respiratory distress, bronchospasm, and pulmonary edema due to its corrosive effects on the respiratory tract [1]. Ingestion of ammonia-containing liquids, though less common, can cause severe damage to the gastrointestinal tract, including burns to the mouth, esophagus, and stomach [3]. Direct contact of anhydrous ammonia gas or liquid with the skin or eyes can result in chemical burns, frostbite, and ocular damage, as it reacts rapidly with moisture in tissues, leading to cellular necrosis and inflammation [4]. These exposure routes highlight the diverse mechanisms through which ammonia can cause harm, emphasizing the need for comprehensive understanding and management strategies to mitigate its toxic effects on human health.

Etiology

Ammonia is one of the most extensively produced chemicals in the United States, with the majority of its production being utilized in chemical fertilizers and animal feeds. This widespread use contributes to various pathways of human exposure, which can lead to significant health risks. One primary route of exposure is through gas leaks from facilities involved in the production, storage, or transportation of ammonia. Workers in these environments are particularly vulnerable to inhalational and dermal exposure due to the potential for accidental releases of ammonia gas [9][10]. Another significant source of exposure arises from the application of ammonia-based fertilizers in agriculture. After these fertilizers are applied to soil, elevated levels of ammonia may persist in the air, placing farmers and agricultural workers at an increased risk of inhalational exposure [11]. In household and industrial settings, ammonia is commonly found in cleaning products, typically in concentrations ranging from 5% to 25%. These products pose a risk of accidental or intentional ingestion, particularly among children, as well as inhalational exposure due to spillage or improper use [12]. Additionally, ammonia is naturally produced by the decay of manure, creating hazardous conditions for farmers and workers in animal confinement buildings. These individuals are at a heightened risk of inhaling ammonia gas, which can accumulate in poorly ventilated spaces [13][14]. Each of these exposure routes underscores the diverse and widespread nature of ammonia-related risks, highlighting the need for stringent safety measures and awareness to mitigate its potential health impacts.

Epidemiology

Ammonia exposure is a significant public health concern, with its epidemiology highlighting both the frequency and nature of incidents. According to the 2017 annual report of the American Association of Poison Control Center's National Poison Data System, there were 1,846 reported cases of single exposures to ammonia, resulting in 15 major adverse events but no fatalities [15]. Additionally, the report documented 1,366 single exposures to ammonia-containing glass cleaners and 489 single exposures to ammonia-containing all-purpose cleaners, with no deaths reported in either category. These statistics underscore the relatively low mortality rate associated with ammonia exposure but emphasize the potential for serious health consequences. The majority of ammonia exposures are unintentional, with ingestion incidents predominantly occurring in children due to accidental consumption of household cleaning products. This demographic is particularly vulnerable due to their curiosity and lack of awareness regarding the dangers of such substances. However, intentional exposure to ammonia-containing household products accounts for 9.2% of cases, primarily involving adults. These intentional exposures are often linked to suicidal attempts or deliberate misuse, highlighting the need for public health interventions to address both accidental and intentional incidents. The data also reveal that occupational exposure, particularly in industries involving ammonia production, storage, or use, remains a concern, though specific statistics on workplace-related incidents are not detailed in this report. Overall, the epidemiology of ammonia exposure underscores the importance of preventive measures, public education, and safety regulations to reduce risks across all age groups and settings.

Pathophysiology

The pathophysiology of ammonia toxicity is primarily driven by its highly reactive nature and its interaction with water in human tissues. Anhydrous ammonia, whether in liquid or gaseous form, reacts exothermically with water to form ammonium ions, releasing significant heat and causing thermal injury to surrounding tissues [16][17]. This reaction also produces an alkaline solution, which induces liquefaction necrosis through protein denaturation and saponification of fats, leading to extensive tissue damage [16][17]. Additionally, ammonia's ability to extract water from tissues initiates a robust inflammatory response, further exacerbating injury [18]. When exposure involves liquid anhydrous ammonia, which is typically stored at extremely low temperatures (-28°F), the combination of chemical and cold-induced thermal injury results in severe tissue damage [19][20]. Inhalation of gaseous anhydrous ammonia primarily affects the respiratory tract, injuring the superficial epithelial layers and increasing susceptibility to infections. Damage to the basal epithelial layer can lead to irreversible scarring, contributing to chronic lung diseases such as bronchiolitis obliterans or pulmonary fibrosis [16]. Ocular and dermal exposure to gaseous ammonia causes corneal injuries and skin burns, respectively, due to its caustic properties [17]. Ingestion of ammonia-containing substances results in severe injuries along the alimentary canal, including chemical burns and potential perforation of hollow viscera, which can lead to life-threatening complications such as peritonitis [19]. While the local effects of ammonia exposure are well-documented, there is limited evidence to suggest that external exposure can lead to systemic hyperammonemia or manifestations of systemic toxicity, such as hepatic encephalopathy. Most systemic effects of ammonia toxicity are associated with endogenous overproduction or impaired elimination, rather than external exposure [18]. Understanding these pathophysiological mechanisms is critical for developing effective treatment strategies and mitigating the long-term consequences of ammonia exposure.

Histopathology

Histopathological examination of tissues following acute ammonia exposure reveals significant damage, particularly in the respiratory system. In the lungs, acute exposure to ammonia leads to pulmonary congestion, edema, and desquamation of the bronchial epithelium [21]. These changes are indicative of severe irritation and inflammation caused by the caustic nature of ammonia, which disrupts the integrity of the epithelial lining. The desquamation, or shedding, of the bronchial epithelium results in the accumulation of cellular debris, red blood cells, and dust cells within the airways. This debris contributes to significant lower airway obstruction, impairing airflow and leading to respiratory distress. The inflammatory response triggered by ammonia exposure further exacerbates tissue damage, promoting the release of cytokines and other mediators that perpetuate injury and hinder repair processes. In cases of prolonged or severe exposure, the histopathological findings may extend to irreversible scarring and fibrosis of the lung tissue. Damage to the basal layer of the epithelium can result in the replacement of normal tissue with fibrous tissue, leading to chronic lung diseases such as bronchiolitis obliterans or pulmonary fibrosis [21]. These changes are characterized by the thickening of alveolar walls and the loss of functional lung parenchyma, which compromise respiratory function over time. Histopathological evidence underscores the destructive potential of ammonia on respiratory tissues, highlighting the importance of early intervention and protective measures to minimize long-term damage. Understanding these changes is crucial for diagnosing and managing the complications associated with ammonia exposure.

Toxicokinetics

Toxicokinetics refers to the study of how a toxic substance enters the body, moves within it, and is ultimately eliminated. In the case of ammonia, its toxicokinetics are influenced by its physical properties, route of exposure, and the body's metabolic processes. Ammonia's pungent odor is detectable at concentrations as low as 5 parts per million (ppm), making significant exposure without the individual's awareness rare [22]. At concentrations up to 100 ppm, ammonia is generally well-tolerated for several hours. However, as concentrations increase, the risk of severe health effects escalates. At 1700 ppm, exposure can cause coughing, laryngospasm, and edema in the glottic region, while concentrations of 2500 to 4500 ppm can

be fatal within approximately 30 minutes. Concentrations exceeding 5000 ppm often lead to rapid respiratory arrest, and levels above 10,000 ppm can cause skin damage [23]. To mitigate these risks, the US National Institute of Occupational Safety and Health (NIOSH) has established safety guidelines. The permissible time-weighted average exposure for anhydrous ammonia over an 8-hour workday is 25 ppm, while the short-term exposure limit, beyond which exposure longer than 15 minutes is dangerous, is 35 ppm. The concentration considered immediately harmful to life or health is 300 ppm [24].

The absorption and distribution of ammonia in the body depend on the route and duration of exposure. Short-term inhalational exposure (under 120 seconds) results in minimal systemic absorption, as most inhaled ammonia dissolves in the mucus of the upper respiratory tract, with 70% to 80% being excreted in exhaled air [25]. However, prolonged inhalational exposure can lead to some systemic absorption, as ammonia can penetrate deeper into the respiratory tract and enter the bloodstream [26]. Ingested ammonia, on the other hand, is readily absorbed into the bloodstream. The liver plays a critical role in its metabolism, converting ammonia into urea through the urea cycle. While quantitative data on the metabolism of exogenous ammonia in humans is limited, studies in rats indicate that most exogenous ammonia is converted into glutamate and urea within 30 minutes [28]. Orally ingested ammonia is almost entirely metabolized into urea in the liver and excreted by the kidneys, with 25% excreted within the first 6 hours and 72% within 3 days [29]. Despite this efficient elimination process, oral ingestion rarely raises systemic ammonia levels high enough to cause systemic toxicity. Dermal exposure to ammonia, particularly in its gaseous or liquid form, primarily causes local tissue damage due to its caustic and exothermic reactions with water in the skin. There is currently no evidence to suggest that dermal exposure results in significant systemic absorption of ammonia [23]. This is likely due to the rapid local tissue damage and the body's ability to neutralize small amounts of ammonia that may penetrate the skin. Overall, the toxicokinetics of ammonia highlight the importance of route and duration of exposure in determining its systemic effects. While inhalation and ingestion can lead to systemic absorption under certain conditions, dermal exposure primarily causes localized injury. Understanding these mechanisms is crucial for developing effective prevention and treatment strategies for ammonia exposure.

History and Physical Examination

A thorough history and physical examination are critical in evaluating patients with ammonia exposure, as the presentation varies depending on the route and severity of exposure. In cases of inhalational injury, patients typically report symptoms such as rhinorrhea, scratchy throat, chest tightness, cough, dyspnea, and eye irritation. Ammonia's strong, pungent odor often alerts individuals to its presence, allowing those who can escape the environment to avoid prolonged exposure. However, in cases of severe or prolonged exposure, patients may develop full-thickness skin burns due to the caustic and exothermic nature of ammonia [23]. For ingestion injuries, patients commonly present with oropharyngeal, epigastric, and retrosternal pain. If perforation of a hollow viscus occurs, abdominal pain and other gastrointestinal symptoms may develop, sometimes as late as 24 to 72 hours after ingestion. A history of accidental or suicidal ingestion of ammonia-containing products, such as household cleaners, is often reported, providing crucial context for the clinical presentation [29].

The physical examination begins with ensuring the stability of the patient's airway, breathing, and circulation. Once stabilized, a systematic examination should be conducted to assess the extent of injury. The level of consciousness should be evaluated first, as altered mental status may indicate systemic toxicity or hypoxia. The head, ears, eyes, nose, and throat should be carefully examined for signs of facial burns, oral ulcerations, or edema, which are common in ammonia exposure due to its corrosive properties. A detailed respiratory examination is essential, focusing on respiratory rate, oxygen saturation, and the presence of stridor, drooling, cough, wheezing, rhonchi, or decreased air entry, which may indicate upper or lower airway injury [21]. The skin should be fully exposed and inspected for burns, particularly in areas that may have come into direct contact with ammonia. Special attention must be given to the eyes, as ammonia can cause severe corneal damage, lens opacities, and even globe perforation, necessitating an urgent ophthalmologic evaluation [23]. In cases of ingestion, an abdominal examination may reveal epigastric tenderness or peritoneal signs, which could indicate visceral perforation. Since these signs may develop hours after exposure, repeated abdominal examinations are necessary to monitor delayed

complications [29]. A comprehensive history and physical examination are indispensable for guiding immediate management and anticipating potential complications in patients with ammonia exposure.

Evaluation Techniques

The evaluation of patients with ammonia exposure requires a systematic approach, as there are no specific laboratory tests to reliably assess the extent of systemic ammonia toxicity. In individuals with preserved liver function, serum ammonia levels do not correlate with external exposure and are of limited diagnostic value. Instead, a combination of routine and targeted investigations is essential to evaluate the systemic and localized effects of ammonia exposure. For all patients, routine laboratory tests should include a complete blood count (CBC) to assess anemia or infection, blood urea nitrogen (BUN) and creatinine to evaluate kidney function, serum lactic acid levels to identify metabolic acidosis, and serum electrolytes to detect imbalances. Prothrombin time (PT) and international normalized ratio (INR) should be checked to assess coagulation status, particularly in cases of severe systemic involvement. Blood typing and cross-matching may be necessary for patients requiring surgical intervention or transfusion. Continuous monitoring of urine output is critical to evaluating renal perfusion and function, especially in cases of significant systemic toxicity.

In patients with suspected respiratory injury, pulse oximetry and cardiac monitoring are essential to assess oxygenation and cardiac function. Serial blood gas analyses help evaluate acid-base status and respiratory efficiency. Chest radiography is necessary to identify pulmonary edema, pneumonitis, or other structural abnormalities. Pulmonary function tests may be useful in assessing airway obstruction or restrictive lung disease. In cases of severe acute inhalation injury, bronchoscopy can provide direct visualization of airway damage and guide treatment. A ventilation-perfusion (V/Q) scan may be indicated if pulmonary embolism is suspected. For patients with suspected ingestion, an abdominal series (X-rays) should be performed to rule out perforation of the gastrointestinal tract. Early endoscopy (within 12 hours) is recommended for patients presenting with stridor, drooling, dysphagia, or significant oral burns, as it is a safe and effective method to evaluate esophageal and gastric injury [30]. Importantly, the absence of oral burns does not exclude esophageal injury, making early endoscopic evaluation necessary for most patients with suspected ingestion. In cases of ocular exposure, a thorough eye examination is critical. A slit-lamp examination with fluorescein staining helps identify corneal abrasions or ulcers. Tonometry measures intraocular pressure, which may be elevated due to inflammation. Conjunctival pH measurement can assess the extent of chemical injury and guide irrigation therapy. These investigations, tailored to the route and severity of exposure, provide a comprehensive evaluation of ammonia-related injuries and guide appropriate management.

Treatment and Management

The management of ammonia exposure is primarily supportive, as systemic toxicity from external exposure is rare, and no specific antidotes exist. The first step in treatment is to remove the patient from the source of exposure and initiate decontamination. Immediate attention should be given to stabilizing the airway, breathing, and circulation. A rapid physical examination should be carried out to assess the extent of injury and determine the need for advanced airway support. Indications for an advanced airway include depressed mental status, deep burns to the face or proximal airway, hoarseness or stridor, and severe respiratory distress. These signs suggest significant upper airway involvement, which may require intubation to prevent airway obstruction and ensure adequate oxygenation. Supplemental oxygen, preferably warm and humidified, should be administered to patients with respiratory symptoms. However, liberal fluid resuscitation should be avoided, as patients with ammonia exposure are at risk for acute lung injury, and excessive fluids may exacerbate pulmonary edema. If skin burns are identified, standard burn management protocols should be followed. The affected areas should be irrigated with tepid water for at least 15 minutes, followed by frequent irrigation for 24 hours to ensure complete removal of ammonia. Avoid applying medications or dressings, as these can interfere with the natural vaporization of ammonia from the skin. Ocular exposure requires immediate and thorough irrigation with tepid water for at least 30 minutes or until the conjunctival pH normalizes to 6.8–7.4. Early consultation with an ophthalmologist is critical, as

ammonia can cause severe corneal damage, lens opacities, and even globe perforation, potentially leading to permanent vision loss.

In cases of oral ingestion, dilution with water or milk can help reduce the caustic effects of ammonia on the gastrointestinal tract. However, inducing emesis is contraindicated, as it can cause further injury during the second pass of the toxin. Patients should be kept nil per oral (NPO) until a thorough evaluation, including early endoscopy, is completed to assess the extent of gastrointestinal injury. Early surgical intervention is associated with improved outcomes in patients with impending perforation or severe injury [31]. For patients presenting with dysphagia, follow-up endoscopy and a barium swallow should be performed weeks later to rule out stricture formation, a common complication of caustic ingestion. The use of corticosteroids in ammonia toxicity remains controversial. While some evidence suggests that steroids may benefit patients with airway edema or hyperreactivity, their routine use is not recommended due to conflicting data and potential adverse effects. Most patients with ammonia exposure can be safely discharged after 6 hours of observation if they remain asymptomatic, can tolerate oral intake, and have no evidence of significant injury. However, hospital admission is warranted for patients with persistent symptoms, endoscopically demonstrated burns, respiratory distress, or abnormal laboratory findings attributable to ammonia exposure. These patients require close monitoring and further evaluation to manage potential complications effectively. In summary, the management of ammonia exposure focuses on decontamination, supportive care, and early intervention to prevent complications. A multidisciplinary approach involving emergency medicine, toxicology, ophthalmology, gastroenterology, and surgery may be necessary to address the diverse manifestations of ammonia toxicity and optimize patient outcomes.

Differential Diagnosis

The differential diagnosis for ammonia exposure varies depending on the route of exposure and the presenting symptoms. Inhalation of ammonia, a highly water-soluble and irritative gas, primarily affects the upper airway, leading to symptoms such as rhinorrhea, cough, and respiratory distress. Other high water-soluble irritative gases, including acrolein, ethylene oxide, formaldehyde, hydrogen chloride, and sulfur dioxide, can produce similar clinical presentations [32]. In cases of severe respiratory distress, alternative causes such as status asthmaticus, anaphylaxis, and foreign body aspiration must also be considered, as they can mimic the effects of ammonia inhalation. Additionally, ammonia exposure often causes severe eye irritation, presenting with acute onset eye pain, redness, and tearing. These symptoms should be differentiated from other ocular conditions such as angle-closure glaucoma, impacted foreign bodies, and corneal abrasions, particularly in the absence of a clear history of ammonia exposure. In cases of ingestion, ammonia's caustic effects on the gastrointestinal tract resemble those of other corrosive substances, such as strong acids or alkalis. Since the management of caustic ingestions overlaps significantly, identifying the specific substance may not be immediately necessary for initial treatment [30]. However, a thorough history and endoscopic evaluation are crucial for guiding long-term management and anticipating complications such as strictures or perforations. For dermal exposure, ammonia-induced chemical burns present similarly to burns caused by other strong alkalis, including sodium hydroxide, potassium hydroxide, and calcium hydroxide. These burns are characterized by liquefaction necrosis, deep tissue injury, and inflammation, necessitating similar decontamination and wound care approaches. In summary, the differential diagnosis for ammonia exposure includes a range of conditions depending on the route of exposure. Clinicians must consider other irritative gases, causes of acute respiratory distress, ocular pathologies, caustic ingestions, and chemical burns when evaluating patients with suspected ammonia exposure. A detailed history, physical examination, and targeted investigations are essential for accurate diagnosis and appropriate management.

Prognosis

The prognosis of ammonia exposure varies significantly depending on the severity and duration of exposure, as well as the route of exposure. In 2017, there were no recorded deaths in the United States due to ammonia exposure; however, approximately 1 in every 125 patients experienced a major adverse event [15]. Mild exposures to ammonia are generally self-limiting, and the absence of symptoms within 24 hours of exposure typically rules out significant injury. In contrast, severe or prolonged exposures often require hospitalization and can result in life-threatening complications or even death [10][33]. For patients with

acute ammonia inhalation, the findings on chest physical examination at the time of admission are the most reliable predictors of long-term morbidity and mortality. Abnormalities such as wheezing, stridor, or decreased air entry indicate significant respiratory injury and are associated with poorer outcomes [33][34]. In cases of dermal exposure, the extent and depth of chemical burns are critical prognostic factors. Deep or extensive burns often require prolonged treatment and may result in scarring or functional impairment. For ingestion injuries, the prognosis is closely tied to the extent and depth of upper gastrointestinal (GI) burns observed during endoscopy. Severe burns, particularly those involving the esophagus or stomach, increase the risk of complications such as strictures, perforation, or long-term dysphagia, necessitating careful monitoring and potential surgical intervention [35]. Overall, early recognition, appropriate management, and close monitoring are essential to improving outcomes in patients with ammonia exposure. While mild cases often resolve without sequelae, severe exposures can lead to significant morbidity, highlighting the importance of preventive measures and prompt treatment.

Complications

Ammonia exposure can lead to a range of complications depending on the route and severity of exposure. Inhalation of ammonia gas erodes the superficial layers of the pulmonary epithelium, predisposed to secondary bacterial or fungal infections. Acute respiratory distress syndrome (ARDS) and acute lung injury are common complications, particularly in cases of severe exposure [36]. Chronic inhalation of mild to moderate levels of ammonia can result in obstructive airway diseases, such as chronic bronchitis or bronchiolitis obliterans, due to persistent inflammation and scarring of the airways. In severe cases, damage to the basal layers of the pulmonary epithelium can lead to irreversible chronic lung disease, potentially necessitating a lung transplant [37][38]. Ingestion of ammonia, while less common, can cause significant acute complications, including aspiration, altered mental status, and perforation of the gastrointestinal tract. However, studies indicate that 83.7% of patients with ingestion injuries do not develop long-term complications [30]. The most frequent long-term complication following ingestion is the development of esophageal strictures, which can lead to dysphagia and require repeated endoscopic interventions. To monitor stricture formation, follow-up with serial endoscopy is recommended in patients with significant esophageal burns [39][40]. Dermal and ocular exposure can also result in complications, such as chemical burns, corneal ulcers, and vision loss. Early and thorough decontamination, along with specialized care, is essential to minimize these risks. Overall, the complications of ammonia exposure underscore the importance of prompt treatment, close monitoring, and preventive measures to reduce morbidity and improve patient outcomes.

Patient Education

Patient education is a critical component of preventing ammonia exposure and minimizing its associated risks. The Agency for Toxic Substances and Disease Registry (ATSDR) provides several key recommendations to help the general public avoid accidental exposure to ammonia. First, when using ammonia-based household cleaners, it is essential to ensure that the area is well-ventilated to reduce the concentration of fumes and prevent respiratory irritation. Ammonia-based cleaners should never be stored in glass containers, as breakage could lead to severe exposure and injury. Proper protective measures, such as wearing gloves and eye protection, should always be used when handling these products to prevent skin and eye contact. Additionally, ammonia-based cleaners must be stored out of reach of children to avoid accidental ingestion or exposure, which can lead to serious health consequences. For individuals living near or visiting agricultural areas, it is important to avoid areas where ammonia-based fertilizers have been recently applied, as high concentrations of ammonia may still be present in the air. Similarly, animal confinement buildings, where ammonia levels can be elevated due to decaying manure, should be avoided without the use of proper personal protective equipment (PPE). Workers who handle or apply ammonia in farming or industrial settings must adhere to safety guidelines provided on equipment labels and use appropriate PPE, such as masks, gloves, and goggles, to minimize the risk of exposure. By following these recommendations, individuals can significantly reduce their risk of ammonia exposure and its associated health hazards. Educating patients and the public about these preventive measures is essential for promoting safety and preventing avoidable injuries [41].

Enhancing Healthcare Teams Outcomes

Enhancing healthcare team outcomes in cases of ammonia exposure requires a coordinated, interprofessional approach to ensure timely diagnosis, effective management, and long-term follow-up. The paramedical team and emergency department play a pivotal role in the initial response, as timely interventions are critical to minimizing long-term sequelae. Emergency Medical Services (EMS) providers can gather valuable information about the exposure environment, which may offer the first clue to ammonia poisoning. They can also initiate decontamination procedures before the patient arrives at the hospital, significantly reducing further injury. Upon arrival, emergency clinicians should conduct primary and secondary surveys and promptly consult relevant specialists, such as ophthalmologists for eye injuries, gastroenterologists for ingestion cases, burn nurses for dermal injuries, and plastic surgeons for severe burns. Early specialist involvement is associated with improved patient outcomes. Long-term follow-up care is essential, depending on the route and severity of exposure. Patients with severe inhalation injuries may require ongoing care from a pulmonologist to monitor for chronic lung diseases, such as bronchiolitis obliterans or pulmonary fibrosis. Those with ingestion injuries should follow up with a gastroenterologist to screen for esophageal strictures, a common long-term complication. In cases of intentional or suicidal exposure, early psychiatric consultation is crucial to address underlying mental health issues. Nurses play a vital role in inpatient care, monitoring patient progress, and providing follow-up evaluations, ensuring continuity of care and timely reporting of findings to the treating clinician. An interprofessional team approach, involving primary clinicians, specialists, and specialty-trained nurses, is essential for optimizing patient outcomes. Collaboration across disciplines ensures comprehensive care tailored to the patient's needs. While most evidence on ammonia toxicity comes from case studies, case series, and systematic reviews, this team-based approach remains the cornerstone of effective management and improved patient outcomes [41].

Role of Environmental Health, Nurses, and Radiologists

The management of ammonia exposure and its associated health effects requires a multidisciplinary approach, with environmental health professionals, nurses, and radiologists playing critical roles in prevention, diagnosis, treatment, and follow-up. Each of these professionals contributes unique expertise to ensure comprehensive care and optimal patient outcomes.

Role of Environmental Health Professionals

Environmental health professionals are essential in identifying, mitigating, and preventing ammonia exposure risks in both occupational and community settings. They conduct risk assessments to evaluate potential sources of ammonia, such as industrial facilities, agricultural operations, and household cleaning products, and develop strategies to minimize exposure. For example, they advocate for proper ventilation systems in workplaces where ammonia is used, enforce safety regulations, and educate workers and the public about the dangers of ammonia and the importance of using personal protective equipment (PPE). Environmental health professionals also monitor air quality in areas where ammonia-based fertilizers are applied or where animal confinement buildings are located, ensuring that ammonia levels remain within safe limits. By addressing environmental factors and promoting preventive measures, they play a pivotal role in reducing the incidence of ammonia-related injuries and illnesses.

Role of Nurses

Nurses are at the forefront of patient care, providing critical support from the initial presentation through recovery. In cases of ammonia exposure, nurses are often the first to assess the patient's condition, triage the severity of injury, and initiate decontamination procedures. They monitor vital signs, administer oxygen, and provide wound care for chemical burns, ensuring that patients remain stable during the acute phase of

treatment. Nurses also play a key role in patient education, teaching individuals and families about the risks of ammonia exposure and how to prevent future incidents. For patients requiring long-term care, such as those with chronic lung disease or esophageal strictures, nurses coordinate follow-up appointments, monitor progress, and communicate findings to the treating clinicians. Their holistic approach to care ensures that patients receive continuous support and guidance throughout their recovery journey.

Role of Radiologists

Radiologists play a crucial role in diagnosing and evaluating the extent of injuries caused by ammonia exposure. In cases of inhalation, chest radiographs and computed tomography (CT) scans are used to assess pulmonary damage, such as acute lung injury, pulmonary edema, or bronchiolitis obliterans. These imaging studies help guide treatment decisions and monitor disease progression. For ingestion injuries, radiologists interpret abdominal X-rays or CT scans to identify complications such as perforation of the gastrointestinal tract, which may require surgical intervention. In cases of dermal exposure, imaging may be used to evaluate the depth and extent of burns, particularly in complex cases involving large surface areas or critical regions like the face and hands. Radiologists also contribute to long-term follow-up by identifying late complications, such as esophageal strictures or chronic lung changes, through imaging studies. Their expertise ensures accurate diagnosis and timely intervention, which are critical for improving patient outcomes.

Interprofessional Collaboration

The integration of environmental health, nursing, and radiology expertise is essential for effective management of ammonia exposure. Environmental health professionals provide the foundation for prevention, nurses deliver hands-on care and patient education, and radiologists offer diagnostic insights that guide treatment. This collaborative approach ensures that patients receive comprehensive care, from initial exposure to long-term recovery. For example, environmental health professionals may identify a workplace hazard that led to ammonia exposure, nurses may stabilize and treat the patient in the emergency department, and radiologists may diagnose and monitor complications such as pulmonary fibrosis or esophageal strictures. By working together, these professionals enhance healthcare team outcomes, reduce morbidity, and improve the quality of life for patients affected by ammonia exposure. In conclusion, the roles of environmental health professionals, nurses, and radiologists are interconnected and indispensable in addressing ammonia exposure. Their combined efforts in prevention, acute care, and long-term management highlight the importance of an interprofessional approach to healthcare, ensuring that patients receive the best possible care at every stage of their treatment.

Conclusion

Ammonia toxicity poses significant health risks due to its widespread use in industrial, agricultural, and household settings. This article highlights the critical importance of a multidisciplinary approach to managing ammonia exposure, emphasizing the roles of environmental health professionals, nurses, and radiologists in prevention, diagnosis, and treatment. Environmental health professionals are instrumental in identifying exposure risks, enforcing safety regulations, and educating the public about preventive measures. Their efforts in monitoring air quality and promoting proper ventilation systems are essential in reducing occupational and environmental exposure. Nurses play a pivotal role in patient care, from initial decontamination and stabilization to long-term monitoring and education. Their ability to assess and manage acute injuries, provide wound care, and coordinate follow-up care ensures continuity and improves patient outcomes. Radiologists contribute by diagnosing and evaluating the extent of injuries through imaging techniques, guiding treatment decisions, and monitoring complications such as pulmonary fibrosis or esophageal strictures. The pathophysiology of ammonia toxicity underscores the need for early intervention. Inhalation can lead to acute respiratory distress and chronic lung disease, while ingestion may cause gastrointestinal burns and strictures. Dermal and ocular exposure can result in severe chemical burns and vision loss. Diagnostic tools, including imaging, endoscopy, and laboratory tests, are crucial for accurate assessment and management. Treatment focuses on decontamination, supportive care, and early specialist

involvement, with preventive measures being the cornerstone of reducing exposure risks. Public education and safety regulations are vital in minimizing ammonia-related incidents. Recommendations include proper storage and handling of ammonia-based products, use of personal protective equipment, and avoidance of high-risk environments such as agricultural areas with recent fertilizer application. By integrating the expertise of environmental health, nursing, and radiology, healthcare teams can effectively address the diverse manifestations of ammonia toxicity and optimize patient outcomes. In conclusion, ammonia toxicity requires a collaborative, interprofessional approach to ensure comprehensive care. Early recognition, prompt treatment, and preventive strategies are essential to mitigate the health impacts of ammonia exposure. Through education, regulation, and interdisciplinary collaboration, the risks associated with ammonia can be significantly reduced, safeguarding public health.

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سمية الأمونيا: دمج صحة البيئة، الأشعة، التمريض، والعلاج التنفسي

الملخص

الخلفية: الأمونيا غاز عديم اللون شديد السمية ذو رائحة نفاذة، ويستخدم على نطاق واسع في المجالات الصناعية والزراعية والمنزلية. يتم إنتاجه طبيعيًا في الجسم البشري، لكنه يصبح ضارًا عند تجاوز مستويات التعرض الآمنة. يحدث التعرض للأمونيا عن طريق الاستنشاق أو الابتلاع أو التلامس المباشر، مما يؤدي إلى إصابات في الجهاز التنفسي، والجهاز الهضمي، والجلد والعين. رغم استخدامه الواسع، فإن التسمم الجهازى الناتج عن التعرض الخارجى نادر، لكن الأضرار المرضية قد تكون شديدة ومهددة للحياة.

الهدف: يهدف هذا المقال إلى تقديم مراجعة شاملة حول سمية الأمونيا، مع التركيز على الفيزيولوجيا المرضية، الوبائيات، المظاهر السريرية، التقييم التشخيصي، الإدارة العلاجية، وطرق الوقاية. كما يسلط الضوء على دور صحة البيئة، التمريض، والأشعة في تقليل المخاطر وتحسين نتائج المرضى.

الطرق: تعتمد المراجعة على تحليل الأدلة من دراسات الحالات، والمراجعات المنهجية، والإرشادات السريرية لتوضيح آليات سمية الأمونيا، ومظاهرها السريرية، واستراتيجيات الإدارة متعددة التخصصات. تشمل المجالات الرئيسية الحركية الدوائية السمية، التغيرات النسيجية، التقنيات التشخيصية، والبروتوكولات العلاجية.

النتائج: يؤدي التعرض للأمونيا بشكل أساسي إلى أضرار مرضية، حيث يسبب الاستنشاق ضيقًا تنفسيًا، والابتلاع يؤدي إلى حروق في الجهاز الهضمي، والتلامس الجلدي أو العيني ينتج عنه حروق كيميائية. قد يؤدي التعرض الشديد إلى أمراض رئوية مزمنة، وتضيق المريء، أو فقدان البصر. تشمل الأدوات التشخيصية التصوير الطبي، والتنظير، والاختبارات المخبرية، بينما تركز الإدارة العلاجية على إزالة التلوث، والرعاية الداعمة، والتدخل المبكر من قبل المتخصصين. تعتبر التدابير الوقائية، مثل التهوية الجيدة واستخدام معدات الحماية، ضرورية للحد من مخاطر التعرض.

الخاتمة: تتطلب سمية الأمونيا نهجًا متعدد التخصصات يشمل صحة البيئة، التمريض، والأشعة، وتخصصات أخرى. التعرف المبكر، العلاج الفوري، والاستراتيجيات الوقائية أساسية لتقليل معدل المراضة وتحسين النتائج العلاجية. يلعب التنظيف العام واللوائح الصحية دورًا مهمًا في الحد من حوادث التعرض.

الكلمات المفتاحية: سمية الأمونيا، صحة البيئة، العلاج التنفسي، الأشعة، التمريض، الرعاية متعددة التخصصات، الوقاية، الإدارة العلاجية.