

Review

An Overview of Chemical Eye Injuries in Young Patients

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Abstract

Chemical eye injuries in young patients represent a significant public health issue, often stemming from exposure to household cleaners, industrial chemicals, and recreational materials. Children are particularly vulnerable due to their natural curiosity and impulsive behavior, as well as a lack of supervision and understanding of hazards. The consequences of such injuries can range from temporary discomfort to severe, long-term visual impairment and ocular morbidity. Effective management requires immediate decontamination through copious irrigation, followed by careful monitoring and potential medical interventions based on injury severity. Long-term outcomes depend on the injury's severity, the development of complications like corneal scarring, and the psychosocial impact on the child. Prevention strategies are essential and involve educating caregivers about chemical hazards, promoting safe storage practices, and implementing community awareness initiatives. Providing first aid training for caregivers can also empower them to respond effectively in emergencies. By addressing these aspects, healthcare providers can improve care for young patients and reduce the incidence and impact of chemical eye injuries.

Keywords: *chemical eye injuries, pediatric population, prevention strategies, management, long-term outcomes, risk factors*

Introduction

Chemical eye injuries are a significant public health concern, particularly affecting the pediatric population. These injuries can result from various chemical agents, including household cleaners, industrial substances, and even materials encountered during recreational activities or crafts. Young patients are particularly vulnerable due to several intrinsic factors, including their natural curiosity, lack of awareness regarding hazards, and limited ability to respond appropriately in dangerous situations. As a result, the incidence of chemical eye injuries is disproportionately high among children and adolescents compared to adults (1).

Unlike adults, pediatric ocular chemical injuries are typically linked to domestic accidents, with the primary sources of injury differing across various studies (2). Numerous studies have identified household chemicals as the most frequent culprits, including detergent capsules, lye, sodium hydroxide, cleaning products, deodorants, and perfumes (3). According to Haring et al., children experienced a higher incidence of acid-related chemical burns compared to those caused by alkaline substances (1). Additionally, a study conducted in Turkey by Korkmaz et al. revealed that the majority (51.6%) of ocular surface injuries in children resulted from unknown or neutral substances (4).

The consequences of chemical eye injuries can be profound, ranging from temporary discomfort to severe, long-term visual impairment and ocular morbidity. The eye, as a delicate and complex organ, is uniquely susceptible to chemical insults, with injuries potentially leading to corneal scarring, cataracts, glaucoma, and even loss of the eye itself (5). The management of these injuries requires a comprehensive understanding of the mechanisms of action of various chemicals, the appropriate immediate first-aid measures, and the long-term implications for ocular health and visual function.

Despite the potential for severe outcomes, there is a notable gap in public awareness regarding the risks associated with common household chemicals and

the appropriate responses to chemical exposure. Furthermore, the clinical management of chemical eye injuries in young patients necessitates a multidisciplinary approach, involving ophthalmologists, emergency medicine specialists, and rehabilitation professionals to optimize recovery and minimize long-term sequelae.

This review aims to provide an overview of chemical eye injuries in young patients by exploring the mechanisms of injury, identifying risk factors, describing clinical presentations, outlining effective management strategies, discussing long-term outcomes, and proposing prevention strategies.

Methodology

This study is based on a comprehensive literature search conducted on 31 October 2024 in the Medline and Cochrane databases. Utilizing medical subject headings (MeSH) and relevant keywords, the search aimed to identify pertinent studies on chemical eye injuries in young patients. To ensure thoroughness, a manual search was also performed through Google Scholar, examining the reference lists of identified papers to find additional relevant studies. We focused on articles discussing the epidemiology, clinical management, outcomes, and prevention of chemical eye injuries in pediatric populations. No restrictions were applied regarding publication date, language, participant age, or type of publication, allowing for a broad exploration of existing literature.

Discussion

Chemical eye injuries arise when harmful substances come into contact with the ocular surface, resulting in various degrees of tissue damage (6). The nature and extent of the injury are influenced by multiple factors, including the type of chemical involved, its concentration, the duration of exposure, and the effectiveness of the eye's protective mechanisms (**Table 1**).

Chemicals are primarily categorized into two groups: acidic and alkaline agents. Acidic substances, such as sulfuric acid, typically cause coagulative necrosis, which results in the denaturation of proteins and limits the extent of

tissue penetration (7). In contrast, alkaline substances, such as sodium hydroxide, tend to inflict more severe damage. They can penetrate the corneal epithelium more readily and lead to liquefactive necrosis, a process that transforms tissues into a viscous liquid. This deeper tissue destruction is particularly concerning, as it can compromise the integrity of the cornea and surrounding structures, potentially resulting in long-term visual impairment. The concentration of the chemical agent also plays a critical role in determining the severity of the injury. Higher concentrations of corrosive materials are associated with more pronounced damage, as they can cause rapid and extensive destruction of ocular tissues. Even brief exposure to highly concentrated alkaline substances can result in significant ocular harm, emphasizing the importance of swift intervention. Duration of exposure to the harmful chemical is another crucial factor affecting injury severity. The longer the eye is subjected to a corrosive agent, the more extensive and irreversible the damage is likely to be. Rapid irrigation of the eye with saline or water is imperative to dilute and remove the harmful agent, thereby minimizing the extent of tissue injury and improving overall outcomes (8). While the eyelids and tears provide some protective mechanisms against chemical exposure, their effectiveness can vary based on the specific circumstances surrounding the injury. Young patients, in particular, may not instinctively close their eyes or react appropriately when faced with hazardous situations, which increases their risk of injury. The absence of immediate protective reflexes can lead to prolonged exposure and, consequently, more severe injuries. A thorough understanding of these mechanisms is essential for healthcare providers, as it enables them to better assess the extent of chemical eye injuries and develop effective treatment protocols tailored to the needs of young patients. This knowledge is critical for improving patient outcomes and mitigating the long-term consequences of such injuries.

Risk Factors

The incidence of chemical eye injuries in young patients is influenced by several interconnected risk

factors that increase their vulnerability to such accidents. One primary factor is the inherent curiosity and impulsiveness of young children. At this developmental stage, children are naturally inclined to explore their surroundings, often engaging with household items, including potentially hazardous cleaning supplies, without an understanding of the risks involved. Their propensity to manipulate objects can inadvertently expose them to harmful chemicals, leading to significant injuries (9).

Another critical risk factor is the lack of supervision commonly experienced by children. Young individuals often lack the judgment and experience necessary to recognize and avoid hazardous situations, particularly in the absence of adult guidance. This lack of supervision can result in quick and unanticipated accidents, as children may encounter harmful substances without adequate precautions or intervention from caregivers (10).

The types of chemicals involved in these injuries also play a significant role. Common sources of chemical eye injuries include everyday household cleaning products—such as bleaches, detergents, and solvents—as well as industrial chemicals found in factory or workshop settings (11). Additionally, art supplies, such as paints and adhesives, can pose risks during creative activities (12). The accessibility of these items often increases the likelihood of exposure, especially in environments where children are permitted to explore freely.

Environmental factors further contribute to the risk of chemical eye injuries in young patients. Homes that lack proper storage practices for chemicals are particularly concerned, as harmful substances may be left within easy reach of children. Parents and caregivers may inadvertently fail to store dangerous materials securely, creating an environment where accidental exposure is more likely to occur. The presence of unsecured chemicals in the household underscores the importance of proactive safety measures (9).

Recognizing these risk factors is essential for developing effective preventive strategies aimed at reducing the incidence of chemical eye injuries

among young patients. By educating parents and caregivers about the potential hazards associated with common household items and emphasizing the importance of supervision and safe storage practices, the risk of these injuries can be

significantly mitigated. Enhanced awareness and proactive measures are vital in safeguarding the health and well-being of children in their everyday environments.

Table 1. Common Chemical Agents Causing Eye Injuries (6)

Chemical Agent	Type	Potential Source	Severity of Injury
Bleach	Alkaline	Household cleaners	Can cause severe damage, including corneal burns
Ammonia	Alkaline	Household cleaners, fertilizers	Can lead to significant ocular surface damage
Sulfuric Acid	Acidic	Car batteries, industrial products	Causes coagulative necrosis, potential for deep tissue damage
Hydrochloric Acid	Acidic	Cleaners, rust removers	Severe damage, can lead to vision loss if untreated
Sodium Hydroxide	Alkaline	Drain cleaners, soaps	Highly corrosive, can penetrate deep into the cornea
Paint Thinner	Organic solvent	Art supplies, industrial solvents	Can cause chemical burns and irritation

Clinical Presentation

The clinical presentation of chemical eye injuries can exhibit considerable variability, but certain symptoms and signs are commonly observed across affected individuals. Patients typically present with acute symptoms that may include sudden onset of redness, pain, excessive tearing, and blurred vision (9). These initial symptoms can escalate rapidly, highlighting the necessity for prompt medical intervention to mitigate potential complications.

Upon examination, healthcare providers may note several key findings that indicate the extent of ocular damage. Commonly observed signs include conjunctival injection, characterized by redness of the conjunctiva, as well as corneal opacification, which indicates changes in the transparency of the cornea due to injury (13). Eyelid edema, or swelling, may also be present, further complicating the clinical picture. The degree of ocular damage is assessed through thorough examination, which is crucial for guiding treatment decisions and predicting patient outcomes.

To facilitate the evaluation of chemical eye injuries, various grading systems have been developed, including the Birmingham Eye Trauma Terminology (14). These systems consider multiple factors, such as the depth of corneal involvement, the extent of limbal ischemia, and associated ocular findings. By classifying the severity of the injury, healthcare providers can better tailor treatment approaches and anticipate the need for surgical intervention or other therapeutic measures (Table 2).

Timely and accurate clinical assessment is essential for effective management of chemical eye injuries. Early identification of the severity of the injury not only informs immediate treatment strategies but also plays a critical role in minimizing the risk of long-term complications, such as chronic pain, vision loss, or cosmetic deformity. The integration of comprehensive examination findings with established grading systems allows for a structured approach to the management of these injuries, ultimately aiming to preserve ocular health and enhance patient outcomes.

Table 2. Grading System for Chemical Eye Injuries: This table outlines various grading systems, including the Birmingham Eye Trauma Terminology (BETT), which classifies the severity of ocular injuries based on corneal involvement and limbal ischemia (14)

Grade	Description of Injury	Clinical Findings	Management Recommendations
I	Minor injury with superficial damage	Mild conjunctival injection, no corneal opacity	Topical antibiotics and anti-inflammatory medications
II	Moderate injury with partial corneal involvement	Corneal opacification, conjunctival injection	Extended irrigation, topical medications, possible follow-up
III	Severe injury with corneal and limbal involvement	Corneal scarring, significant visual impairment	Urgent surgical intervention, potential grafting
IV	Very severe injury with total corneal destruction	Complete corneal opacity, potential eye loss	Immediate surgical intervention, long-term rehabilitation needed

Management Strategies

The management of chemical eye injuries necessitates prompt and effective intervention to minimize tissue damage and promote optimal recovery. The first and most critical step in the management process is immediate decontamination of the affected eye. This involves copious irrigation with saline or water, ideally initiated within minutes of exposure to the harmful chemical. The primary objective of this initial irrigation is to dilute and remove the offending agent from the ocular surface. Healthcare providers recommend that irrigation continues for a minimum of 15 to 30 minutes to ensure thorough flushing of both the conjunctival sac and the corneal surface, thereby significantly reducing the risk of severe ocular injury (15).

Following initial irrigation, it is essential to monitor patients closely for the development of complications. The severity of the injury dictates the need for further treatment. For mild injuries, medical management typically involves the application of topical antibiotics to prevent secondary infections and anti-inflammatory medications to alleviate discomfort. However, in more severe cases, systemic medications or surgical interventions may be warranted. For instance, patients with significant corneal damage or limbal ischemia may require procedures such as limbal stem cell transplantation or corneal grafting to restore ocular surface integrity and function (6).

Long-term management is also a crucial component of care for young patients who have sustained chemical eye injuries. Regular follow-up appointments are essential for monitoring the recovery process and addressing any complications that may arise, such as scarring or chronic pain. These assessments facilitate timely interventions and help ensure that appropriate rehabilitative services are provided, particularly for those experiencing visual impairment or functional deficits due to the injury.

Long-Term Outcomes

The long-term outcomes for young patients who experience chemical eye injuries are influenced by several interrelated factors, most notably the severity of the injury, the nature of any resulting complications, and the psychosocial implications of the injury.

The severity of the initial injury plays a critical role in determining recovery trajectories. Deeper injuries, particularly those that compromise the cornea or limbus, are associated with a higher likelihood of lasting visual impairment and may lead to chronic pain or discomfort (16). Prompt and effective treatment can mitigate some of these adverse effects, but severe injuries often necessitate ongoing management and may result in significant long-term challenges for affected individuals.

Complications arising from chemical eye injuries can also have profound implications for young patients. Common complications include corneal scarring, which can obstruct vision and require surgical intervention, as well as conditions such as dry eye syndrome and photophobia (17). These complications can detrimentally affect not only visual function but also overall quality of life, making it imperative for healthcare providers to monitor and address these issues during follow-up care.

Beyond the physical consequences, the psychosocial impact of chemical eye injuries can be substantial, particularly when vision is compromised. Young patients may experience anxiety, depression, or diminished self-esteem as they navigate the emotional repercussions of their injuries. The need for additional support to cope with these psychological aspects cannot be understated; healthcare providers should consider incorporating mental health resources and counseling services as part of the comprehensive care plan.

Finally, patients who experience long-term complications may benefit from specialized rehabilitation services tailored to their individual needs. Vision therapy can help enhance functional outcomes, while counseling can provide necessary emotional support to address the challenges stemming from their injuries. Such rehabilitative services play a crucial role in facilitating adaptation to visual deficits and enhancing the overall quality of life for young patients (18). Awareness of these potential long-term outcomes is essential for healthcare providers, enabling them to offer comprehensive care and support for affected individuals and their families. By addressing the multifaceted aspects of recovery—from physical rehabilitation to psychological support—providers can significantly improve the trajectory of young patients recovering from chemical eye injuries.

Conclusion

Effectively managing chemical eye injuries in young patients demands immediate intervention, ongoing rehabilitation, and targeted prevention

strategies. Prompt decontamination through extensive irrigation is crucial for minimizing damage, while vigilant monitoring can address long-term complications such as corneal scarring and chronic pain. It is equally important to consider the emotional toll these injuries can take on young patients, necessitating integrated mental health support. By emphasizing safe chemical storage, caregiver education, and first aid training, we can significantly reduce the incidence of these injuries. A collaborative effort among healthcare providers, families, and communities is essential to enhance recovery outcomes and safeguard children's ocular health.

Disclosure

Conflict of interest

There is no conflict of interest

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Non applicable

Data availability

Data that support the findings of this study are embedded within the manuscript.

Author contribution

All authors contributed to conceptualizing, data drafting, collection and final writing of the manuscript.

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