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HOT TOPICS IN PAIN AND HEADACHE (N ROSEN, SECTION EDITOR)

Postoperative Management of Corneal Abrasions and Clinical Implications: a Comprehensive Review

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Abstract

Purpose of Review Total patient care is of extreme importance during the administration of anesthesia. Proper care of the eye is necessary during all anesthetic administrations, especially during the administration of general anesthesia or monitored anesthesia care. By paying attention to details, the likelihood of an occurrence of eye injuries is reduced.

Recent Findings Though perioperative eye injuries are rare during general anesthesia, they do account for 2–3% of claims against anesthesiologists. Ocular injuries may occur during general anesthesia even when tape has been utilized for eye closure. Corneal abrasions are the most common injuries that have been attributed to direct trauma to the eye, exposure keratopathy, or chemical injury. Using a hydrogel patch during general anesthesia is also associated with more frequent corneal injury than previously thought.

Summary Prevention of anesthesia-related eye injuries assumes a high priority since the eye is one of the major sense organs of the body. The eye can be damaged during anesthesia for both non-ophthalmic and ophthalmic surgeries.

Keywords Corneal abrasions · Eye injury · Perioperative eye injury · Ocular injury · Eye trauma

Introduction

Corneal abrasions (CAs) are the most prevalent perioperative ocular injuries. CA is defined as a defect in the epithelial surface of the cornea, the most anterior portion of the eye [1••, 2]. While most of the damage to the white area of the eye is insignificant, even minor abrasions to the cornea are hastily filled by healthy cells to prevent refractive

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irregularities or vision-diminishing infection [3]. The cornea is a highly organized avascular arrangement of cells and proteins vital for vision function. It is responsible for barrier protection, visible light refraction, and ultraviolet (UV) light filtration [1••, 2, 3, 4••, 5••]. The cornea is protected by pre-corneal tear film made up of three layers: the outer lipid, deeper aqueous layer, and innermost mucin layer [5••]. The lipid layer lubricates the aqueous layer which in turn oxygenates the corneal epithelium [5••]. The underlying mucin layer creates a hydrophobic coating that protects the corneal surface [5••]. The pre-corneal layer's solidity is maintained through involuntary blinking. Related to its location on the eye, the cornea is highly susceptible to injury. Although the origin of injury is often not identified, mechanical trauma, such as being hit or scratched in the eye, is a common factor that may lead to CA [1••, 2, 3, 4••, 5••]. Additionally, foreign bodies, contact lens wear, corneal drying, and chemical or flash burns may damage corneal epithelial cells leading to the development of CA [2, 3]. The cornea is also highly innervated by the trigeminal nerve [3, 4••]. As a result, CAs can cause eye pain, blurred vision, headache, discomfort when blinking or opening the eye, excessive tearing, photophobia (light sensitivity), gritty feeling, and foreign body sensations. Small CAs can be extremely uncomfortable for patients, while deep CAs can cause corneal scarring, a defect that requires a transplant to restore vision [4••]. With regard to perioperative CAs, the majority occur secondary to insufficient closing of the eyelids (lagophthalmos) [5••]. During normal sleeping conditions, the orbicularis muscle keeps the eyelid closed; however, general anesthesia limits tonic contraction [5••]. This manuscript will discuss risk factors, incidence of CA during anesthesia, anesthesia effects on the eye, types of injury, prevention of injury, diagnosis, chemical injury, ocular protection, treatment, pain relief, perioperative prevention of CA, and current clinical studies related to CA.

Risk Factors

CAs are the most common ocular injuries in the perioperative period for non-ocular surgeries [6]. Perioperative CAs can cause several undesired sequelae, including ocular infection and vision loss. The overall incidence of corneal abrasion during general anesthesia has been decreasing with advancing medical knowledge. In 1977, a study found a CA incidence of 44% in general anesthesia practice before it was common practice to tape the eyes shut, and eyes were left open and unprotected intraoperatively [7]. More recent studies have found a range of CA incidences during general anesthesia from 0.056% to 0.17% [3, 8–10]. Additionally, CAs in the perioperative period affected a reported 19,903 people from 2009 to 2013 [2].

Perioperative CAs have several different causes, many of which can be prevented with intentional care. The majority of perioperative CAs are assumed to come from lagophthalmos during general anesthesia. Lagophthalmos, the inability to fully close the eyelid from decreased contraction of the orbicularis oculi muscle, leads to corneal dryness and subsequent abrasion. It is important to ensure full eye closure to avoid exposure keratopathy. It is important for healthcare providers to be aware that the eyelids do not close in 59% of patients because in 80–90% of perioperative CAs, no obvious traumatic mechanism is identified [8, 11]. Furthermore, the cornea is an avascular tissue that relies on constant bathing by tear film to stay oxygenated. This tear film is distributed around the cornea during blinking or eye closure. Lagophthalmos in general anesthesia allows the cornea to dry out, which is a predisposing factor for corneal abrasion [12].

In addition to lagophthalmos, general anesthetics have other effects on the eye that compound with dryness and increase the patient's risk for CA. Often the etiology of CA is hard to determine because of the interrelated effects of anesthesia. Under general anesthesia, Bell's phenomenon and firm stability of the eye is absent. Bell's phenomenon is an upward and outward movement of the eye when an attempt is made to close the eyes, and is a normal defense reflex present in about 75% of the population. Bell's phenomenon results in elevation of the globes when blinking or when threatened (such as when an attempt is made to touch an awake patient's cornea). It becomes noticeable only when the orbicularis oculi muscle becomes weak, and the intent of including this statement may be to postulate that weakness such as this may occur at the onset of general anesthesia. This "Bell's phenomenon" is present behind forcibly closed eyelids in most healthy people, and should not be regarded as a pathognomonic sign. Due to Bell's phenomenon, traumatic abrasions are generally located in the central or inferior cornea, but this "reflex" may be changed by administration of anesthesia. The cornea may remain in the vulnerable space between the upper and lower eyelids instead of rotating upwards to be protected under the upper eyelid during eye closure. General anesthetic drugs have direct effects on eye reflexes and tear production. The loss of the corneal blink reflex allows for prolonged irritation

Table 1 Contributing factors of CAs from general anesthesia

Lagophthalmos
Absent Bell's Phenomenon
Loss of corneal blink reflex (CN V sensation, action from CN VII on orbicularis oculi)
Decreased tear production
Decreased tear film stability
Increased venous outflow pressure
Elevated intra-ocular pressure

of the cornea without a protective blink. Reflex loss combined with decreased tear production and decreased stability of tear film from anesthetic drugs increases risk for corneal abrasion during administration of general anesthesia. Additionally, when pressure is applied to the eye from a facemask or other equipment, venous outflow (which is normally at a very low pressure) is further impeded; this resulting decrease in outflow from an externally applied pressure increase easily leads to edema of the cornea. The application of surface heating materials such as the Bair-Hugger with its plastic drape placed over the patient's face also increases the chances of drying out the eyes and as such, the major presenting complaint of such patient will be "a painful eye or feeling of foreign object in the eye" in the postoperative care unit. Tracheal intubation with PEEP and head positioning in the OR also elevate intra-ocular pressure. The combined effects of corneal edema and increased IOP place the patient at higher risk for corneal abrasion [3, 12–14]. See Table 1.

One-fifth of perioperative CAs are related to direct trauma or chemical injury [11]. Further, if antiseptic or cleaning material are mistakenly spilled into the eyes, chemical injury can occur. The only non-toxic antiseptic skin preparation to the cornea is povidone-iodine 10% aqueous solution. This, therefore, is the agent of choice in facial skin preparation. This is discussed in further detail in the "Types of *Eye* Injury" section. Reported traumas causing CAs include [6, 11, 14]

- Oxygen masks slipping up into patient's eyes
- ID cards, watch straps, or other plastic wristbands/cards dangling into patient's eyes during intubation or other procedures and checks
- Chemical spills
- Halothane irritation of the eyes, especially when eyes are covered in a paraffin ointment that increases potency of anesthetic gas irritation to the cornea
- Surgical drapes or instruments going into patient's eyes
- Patients rubbing their eyes in recovery, especially if they are wearing a finger pulse oximeter

To decrease morbidity from CAs during general anesthesia, it is imperative to identify which patients are at risk, then prevent injury or intervene as soon as possible. Current literature lists many risk factors for perioperative CA, which are included in Table 2 [3, 8, 10, 12–14]. Factors listed in italics are the agreed upon, while the upright factors are found in fewer studies and some have been contested [2].

There are several methods of preventing perioperative corneal injuries. These include manual closure of eyelids, simple taping of eyelids shut, use of eye ointment, paraffin gauze, bio-occlusive dressing, or suture tarsorrhaphy in some cases. None of these is completely effective. Hence, extreme vigilance cannot be over-emphasized.

Types of Eye Injury

Presentation of Injury

Early detection and evaluation of CA in the perioperative setting is important for successful treatment. Signs and symptoms of CA typically present in the early postoperative period. These include complaints of eye pain, blurry vision, tearing, redness, photophobia, and foreign body sensation [3]. Additionally, patients in the postoperative recovery area may complain of pain with blinking because the eyelid rubs the corneal abrasion with each blink [13]. See Table 3.

Diagnosis

Definitive diagnosis of corneal abrasion is confirmed with a cobalt-filtered light and application of fluorescein. Fluorescein staining is used to reveal a defect in the corneal epithelium resulting from mechanical or chemical injury. Following application of topical anesthetic (proparacaine 0.5%) into the eye, the lower lid is retracted downward and a fluorescein strip is touched to the bulbar conjunctiva. As the patient blinks, the dye spreads and stains the exposed basement membrane which shows yellow-green when a corneal abrasion is present. See Fig. 1.

Ophthalmoscopes, slit lamps, and Wood's lamps with a cobalt blue filter illuminate a corneal defect as yellow-green after fluorescein staining [1••]. A slit lamp is helpful in determining the extent of a corneal abrasion. In the absence of a slit lamp, use of a cobalt blue light with fluorescein helps determine the size and location of a corneal abrasion [13]. See Fig. 2.

Table 2 Risk factors for perioperative corneal abrasion

Longer surgery duration	*Advanced patient age*
Use of general anesthesia drugs	*History of ophthalmic issues* (exophthalmos, proptosis, dry eyes)
Lateral position during surgery	*Oxygen use to/from PACU*
Surgery on a Monday	Higher estimated blood loss
Trendelenburg position	Prone position

Table 3 Presentation of perioperative CA

Signs	Symptoms
Scleral injection and redness	Eye pain
Blinking	Blurred vision
tearing	Photophobia
	Scratchy/foreign body sensation

Mechanical Injury

As previously mentioned, CA may result from direct trauma to the cornea during induction of general anesthesia and intubation. With loss of the ciliary reflex following induction of general anesthesia, the unprotected eye is susceptible to injury by activities and equipment associated with mask ventilation and laryngoscopy including improperly sized masks, badges, stethoscopes, watches, the anesthesia provider's fingers, and the laryngoscope itself.

Patients undergoing surgery requiring the lateral or prone position and patients having head or neck surgery are more susceptible to direct trauma to the eye and corneal abrasion. Furthermore, patients undergoing lumbar laminectomy in the prone position with the head turned to the side are particularly more susceptible to CA, typically in the lower positioned eye, as compared to all other neurosurgical procedures [15]. Pressure applied to the globe of the eye can reduce choroidal blood flow. The avascular nature of the cornea makes it more susceptible to decreased blood flow from the choroidal blood supply to the peripheral cornea, with subsequent reduced oxygen delivery, resulting in corneal edema. Corneal abrasion can occur in the presence of a dry environment, potentially resulting in desquamation of the eye's epithelial layer.

During or following emergence from general anesthesia, patients often rub their eyes, making the pulse-oximeter probe a potential source of trauma to the cornea. Placing the probe on the non-dominant little or ring finger reduces the risk of iatrogenic corneal abrasion. Additionally, to reduce the risk of mechanical trauma during occlusive tape removal at the end of surgery, it is recommended to remove tape from the upper to lower lid. Direct mechanical trauma may occur in the immediate postoperative period and in the recovery area by the patient's own fingers. Other objects that may cause a corneal abrasion in the recovery phase are face mask or nasal cannula, pulse oximeter probe, and a pillow. Restless activity and recovering in the lateral position also increase the risk of corneal injury following anesthesia [13].

Fig. 1 Corneal abrasion after fluorescein stain

Fig. 2 Corneal abrasion after fluorescein stain under cobalt blue light

Chemical Injury

Chemical injury may occur from surgical prep solutions applied to the unprotected eye. Direct chemical trauma to the cornea can result from inadvertent spillage of sterilizing chemicals during surgical preparation. Antiseptic solutions with detergent readily penetrate the corneal epithelium, potentially causing damage to the underlying structures of the eye, leading to ischemia. De-epithelialization and edema of the cornea is caused by antiseptic solutions containing chlorhexidine, cetrimide, alcohol, and aqueous povidone-iodine containing phenol. The only currently available antiseptic skin preparation which is non-toxic to the eye is preservative-free povidone-iodine in aqueous solution. Ophthalmic ointments are sometimes used in addition to taping the eyelids while under general anesthesia. Prevention of accidental corneal abrasions during the administration of general anesthesia is accomplished easily and effectively by simply placing a piece of tape over the completely closed eyelids. Ointments containing preservatives, methylparaben and chlorobutanol, may cause chemical injury. If ointment is used, it should be preservative-free. Irritating properties of the anesthetic gases, particularly those administered by face mask, and preservative-containing eye ointments may cause chemical injury [13, 15].

Perioperative Prevention of Corneal Abrasion

Prevention of the occurrence of CAs is possible, and tape application over the closed eyelids is the best method for decreasing the occurrence of CA's. Accidental scratching of the exposed cornea by the hands or fingernails of the anesthetist during laryngoscopy and intubation or pressure by instruments or surgeon's hands have been reported as causes of perioperative eye trauma [16]. A 2013 study of techniques for corneal protection during non-ocular surgery found that the simple application of tape over the closed eyelids was found to provide equal or superior protection to other interventions and had fewer side effects when compared to other methods of corneal protection such as petroleum gel application [15]. Simply closing the eyelids and taping them reduces the chance of unintended corneal or scleral contact with a foreign object; the application of lubricants does not generally reduce risk of corneal or scleral damage during most surgical procedures. It must be emphasized that if an eyelid partially opens beneath any occlusive dressing or eyelid tape, this may still allow the eye to be injured from contact with the adhesive layer of the tape itself [16]. As mentioned previously, it is important to be certain the eyelid is completely closed prior to the application of the tape or adhesive dressing. Even the tape which is used for this task should be considered, since some tape may be more permeable to fluids (which may cause a chemical abrasion) than other tape products.

In a study of common tapes used in the Operating Room and permeability of the tape to a colored chlorhexidine prep solution, the researchers discovered that while many tapes allowed the chlorhexidine solution to permeate through the tape, 3M Durapore, 3M Tegaderm Film, and Hy-Tape did not allow the fluid to permeate through the tape [17]. Application of petroleum gel lubricant has been used in attempts to protect the eye and apply additional lubrication, but it is flammable and certainly should be avoided when open oxygen and electrocautery are used around the face [15].

In summary, the best prevention and avoidance of perioperative eye injuries remains summed up in one word: vigilance. Each person who is responsible for providing anesthesia to the patient should pay attention to activities which have the potential to cause eye injuries. Potential eye injuries can be prevented by carefully closing the eyelids immediately following anesthesia induction and loss of the reflex blink response to lightly stroking the eyelashes, then applying a piece of tape or similar adhesive dressing over the closed lids. When there is concern that liquids will be used around the eye during the surgical procedure, and a simple piece of tape may not provide adequate protection, a small 6 cm × 7 cm Tegaderm™ Film may be carefully applied over each closed eyelid and surrounding skin of the face to provide a better and more "water-tight" seal for the duration of the surgical procedure [18••]. If this is applied for eye protection during the surgery, removal at the end of the procedure is best accomplished by peeling the dressing down from the top of the eye to the bottom, thereby keeping the eyelid completely closed until the Tegaderm™ Film is completely removed from the face.

Detection of Corneal Abrasion in the Postoperative Period

The occurrence of a corneal injury during the time of anesthesia is generally detected initially by the patient's tearing from the injured eye, miosis, report of a sensation of the presence of a foreign body, and/or pain in the affected eye. These symptoms are often accompanied by photophobia. Frequently, this will be noted in the post-anesthesia recovery room but may not be noticed until after the effects of opioid and other sedative agents have resolved in the postoperative period. Eye damage may also occur during the immediate postoperative period in the recovery room by eye contact by the oxygen face mask, contact with bedclothes, or by the patient's fingers [16]. Confirmation of the injury is made by application of a moistened fluorescein strip to the surface of the eye. Using cobalt blue illumination or a Wood's lamp, areas of CA exhibit a distinctly yellow-green stain when examined in this manner (see Fig. 2.). If this stain is noted to be in the inferior third of the eye and is crescent-shaped, this is an indication that the likely cause was incomplete eyelid closure during the procedure. The appearance of this fluorescein stain from desiccation due to incomplete eyelid closure is distinctly different from the appearance from abrasions caused by a foreign body present in the eye or from eye contact with an irritating chemical.

Ocular Treatment for Infection Prevention and Pain Relief

Treatment of perioperative CAs should aim to prevent infection and control pain without reducing the rate of corneal healing [1••, 12]. Symptomatic care is the goal of treatment. Potential complications of CA include bacterial keratitis, corneal ulcers, and recurrent erosion syndrome, which can progress to corneal ulcer and subsequent blindness [1••, 12, 19]. To prevent infection, topical antibiotic ointment should be applied for all cases of corneal abrasion. For uncomplicated abrasions, erythromycin 0.5% ophthalmic ointment applied four times a day for 48 h is the first choice of treatment [1••, 3, 12]. Other antibacterial options include polymyxin B/trimethoprim (Poly-trim) ophthalmic solution, and sulfacetamide 10% ophthalmic ointment or solution [1••]. Antibiotics with activity against Gram-negative organisms should be considered in patients who wear contacts due to potential for pseudomonal infections [1••, 12].

Treatment should avoid neomycin because of its increased risk of contact hypersensitivity. Also contraindicated for topical treatment are formulations with steroids, because they increase susceptibility of infection and may delay healing [1••, 12]. Antibiotics can be applied by solution or ointment. Ointment may act as a lubricant, providing more pain relief than solution and is retained in the eye longer, acting as a film to prevent tear evaporation [1••, 12].

Small abrasions are classified as those that occupy less than one-fourth of the cornea. These small abrasions often heal overnight, and oral NSAIDs may be used to manage pain while the abrasions heal. The use of topical NSAIDs or topical anesthetics in addition to oral NSAIDs is currently debated. Larger abrasions may require 48 h to heal, and in addition to NSAIDs, parasympatholytic drops, also known as cycloplegics, and patching may be considered during healing. Despite recommendations, there is a lack of consensus for how to best manage pain following corneal abrasion.

Cycloplegics prevent the eye from responding to light, thus possibly reducing movement-induced pain while the cornea heals. Short-acting cycloplegics include one drop of cyclopentolate (0.5 to 1%) twice daily or one drop homatropine (2.5 to 5%) once daily. Even short-acting cycloplegics may cause side effects for up to 36 h, including causing glare and lack of accommodation, resulting in difficulty reading and driving. These side effects may make the use of cycloplegics unrealistic for pain control of small abrasions, and there is a lack of strong evidence supporting efficacy of cycloplegics at relieving pain [20, 21].

Patching acts as a barrier to mechanical and chemical injury, as well as infection. While patching was once recommended to allow for corneal healing, recent studies concluded that patching neither reduces pain nor aids in healing of CA and may actually delay healing [1••, 12, 22, 23]. Patching also inhibits depth perception and may not be well tolerated by patients. Despite patching's low efficacy at relieving pain and healing time, it may be considered to reduce the incidence of CA perioperatively [22].

The use of topical anesthetics for management of CA is controversial. A recent review examined the results of ten randomized controlled trials to determine the outcomes of patients receiving topical analgesics. The review concluded that topical NSAIDs reduced pain symptoms, while topical cycloplegics and topical anesthetics did not significantly reduce pain [20]. Patients using topical NSAIDs also reported greater pain relief [24]. Additionally, topical anesthetic, such as a 0.5% proparacaine solution, were once thought to lead to delayed wound healing. Overuse of topical anesthetics can potentially have serious side effects due to lack of pain perception and can even evolve to blindness. While these concerns for safety confirm the need for close monitoring of treatment, recent literature suggest topical anesthetics may be more effective and cause less healing impairment than once thought [12, 21]. A recent study examining two randomized, double-blind controlled trials suggests that when used appropriately at dilute concentrations, topical anesthetics can be extremely efficacious at managing pain with no adverse events [25]. While more evidence is required, solutions of 0.05% proparacaine or 1% tetracaine have been demonstrated to improve pain symptoms without impairing healing [12, 26, 27•, 28•].

Another review by Wakai et al. further examined the same randomized controlled trials to compare topical NSAIDs (1% indomethacin, 0.03% flurbiprofen, 0.5% ketorolac, 0.1% indomethacin, 0.1% diclofenac) to other traditional methods including artificial tears, patching, antibiotic eye drops, and placebo drops. This review determined that it was unclear if topical NSAIDs reduced pain relative to the control, but NSAIDs may reduce patients' use of oral painkillers [29]. If topical NSAIDs are used, they should be used for only uncomplicated abrasions and for no longer than 2 days due to corneal toxicity with prolonged use [1••, 12, 20, 29]. Topical NSAIDs are also more expensive than topical anesthetics, and this should be discussed with patients before being prescribed. Both studies determined further research needs to be done to conclude the best recommendations for managing pain after corneal abrasion [20, 29].

To effectively treat perioperative CA and manage pain, physicians should prescribe a topical antibiotic such as erythromycin 0.5% ophthalmic solution, paired with oral NSAIDs. Further pain management may include a low-dose topical anesthetic (0.05% proparacaine or 1% tetracaine) or a topical NSAID (1% indomethacin, 0.03% flurbiprofen, 0.5% ketorolac, 0.1% indomethacin, 0.1% diclofenac) at the discretion of the physician. Topical cycloplegic should only be considered in management of large CA, and patching is no longer recommended. See Table 4.

Recent Clinical Findings

A 2012 case report discussed a patient diagnosed with perioperative corneal abrasion in the right eye shortly after a laparoscopic inguinal hernia repair [30]. The authors then reviewed

Table 4 Types of CA infections and corresponding treatments

Pain relief agent	Indication
NSAIDs	Small and large CA
Topical NSAIDs	Consider for small CA
Topical anesthetics	Consider for small CA
Topical cycloplegics	Large CA
Patching	No longer recommended

ophthalmology consults placed by anesthesia within the past 6 months and discovered six cases of consults placed for perioperative corneal abrasion when compared to the prior 6 months, when there were no consults placed. The anesthesia department of the authors' facility held an interdepartmental meeting attended by all departments and collaborated on strategies to reduce the incidence of perioperative abrasions. Strategies included a formal incidence-tracking mechanism, frequent intraoperative reassessments to make sure the eye is closed, and taping the eyelid horizontally rather than vertically [30].

A retrospective review study in 2014 reviewed patients diagnosed with corneal abrasions over a 2-year period in intraoperative and postoperative patients [3]. Corneal abrasion cases were compared to unmatched controls to determine risk factors, treatment time, and most commonly prescribed treatments for corneal abrasions. A total of 78,542 surgical cases over a 2-year period were reviewed. Of these cases, corneal abrasions occurred in 0.11% (n = eight six). The most common type of surgery that occurred in the corneal abrasion group was urological, 31% versus 11% in control cases, with robotic prostatectomy being the most common type of urological surgery (48%). Duration length of surgery was longer for corneal abrasion group, 3.85 h vs 1.7. Most of the corneal abrasion group received general anesthesia when compared to control (95% versus 47%, respectively). In the corneal abrasion group, 6% were in prone position and 25% were in Trendelenburg position. More corneal abrasions occurred in the main PACU versus ambulatory PACU or other recovery sites (69% versus 24%). All the aforementioned percentages were statistically significant [3].

Another prospective, randomized double-blinded study conducted in 2014 evaluated the efficacy of hydro-gel eye patch in preventing corneal abrasions [31]. Seventy-six patients were randomly divided into two groups, hydrogel eye patch group, and adhesive tape group (control group). The hydrogel patch group had 12 eyes (15.8%) that showed corneal injury with fluorescein under a slit lamp immediately after surgery, while the control group had 30 eyes (39.5%) ($P < 0.01$). The authors concluded that hydrogel eye patch is superior to adhesive tape in preventing corneal abrasions [31].

An observational, single-institution study in 2015 assessed the effectiveness of a pre-established anesthesiology-based protocol for the management of corneal abrasions [10]. A total of 91,064 surgical cases over a 5-year period were reviewed. The incidence of corneal abrasion was 0.13% ($n = 118$) during this period. The anesthesia department was able to manage 93.22% ($n = 110$) of perioperative corneal abrasions, while ophthalmology was consulted for the remaining eight. The study found that older age and longer duration time of surgery were significant risk factors of corneal abrasion. The authors concluded that minor corneal abrasions can be managed safely and effectively using an anesthesiology-based algorithm approach [10].

Another 2015 literature review evaluated randomized control trial studies using topical anesthetics for less than 72 h in adult patients [32]. The review was unable to find evidence of superiority of topical anesthetics over placebo for corneal abrasion treatment. Currently, topical anesthetic treatment for corneal abrasion is not supported by evidence [32].

A prospective, randomized double-blinded study in 2016 compared the efficacy of eye-protection methods used in 72 patients (i.e., 144 eyes) [33]. These patients were randomly divided into four groups: control group (manual eye closure), tape group (bandage attached over the eyelid), ointment group (eye ointment instilled in eye prior to manual eye closure), and ointment-tape group; however, the authors found no significant difference in the indigence of corneal abrasions amongst the groups (23.5%, 16.7%, 21.6%, 16.2%, respectively; $P = 0.826$) [33].

A literature review evaluating randomized controlled trials in 2017 addressed the efficacy and safety of three classes of topical eye medications used for analgesia in corneal abrasions: topical non-steroidal anti-inflammatory drugs (NSAIDs) ($n = 6$), topical anesthetics ($n = 3$), and topical cycloplegics ($n = 1$) [20]. The authors concluded that evidence was there to support the use of topical NSAIDs as the standard for the management of corneal abrasions, and they were deemed as a safe option for to use for wound healing. Further studies were needed to encourage the use of topical anesthetics and topical cycloplegics [20].

Conclusion

CAs are the most commonly occurring ocular injury in the perioperative period. Most often, the abrasions heal in 24 to 48 h, but some cases progress to serious eye infections leading to permanent vision loss. This review looks at the etiology and treatment options for CA, focusing on the role of the anesthetist in the postoperative management of CA.

The key to preventing CAs in the OR is to first identify patients at risk (old age, long surgery, preexisting ocular condition; see table for complete list). All patients should have their eyes closed by tape or Tegaderm immediately after intubation to minimize corneal drying from lagophthalmos. This tape should be left in place until the end of the procedure and should be removed from the top to the bottom, so the eye stays fully closed. Every provider giving care to the patient should be cognizant of the drugs and materials in their possession to reduce risk of trauma to the patient's eyes. In the PACU, bedding, tubing, and masks should all be secured and away from the patient's eyes. Pulse oximetry probes should be moved to the non-dominant small finger to prevent injury from the patient's own fingers.

CAs are normally found in the PACU when the patient complains of tearing, foreign body sensation, blurred vision, photophobia, and eye pain. These complaints should lead to immediate fluorescein examination and evaluation for CA. After a corneal abrasion is identified, there are two main arms of management—pain control and infection prevention. For most uncomplicated patients, topical ophthalmic erythromycin ointment is the first antibiotic choice and oral NSAID therapy is the first pain management choice. Topical NSAIDs or topical anesthetics may also be prescribed at the discretion of the physician with close monitoring. Selecting the best pharmacotherapy for patients involves balancing infection prevention and pain control with delayed corneal healing and the inconvenience of some therapies. Provider awareness and vigilance are the keys to reducing risk factors and promptly detecting CA in the perioperative period.

Compliance with Ethical Standards

Conflict of Interest Jordan S. Renschler, Kelsey D. Cramer, Best O. Anyama, Easy C. Anyama, Julie A. Gayle, Cassandra M. Armstead-Williams, Chizoba N. Mosieri, J. Arthur Saus, and Elyse M. Cornett declare no conflict of interest. Alan D. Kaye serves on the Speakers Bureau of Depomed and Merck.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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•• Of major importance

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