

Eye care in the intensive care unit during the COVID-19 pandemic

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Abstract

Ocular complications in critical care patients are common. There has been a surge in intensive care admissions following the COVID-19 outbreak. The management of COVID-19 exposes patients to a number of specific risk factors for developing ocular complications, which include non-invasive ventilation, mechanical ventilation and prone positioning. Consequently, it is likely that there will be an increase in the number of ocular complications secondary to the management of COVID-19 patients in the intensive care unit setting, and these complications could lead to permanent visual loss and blindness. Increased awareness of eye care in the intensive care unit setting is therefore vital to help prevent visual loss and maintain quality of life for patients recovering from COVID-19.

Key words: Coronavirus; COVID-19; Eye care; Intensive care; Ocular; Ophthalmology

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Background

The COVID-19 outbreak was declared as a pandemic and a global health emergency by the World Health Organization on 11 March 2020 (World Health Organization, 2020a). There were 3 862 676 confirmed cases worldwide with 265 961 deaths related to COVID-19, with 211 368 of these cases confirmed and 31 241 deaths in the UK, as of 9 May 2020 (World Health Organization, 2020b). This has seen a surge in patients being admitted to critical care units across the UK, with the capacity of these units increased to accommodate this demand, resulting in unprecedented numbers of patients receiving critical care treatment. This treatment often involves non-invasive ventilation or mechanical ventilation because an acute respiratory distress syndrome-like condition can develop in COVID-19 patients (Phua et al, 2020). Prone positioning of mechanically ventilated patients (lying chest down) significantly improves oxygenation in patients with severe acute respiratory distress syndrome (Guerin et al, 2004), as well as reducing mortality when used early and for 16 hours a day or more (Sud et al, 2014).

Ocular complications in critically unwell patients are common. Up to 42% of intensive care unit patients can have signs of damage to the corneal surface of the eye (exposure keratopathy), which can lead to secondary complications and ultimately irreversible visual loss (Rosenberg and Eisen, 2008; Bird et al, 2017). Visual impairment is associated with a reduced quality of life, loss of independence, reduced mobility and poor mental health; an increased rate of all-cause mortality has also been found in individuals with visual impairment (Swanson and McGwin, 2004; Vu et al, 2005; Langelan et al, 2007; Christ et al, 2014). It is likely that the rise in intensive care unit admissions during the COVID-19 pandemic will significantly increase resulting ocular complications. Therefore, if these patients receive correct eye care, visual loss and its associated morbidity can be prevented.

This article provides an overview of ocular complications in critically unwell patients for health-care professionals involved in eye care in the intensive care unit setting during the COVID-19 pandemic.

Pathophysiology of ocular surface disease in intensive care patients

The surface structures of the eye are most at risk from damage in the intensive care patient, specifically the cornea (the transparent anterior surface of the eye). The main refractive power of the eye is provided by the cornea, which enables light to be focused onto the

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retina (Hearne et al, 2018). The cornea is densely innervated by pain fibres and is protected by production of the tear film, the blink reflex and the ability to maintain eyelid closure while asleep. Sedated patients are at high risk of developing complications as a result of corneal exposure; 75% of patients who are heavily sedated have incomplete closure of the eyelid, known as lagophthalmos (Mercieca et al, 1999; Rosenberg and Eisen, 2008). **Table 1** outlines assessment of lid closure. Tonic contraction of the orbicularis muscle maintains lid closure during sleep and the blink reflex regulates regular eye closure while awake, helping to protect the ocular surface by continuously distributing the tear film across the cornea.

In critical care patients, muscle relaxants reduce tonic contraction of the orbicularis oculi muscle which can lead to lagophthalmos. Sedation or a reduced conscious level can reduce the blink rate and inhibit the protective blink reflex, as well as preventing patients from reporting symptoms of pain or discomfort which can alert clinicians to potential damage to the ocular surface (**Table 2**) (Grixti et al, 2013). Therefore, this exposes the ocular surface, predisposing the cornea to direct damage (corneal abrasion) or secondary complications, because of the loss of these protective mechanisms.

Ocular surface damage can also arise directly from gas flow from oxygen or non-invasive ventilation face masks which exert a direct drying effect on the corneal surface (Mercieca et al, 1999). Elevated venous pressure from positive pressure ventilation and/or prone

Table 1. Assessment of lid closure and grading of lagophthalmos




Grade of lagophthalmos	Clinical assessment	Clinical appearance	Management
Grade 0	Eyelids close completely		No action required
Grade 1	Incomplete lids closure, conjunctiva exposed only (no corneal exposure)		Lubricating ointment to be applied every 4 hours
Grade 2	Incomplete lid closure, cornea exposed (iris visible)		Lubricating ointment to be applied every 4 hours and lid taping

Table 2. Risk factor associated with ocular surface disease in intensive care patients

Risk factor	Mechanism of ocular surface damage
Reduced conscious level	Reduction in blink rate and lagophthalmos (further increased risk because of the inability to report symptoms from ocular surface damage)
Use of muscle relaxants and sedation	Reduction in blink rate, loss of blink reflex and lagophthalmos
Oxygen and non-invasive ventilation masks	Direct drying of corneal surface from gas flow
Mechanical ventilation	Increased venous pressure with conjunctival oedema causing lagophthalmos Exposure of ocular surface to microorganisms from tracheal suctioning
Prone position	Increased venous pressure with conjunctival oedema causing lagophthalmos Direct corneal injury sustained while positioning
Neurological injury resulting in facial nerve palsy	Lagophthalmos secondary to muscle weakness as a result of cranial nerve VII (facial) nerve palsy
Intensive care unit environment	Increased exposure to microorganisms (including multi-resistance organisms)
Pre-existing ocular surface disease	Increased susceptibility to infection
Increased length of intensive care admission	Increased exposure to all risk factors

positioning of ventilated patients, as seen in a number of COVID-19 patients, can result in conjunctival oedema (chemosis), exposing the surface of the eye as a result of mechanical lifting of the upper eyelid (Grixti et al, 2013). Indirect damage to the unprotected corneal surface is termed exposure keratopathy, and this can lead to secondary complications with the potential for permanent visual loss including microbial keratitis, corneal scarring and perforation (Hearne et al, 2018). Any damage of the corneal surface that causes scar tissue formation or an opacity of the cornea can reduce the amount of light entering the eye and alter its refractive power, leading to visual loss. Severe damage to the cornea can result in irreversible blindness, necessitating the need for corneal transplant. Therefore, the prevention, recognition and management of such conditions (by following local protocols where available) is vitally important in the critical care setting when patients are often unable to alert clinicians to potential ocular problems.

Recognition and management of ocular surface disease in intensive care patients

Corneal abrasion

Corneal abrasion is a common condition caused by a superficial breaching of the corneal epithelium. This results in a red and painful eye, and the abrasion can be identified with fluorescein eye drops, which stain the abrasion bright yellow/green when a blue light is applied (Figure 1). A simple corneal abrasion is treated with chloramphenicol ointment applied four times a day for 5–7 days (Lightman and Montgomery, 2017).

Exposure keratopathy

Exposure keratopathy refers to damage of the corneal epithelium from prolonged exposure of the ocular surface to the outside environment, and primarily occurs secondary to incomplete lid closure (lagophthalmos). Patients can have a red eye, and fluorescein eye drops can reveal areas of staining as a result of damaged corneal epithelium (Figure 2). Treatment is of the underlying cause: preventative measures in the presence of lagophthalmos or removal of offending risk factors where possible (Table 1). If prolonged, exposure keratopathy can result in secondary corneal infection, ulceration and scarring (Lightman and Montgomery, 2017).

Chemosis

Chemosis is swelling of the conjunctiva (Figure 3) as a result of increased venous pressure and subsequent oedema. This is common in patients who are ventilated in the prone position and also those with generalised oedema (such as in fluid overload, hypoalbuminaemia or

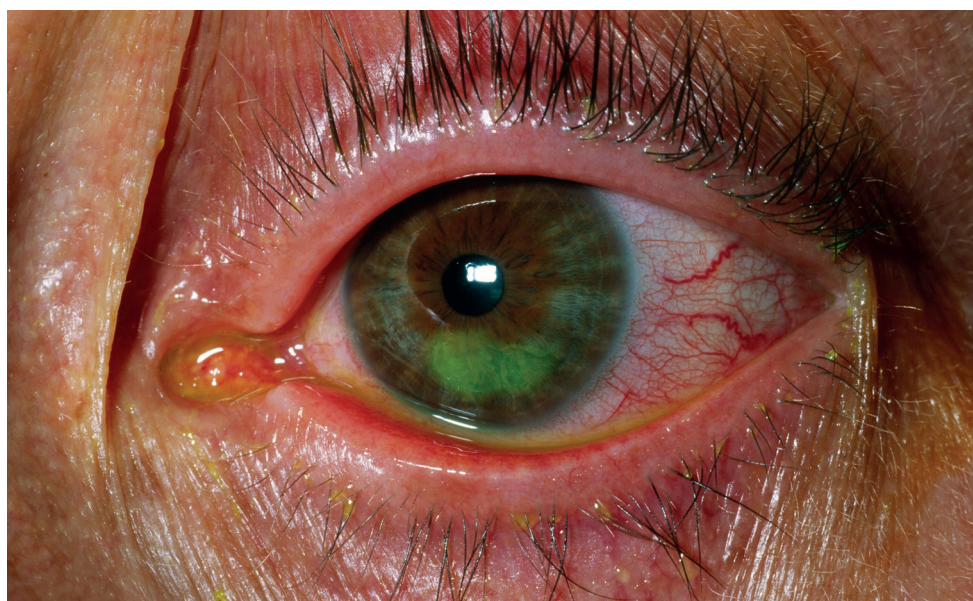


Figure 1. Inferior corneal abrasion, area stained green with fluorescein.

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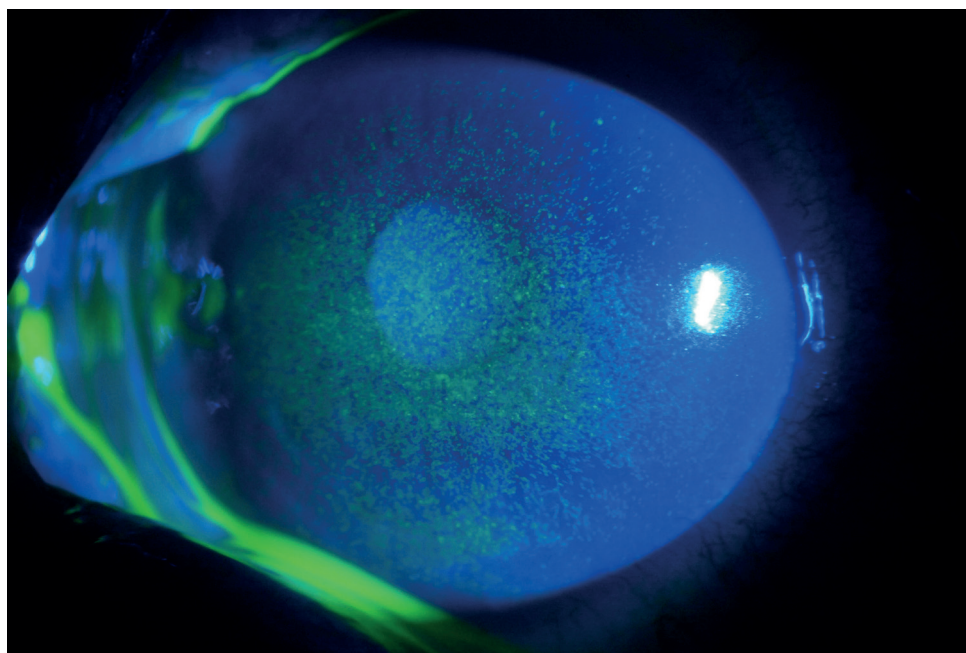


Figure 2. Corneal epithelium damage, green staining with fluorescein caused by areas of epithelial cell loss.

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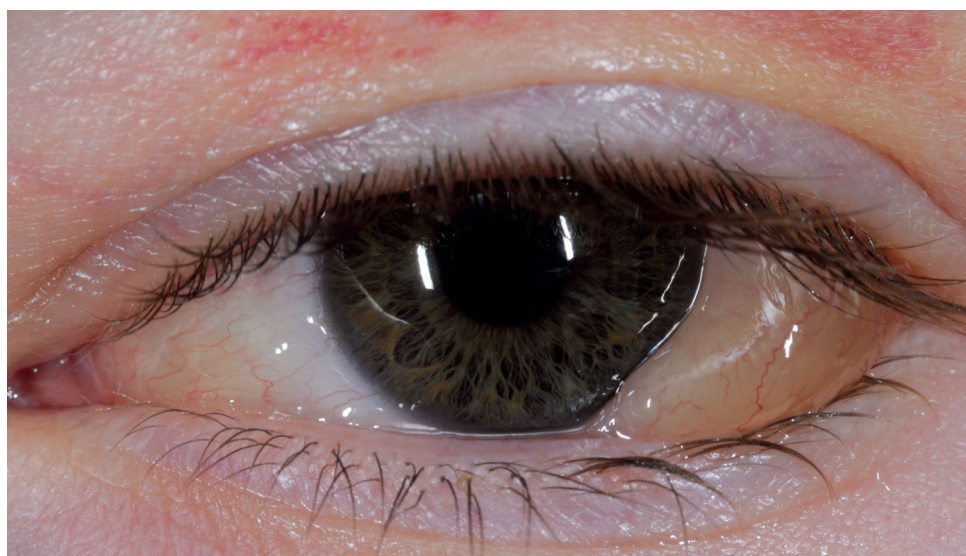


Figure 3. Chemosis, swelling of the conjunctiva (white of the eye).

capillary leak in systemic inflammatory response syndrome) (Grixti et al, 2013; Hearne et al, 2018). This chemosis can result in lagophthalmos, as the lid is unable to close fully over the ocular surface, and can cause uneven tear distribution, predisposing to exposure keratopathy and its associated complications (Grixti et al, 2013). Chemosis should be managed according to preventative measures outlined in [Table 3](#). However, if severe these measures may not be adequate and referral to ophthalmology is required as it may be necessary to close the eyelids with sutures (tarsorrhaphy) to protect the ocular surface (Lightman and Montgomery, 2017).

Infection

In the intensive care unit setting the eye often becomes colonised with bacteria and respiratory secretions, which are a major cause of ocular infection in intubated patients; *Pseudomonas aeruginosa*, *Staphylococcus epidermidis* and *Acinetobacter* spp. are the most commonly isolated bacteria in this cohort (Mela et al, 2010). The infection is often spread to the eye in the process of endotracheal suctioning (Ramírez et al, 2008; Hearne et al, 2018). Therefore,

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Figure 4. Microbial keratitis secondary to *Pseudomonas aeruginosa*. The light beam from the slit lamp is visible in the centre of eye with a round opacity on the inferior corneal surface as a result of bacterial infection.

covering the eyes during airway suctioning and avoiding direct contact between equipment and the eye can help to reduce infection rates (Lightman and Montgomery, 2017).

Microbial keratitis

Most pathogens cannot penetrate an intact cornea, but loss of integrity of the corneal epithelium as a result of exposure keratopathy or corneal abrasion means corneal infection can occur, termed microbial keratitis (Hearne et al, 2018). Most cases of microbial keratitis are caused by bacteria (other causes are herpes zoster and herpes simplex viruses, and fungi) and result in a red eye, with an opacity on the cornea (Figure 4). Microbial keratitis can cause visual loss as a result of corneal scarring, and severe ulceration can lead to perforation of the cornea. Urgent ophthalmology referral is needed if microbial keratitis is identified (Lightman and Montgomery, 2017).

Conjunctivitis

A red sticky eye in an intensive care patient can be caused by bacterial conjunctivitis (Figure 5). If no features of microbial keratitis are present, swabs of the discharge should be taken and sent for microbial culture and sensitivity, then the eyes cleaned separately. Chloramphenicol ointment should be applied to the affected eye four times a day for 7 days. If there is significant improvement within 24–48 hours treatment should continue regardless of sensitivity results, but if there is little or no improvement, treatment should be tailored to sensitivity results and an ophthalmology opinion sought (Lightman and Montgomery, 2017).

Other ocular complications in intensive care unit patients

Although less common than conditions affecting the ocular surface, a number of other ocular complications can arise in the intensive care unit setting (Table 3). Reduced perfusion of ocular structures, damage to the optic nerve or more rarely a severe infection of the eye itself can lead to rapid and irreversible loss of vision (Stambough et al, 2007; Grixiti et al, 2012). Intraocular pressure increases in patients ventilated in the prone position (Saran

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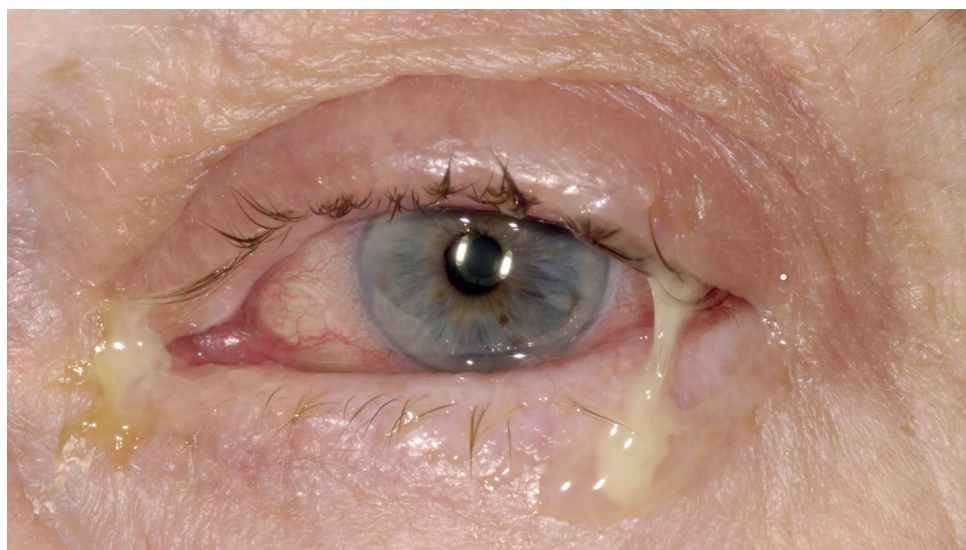
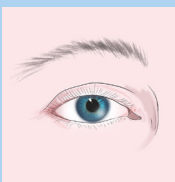
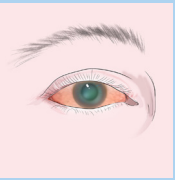
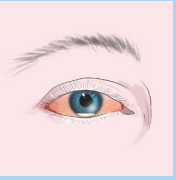


Figure 5. Bacterial conjunctivitis, purulent discharge with conjunctival injection (redness) and upper lid swelling.

et al, 2019), as a result of direct compression of the eyes or as a result of gravitational effects leading to oedema, increased venous pressure and ocular swelling (Cheng et al, 2001). Raised intraocular pressure can lead to reduced ocular perfusion pressures, causing damage to the retina through occlusion of the blood supply (central retinal artery occlusion) or indirect damage to the optic nerve in the case of ischaemic optic neuropathy resulting in painless visual loss (Stambough et al, 2007). Prone ventilation during spinal and lung transplant surgery causes visual loss from ischaemic optic neuropathy (Chang and Miller, 2005; Panchabhai et al, 2016). The length and duration of prone positioning in managing COVID-19 patients with respiratory failure has the potential to cause visual loss in these patients as a result of ischaemic optic neuropathy.

Table 3. Recognition and management of other ocular complications in intensive care patients			
Condition	Risk factors (in context of patient)	Clinical features	Management
Painless visual loss (multiple causes)	Retinal artery occlusion: Prone positioning, hypotension, arrhythmias, hypercoagulable state Ischaemic optic neuropathy: Prone positioning, hypotension, anaemia Retinal detachment: trauma	Normal external appearance of eye Pupil may be unreactive, relative afferent pupillary defect may be present Painless	 Immediate referral to ophthalmology
Acute glaucoma	Prone positioning	Red eye Fixed, mid-dilated pupil (unreactive to light) Cloudy or hazy corneal Severe pain, headache, nausea, blurred vision (in conscious patient)	 Immediate referral to ophthalmology
Endophthalmitis (bacterial or fungal) (exogenous or endogenous)	Septic patients, fungal or bacterial culture positive patients, long duration of indwelling catheters Non-improving corneal ulcer or surface infection	Red eye Hypopyon (pus or fluid level behind cornea) Blurred vision and severe pain (in conscious patient)	 Immediate referral to ophthalmology

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More rarely patients nursed in the prone position can develop acute glaucoma in which the drainage of the eye becomes blocked as a result of forward movement of the lens and iris, causing a sudden and sustained rise in intraocular pressure (Table 3 shows presenting features). This can rapidly cause devastating irreversible visual loss as a result of direct optic nerve damage (Hearne et al, 2018). Furthermore severe or persistent hypotension, which is common in intensive care unit patients, can also result in ischaemic optic neuropathy and permanent visual loss (Stambough et al, 2007). Endogenous endophthalmitis, a severe infection of the eye caused by systemic spread of infection through the bloodstream, should always be considered in a septic patient with a red eye (Table 3) (Grixti et al, 2012). Exogenous endophthalmitis most commonly occurs following ocular surgery but can also result from untreated microbial keratitis, which leads to ulceration and perforation of the cornea (Bird et al, 2017).

Protecting the eye in intensive care unit patients

Assessment of lid closure

Eyelid closure must be assessed at the time of admission and at least daily thereafter, with findings clearly documented. It is crucial to examine for the presence of incomplete closure of the eyelid (lagophthalmos) and, if it is present, the grade of severity must be assessed to help determine management (Table 1) (Lightman and Montgomery, 2017).

Assessment of cornea and conjunctiva

The cornea and conjunctiva should be assessed at least daily with findings clearly documented in the notes (Table 4). For assessment, the eye should be opened and a bright light directed onto the surface of the eye to look for conjunctival redness, swelling, discharge and any opacities on the cornea. If there are concerns of corneal damage, further assessment can be carried out by applying fluorescein drops and viewing the cornea using a blue light (commonly found on ophthalmoscopes). It can be useful to obtain imaging of ocular surface pathology (following local policies and guidelines) for referral and monitoring purposes.

Applying preventative measures to protect the eye

Protective measures for the ocular surface should be initiated to prevent the development of exposure keratopathy secondary to lagophthalmos and its associated complications. Preventative measures in patients who are ventilated prone are also crucial to reduce the risk of associated complications from reduced retinal artery perfusion, ischaemic optic neuropathy and acute glaucoma (Intensive Care Society and Faculty of Intensive Care Medicine, 2019).

To clean the eye

Before applying lubricating ointment, the eye should be bathed with saline-soaked gauze and cleaned from the inner to outer lid in a downward direction (Figure 6) (Lightman and Montgomery, 2017).

To apply ointment to the eye

Ointments are superior to eye drops in intensive care patients as they remain on the ocular surface for a longer period of time. Figure 7 shows application instructions (Hearne et al, 2018). Ointment should be reapplied every 4 hours when indicated, with the eye cleaned before application to remove any old ointment. If administration of multiple different drops is required, there should be at least a 2-minute interval between the application of

Table 4. Assessment of cornea and conjunctiva in intensive care patients

Corneal and conjunctival changes	Management
Cornea normal	No action needed – continue to assess daily
Redness, discharge, conjunctival swelling, lagophthalmos (grade 2)	Apply lubricating ointment 4-hourly+lid taping. If no improvement after 24–48 hours make daytime ophthalmology referral
Opacities on cornea	Urgent daytime ophthalmology referral

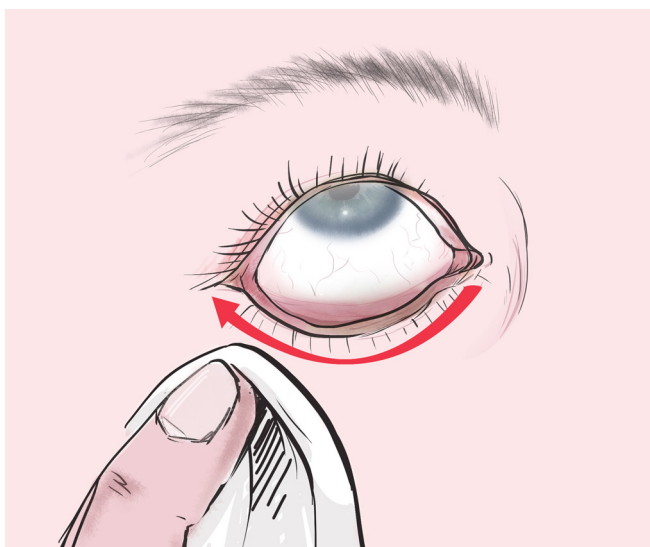


Figure 6. Cleaning the eye.

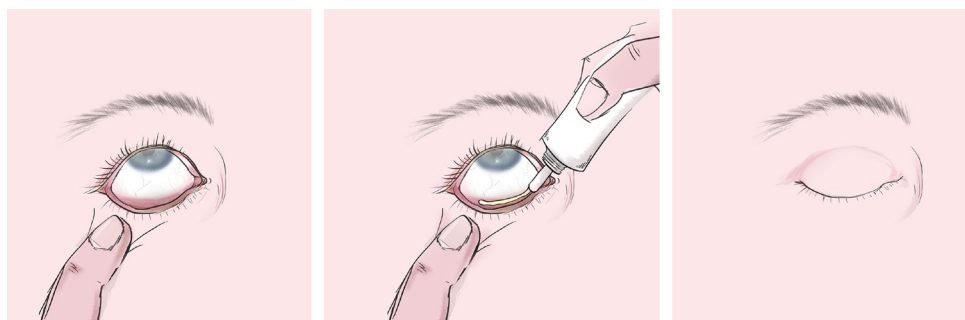


Figure 7. Applying ointment to the eye.

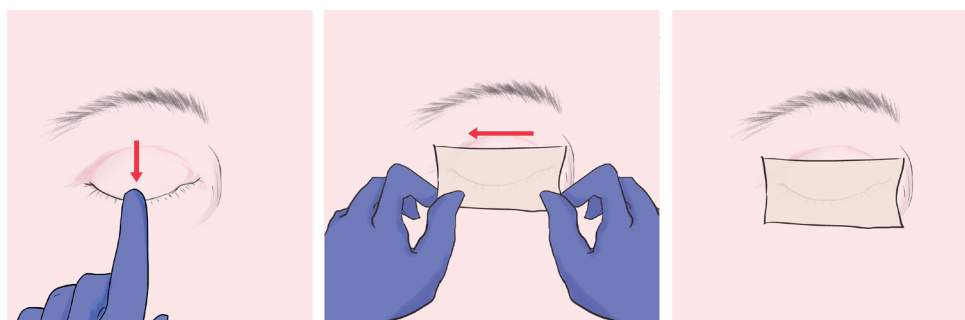


Figure 8. Taping of the eyelids.

each set of drops. Ointment should always be applied after drops as ointment acts as a water repellent, preventing the absorption of drops (Lightman and Montgomery, 2017).

To apply tape

If taping is required, as for grade 2 lagophthalmos (Table 3), ointment should first be applied to the eye in all cases. It is important to ensure that the surrounding skin is free from ointment to allow the tape to be secured correctly (Figure 8) (Lightman and Montgomery, 2017). Caution should be taken when removing tape from the eye to avoid any damage to the cornea from the lashes, fingers or tape.

Preventative measures in prone patients

An eye assessment should be carried out before proning (Tables 3 and 4), with the application of ointment and taping of the lids to prevent corneal abrasion during positioning (Intensive

Care Society and Faculty of Intensive Care Medicine, 2019). When positioning patients prone, direct pressure on the eyes should be avoided and continuous re-assessment of this position undertaken. Maintaining normotension and adopting a slight reverse Trendelenburg position (30° head-up positioning) decreases facial oedema and periorbital swelling, ensuring good ocular perfusion is maintained (Stambough et al, 2007). A prone checklist has been implemented in many hospitals to reduce complications, including those related to the eye. Part of the checklist includes ensuring the eyes are lubricated and taped and post-procedure the pressure areas are checked, ensuring there is no direct pressure on the eyes (Intensive Care Society and Faculty of Intensive Care Medicine, 2019).

Conclusions

Ocular complications in critically unwell patients are common. Given the unprecedented increase in intensive care unit admissions in the wake of the COVID-19 pandemic, it is likely the number of these will increase. Furthermore, COVID-19 patients are exposed to specific risk factors for developing ocular complications, including non-invasive, mechanical and prone position ventilation. The consequence of this is a likely increase in the frequency of eye complications secondary to intensive care unit management, with the potential for permanent visual loss in these patients. Therefore, increased awareness of eye care and complications in the intensive care unit setting is vital to help prevent visual loss and maintain quality of life for those recovering from COVID-19.

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Conflicts of interest

The authors declare no conflicts of interest.

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Key points

- Ocular complications are common in intensive care patients.
- The management of COVID-19 exposes patients to a number of specific risk factors for developing ocular complications including prone position ventilation.
- Common ocular complications in intensive care are often the result of incomplete closure of the eyelids (lagophthalmos) and include exposure keratopathy, corneal abrasion and microbial keratitis.
- Ocular complications related to intensive care admission have the potential to lead to permanent visual loss and irreversible blindness.
- Significant numbers of individuals recovering from COVID-19 to have substantial morbidity associated with visual loss.
- Simple eye care applied in intensive care can prevent ocular complications and visual loss.

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