Chapter

Prevention of Corneal Injury in Critically Ill Sedated and Mechanically Ventilated Patients: Theoretical and Evidence-based Practice

Patricia R. do Prado and Fernanda R.E. Gimenes

Abstract

Any prolonged loss of consciousness due to sedation in critically ill patients may result in eye injuries which may go unnoticed as the patient cannot express his/her reduced vision or pain. Loss of blinking movement and eyelid malocclusion can cause some eye injuries as keratopathies and ulcers, which are the most common eye injuries in these patients. In at-risk patients (intubated and ventilated), screening for corneal injuries should be carried out using a fluorescein test. Protection of the cornea depends on its moisturization, which itself depends on eyelid closure, blinking, and the quality of the aqueous film present on the cornea. These protective components are regularly reduced in critically ill patients. Some cohort studies indicate that the peak incidence of corneal injuries occurs after first-week admission in critically ill patients. In intubated and ventilated patients, an eye gel and polyethylene chamber are the most effective interventions to prevent corneal injuries.

Keywords: corneal injury, intensive care units, nursing care, prevention and control

1. Introduction

Currently, more than 10 million people in the world are affected by eye diseases that can result in irreversible corneal injuries. In critically ill sedated and intubated) patients, who often fail to notify nurses of possible eye problems, assessment, prevention, and treatment of eye injuries are imperative [1–3].

The cornea is the anterior structure of the eye through which ultraviolet rays enter and is responsible for refraction, focusing the rays on the retina to provide adequate vision. The cornea has five distinct layers: epithelium, Bowman's layer, stroma, Descemet's membrane, and endothelium. The epithelium is the first layer of the cornea and contains superficial nerves to protect and regenerate the eye. Next, there is the Bowman layer/membrane, which is very resistant and has the main function of serving as a barrier against microorganisms. The stroma is the most consistent layer

of the cornea, occupying 90% of its thickness. Descemet's membrane is resistant to the penetration of microorganisms and gets thicker over the years. The endothelium is the innermost layer of the cornea and has the function of hydrating the eyes [4, 5].

To maintain a healthy cornea and good vision, each layer must function properly [1, 4]. The proper functioning of these layers also depends on the blinking and closing mechanisms of the eyelids, which provide corneal lubrication and protection, respectively [1, 6–8].

In critically ill patients using sedatives, muscle blockers, and mechanical ventilation, the protective mechanisms of the corneas are altered and do not provide blink and close eyelids reflex whose corneas are exposed and may present with dryness, exposure keratitis, and ulcers which result in temporary or permanent loss of vision [8–12].

In this chapter, we will address the main corneal injuries, risk factors, and interventions to prevent corneal injuries in critically ill patients.

2. Epidemiology, definition, and prevention of corneal injuries

2.1 Corneal injuries: Incidence

The incidence of corneal injury in sedated and ventilated critically ill patients ranges from 2.6 to 60.0%. According to previous studies, the incidence of corneal injury is lower in units that have eye care protocols implemented and nursing training to prevent the event. However, evidence-based practices are still incipient [2, 13–15]. Developing and implementing continuing education programs for promoting eye care knowledge, attitude, and practice are strongly recommended [2, 16, 17].

Several prospective cohort and clinical-randomized studies evaluated the occurrence of corneal injury in adult ICU patients. In India, incidences of 13.2% [18] and 21.0% [19] were identified in 5 days of follow-up. In Iran, also on day 5 follow-up, 32.2% had dry eye disease (DED) and 13.8% developed corneal injury [13]. In Jordan, 57% had exposure keratopathy [20].

In Brazil, incidences of 16.3% were identified in Acre [9], 20.0% in Rio de Janeiro [10], and 59.4% in Minas Gerais [21], respectively. The difference in the incidence of corneal injury in critically ill patients in the same country can be explained by the characteristics of the patients (percentage of sedated patients, on mechanical ventilation, with corneal exposure, autoimmune diseases, and diabetes, for example) that may contribute to an increased risk of corneal injury. Nevertheless, the climate and relative humidity characteristics have never been evaluated in studies, although the literature has already shown the causality between lower humidity and greater risk for DED and corneal injury, a fact that should be considered in future research [22, 23].

In Minas Gerais, Brazil [21], where the incidence of injury was 59.4%, the prevalence of patients on mechanical ventilation was higher, 78.7% against 58.3% in Rio de Janeiro (Santos et al., 2023) and 64.2% in Acre [8]. Still, in Minas Gerais, the climate is equatorial and dry in winter, with a relative humidity of around 20%. In the states of Rio de Janeiro and Acre, the climates are tropical maritime hot and humid, and tropical humid, with humidity around 80%, respectively, which can also interfere with the incidence of corneal injury [22, 23].

In addition, the incidence of corneal injury is lower in critically ill pediatric patients due to shorter mechanical ventilation time and lower occurrence of chemosis

(conjunctival edema). In the United States, an incidence of 19% of corneal injury in children and 60% in critically ill adults was identified [24].

The main changes in the corneas are dry eye disease, exposure keratitis, and corneal ulcers, which will be discussed below.

2.2 Corneal injuries definition

The ICU is an environment predisposing to the development of dry eye disease and, consequently, corneal injuries [8, 25–27].

Dry eye disease occurs due to impaired tear film production or increased evaporation. In ICU patients, the tear film is compromised due to disorder in the mechanisms responsible for ocular lubrication and protection. This occurs due to the use of sedative drugs and muscle relaxants that prevent blinking and closing the eyelids [8, 25–27].

Also, mechanical ventilation with high end-expiratory pressure (PEEP) and orotracheal tube with strong fixation contribute to the appearance of conjunctival edema and chemosis. Chemosis impairs eyelid closure and causes lagophthalmos [6–9, 12, 25–28].

In addition to the patient's intrinsic problems, the ICU is a unit with air conditioning which favors greater evaporation of the tear film. Still, there are many microorganisms that can colonize the cornea causing fungal or viral keratitis or ulcers, for example. Critically ill patients receive many interventions, which can accidentally injure the patient's corneas during airway aspiration, prone positioning, bed bath, and changing central access dressings or orotracheal tube [1, 6, 7, 12, 25, 28].

Therefore, in patients who do not blink and close their eyes properly, the corneas are vulnerable to ocular dryness which is the first stage of corneal injury. If there are no interventions for this condition, the patient may develop exposure keratitis and corneal ulcers that can cause temporary or permanent loss of vision [1, 7, 12, 25, 26, 28].

Figure 1 shows the pathophysiology of corneal injury in critically ill patients.

2.2.1 Dry eye disease

Dry eye disease (DED) is a multifactorial disease characterized by loss of tear film homeostasis and accompanied by ocular symptoms, in which tear film instability and hyperosmolarity, ocular surface inflammation and damage, and neurosensory abnormalities play etiological roles [25].

The main causes, in sedated and mechanically ventilated patients, are lack of lubrication due to loss of blinking movement, incomplete eyelids closure, which exposes the corneas, environment with low humidity due to the use of air conditioning, invasive interventions, which can lead to corneal trauma and lacerations, and prone positioning. In addition to these factors, patients with autoimmune diseases such as lupus erythematosus and myasthenia gravis, diabetes, and those with chronic ocular graft-versus-host disease have altered tear production. Besides, patients with vitamin A and omega 3 deficiency seem to be more susceptible to dry eye disease [22, 23, 25, 27, 29–33].

Another risk factors for DED include drugs associated with the induction of tear deficiency such as benzodiazepines, oral contraceptives, beta-blockers, hydrochlorothiazide, antiarrhythmics, anticholinergics, antihistamines, decongestants, tricyclic antidepressants, monoamine oxidase inhibitors, antineoplastics, antiparkinsonians, antidiarrheals, thiabendazole, and retinoids [7, 23, 33].

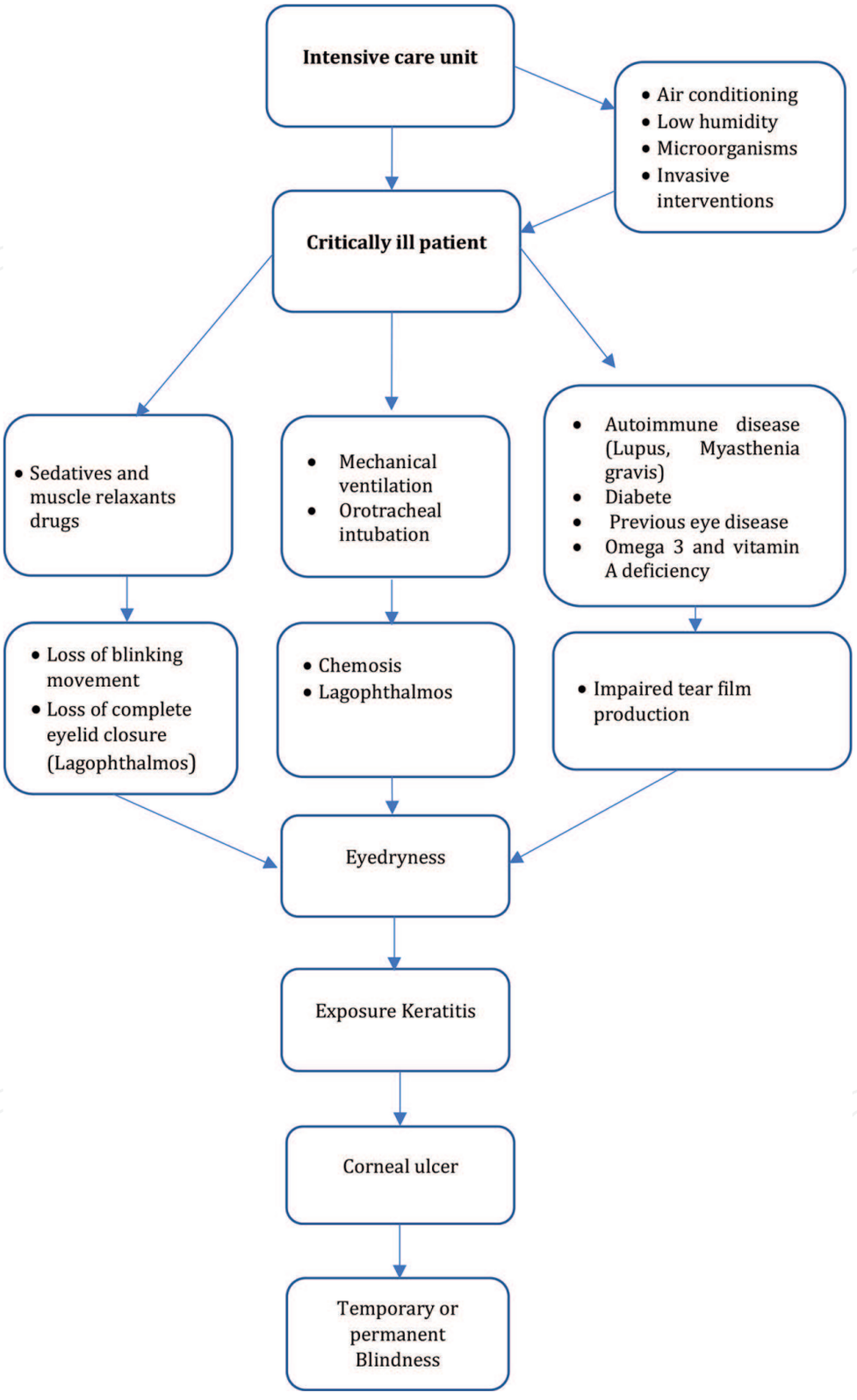

Figure 1.
Pathophysiology of corneal injury in critically ill patients.

The main signs and symptoms of DED are reddish and dull conjunctiva, feeling that there is a foreign body in the eye such as a speck or small particles of dust, burning, itching, ocular discharge, and blurred vision [1, 7, 23, 26, 33].

DED confers inflammation and infections that make the cornea opaque and can lead to vision loss. Thus, patients with DED need to receive lubrication and ocular protection.

2.2.2 Keratitis

"Keratitis is a clinical entity in which inflammatory cells infiltrate different layers of the cornea in response to noxious stimuli from exogenous infectious agents or autoantigens. The inflammatory reaction can result in suppurative fusion of the corneal epithelium and stroma, resulting in the formation of ulcers. This not only results in loss of corneal clarity but also threatens the integrity of the globe and can result in blindness." It is necessary to identify the etiologic agent based on clinical features and appropriate diagnostic tests and to manage these patients with the latest treatment options [27].

In addition to dry eye disease, other causes should be investigated, such as herpes simplex virus type I, bacteria, viruses or fungi infections, ocular trauma caused by equipment or prone positioning, vitamin A and omega 3 deficiency, allergy or sensitivity to cosmetics, and environmental pollution [1, 7, 31, 34, 35].

The main signs and symptoms of keratitis are redness conjunctiva, eye pain, photophobia (sensitivity to light), burning, and blurred vision. The diagnosis of keratitis and corneal ulcer requires confirmation by examining stained smears of corneal scrapings and laboratory cultures of these scrapings.

When it is used, an ophthalmoscope with cobalt blue light and the instillation of fluorescein eye drops pits are visualized on the cornea due to the fluorescein effect and its intensity depends on the severity of the keratitis [1, 6, 7, 31, 34, 35].

2.2.3 Corneal ulcer

A corneal ulcer is one of the presentations of keratitis. It is an ocular emergency characterized by the destruction of epithelial cells secondary to inflammation and necrosis of the corneal stroma. The ulcer appears as a white or grayish spot in the eye that, if left untreated, can lead to blindness. The main causes are lagophthalmos, which causes DED, bacteria, viruses, fungi, amebae, and abrasions/traumas [1, 6, 7, 36, 37].

The main manifestations are conjunctival hyperemia, photophobia, pain, and severe visual disturbances. Diagnosis is performed by the instillation of fluorescein eye drops and visualization through an ophthalmoscope with cobalt light. Microscopic examination of scrapings can identify Acanthamoeba [7, 11, 37].

Treatment will involve the instillation of antibiotic, antifungal, anti-inflammatory, and corticoid eye drops depending on the identified cause [8, 38]. In some cases, surgery and/or corneal transplantation is required to remove the cloudy cornea and replace it with a healthy, transparent cornea [36, 37].

Critical patients are more vulnerable to corneal injury due to changes in the protective mechanisms of the corneas. The prevention of this type of injury depends on the daily assessment by the nursing team, especially in patients with a lowered level of consciousness, using sedative drugs and neuromuscular blockers. In those patients, eye lubrication and protection are recommended [3].

2.3 Corneal injuries: risk factors

The main risk factors for the development of corneal injuries in sedated and ventilated critically patients are mechanical ventilation, sedatives, lagophthalmos, chemosis, and hospitalization for more than 7 days [8–10, 12, 20, 21, 24, 38].

Patients on mechanical ventilation had a chance (ODDS) between 37.8 [10] and 117 [21] times to develop a corneal injury compared to non-ventilated patients.

Patients with lagophthalmos had between 13.4 [10] and 17.15 [8] higher risk (hazard ratio) for corneal injury compared to those without lagophthalmos. In addition, patients with chemosis had between 7.39 [8] and 25 times more chance of presenting the event [10]compared to those who did not have chemosis.

Hospitalization longer than 7 days is also a higher risk factor for the development of corneal injury in critically ill patients (OR: 11.96; 95% CI: 3.27–43.66) [8]. Thus, research involving the assessment of corneal injury should be carried out with a minimum follow-up of 7 days [8, 9, 21, 24].

2.4 Prevention of corneal injuries

The high incidence rate of corneal injury in sedated and mechanically ventilated patients reflects that eye care has been neglected by the health team. This occurs due to the lack of knowledge and attitude of nurses and the absence of patient complaints about dryness and visual discomfort that can culminate in temporary or permanent loss of vision, with preventable adverse events [15, 38–40].

Many interventions have been tested in randomized clinical trials, and recent systematic reviews recommend that eye gel and a polyethylene chamber are the most effective interventions to prevent corneal injury [3, 41–45].

The polyethylene chamber has already been tested in several international and national studies. It has a low cost, is easy to handle, has greater durability, and demonstrated higher effectiveness when compared to eye drops [38, 45]. In addition, the intervention does not require a medical prescription. Studies conducted in Brazil [21], Australia [44, 46], Turkey [47], and Iran [41, 43] demonstrated the effectiveness of the polyethylene chamber; however, the researchers used handmade chambers. Accordingly, it is necessary to create and assess the effectiveness of a polyethylene chamber specifically designed to prevent corneal injury in sedated and mechanically ventilated patients.

The prevention of corneal injury consists primary of ocular lubrication, preferably with gel or ointment eye, and protection of the corneas with a polyethylene chamber for critically ill patients with compromised blinking and closing eye mechanisms. As a recommendation, we suggest that nurses develop an eye care protocol, including eye gel lubrication, for 4 or 6 hours, and a polyethylene chamber, for 12 hours, for sedated mechanically ventilated critically ill patients. In addition, a polyethylene chamber must be commercially available to prevent the event [3, 17].

Educational initiatives should focus on knowledge to improve eye care of patients in ICU18 [39, 40, 47],. Training nurses based on updated clinical guidelines and eye care protocols can improve the knowledge, attitude, and practice of ICU nurses [2, 16, 17].

3. Conclusions

Corneal injury is still common in critically ill sedated and mechanically ventilated patients. The main risk factors are sedative drugs, mechanical ventilation, chemosis, lagophthalmos, and length of stay. Patients in these conditions, with altered blinking and eyelid closing reflexes, need to have their corneas lubricated with ocular gel every 6 hours and eye protection with a polyethylene chamber. Efforts should focus on

education, training, and development of eye care protocols with emphasis on risk factors assessment and on the implementation of evidence-based nursing interventions.

Conflict of interest

The authors declare no conflict of interest.

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