Ocular Surface Disorders in the Critically Ill

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Abnormalities of the cornea and conjunctiva occur in association with neurological diseases, nocturnal lagophthalmos, coma, infection, and mechanical ventilation. We investigated the incidence and causes of ocular surface disorders in critically ill patients. In a retrospective study, the presence of conjunctivitis and corneal erosion was determined by reviewing the medical charts of 143 mechanically ventilated patients (intensive care unit [ICU] stay ≥7 days). In the subsequent prospective study, 15 patients who had sedatives or muscle relaxants administered continuously for more than 48 h in the ICU were investigated. Corneal erosion was examined using a slit lamp once a day. Ocular surface disorder was found in 28 of the 143 patients (20%) whose ICU stay exceeded 7 days. The incidence increased with continuous sedation (35% vs 15%). The incidence also increased with continuous neuromuscular blockade (39% vs 11%). In the prospective study, nine patients (60%) developed corneal erosion. A patient's inability to fully close his or her eyes increased the incidence ($P < 0.01$) of corneal erosion. Protective eyelid taping was effective in preventing and treating the corneal erosion. In conclusion, the critically ill often develop ocular surface disorders, especially when sedated and immobilized. A close relationship was observed between these conditions and the inability to close one's eyes.

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Abnormalities of the cornea and conjunctiva may occur in association with neurological diseases (1, 2), trauma (1), nocturnal lagophthalmos (2), coma (3–5), infection (4–6), and mechanical ventilation (4–6). There have, however, been few reports on the incidence of eye complications in the intensive care unit (ICU) (3–6). Some reports imply that the prevention of eye complications in the ICU was the most effective way to avoid postrecovery visual loss (4–6). The objectives of the present study were to determine how often ocular surface disorders occur in ICU patients and to determine the causal factors. We began by reviewing medical charts to ascertain the incidence of conjunctivitis and corneal erosion. We then performed a prospective study of corneal erosion to determine the incidence in a high-risk group.

Methods

This study was approved by the Institutional Review Board of Osaka University Medical School. Informed consent was not required in the retrospective chart review, but written consent was obtained from each patient or patient's family in the prospective study.

Retrospective Chart Review

We reviewed the medical records of 143 consecutive patients whose ICU stay from 1990 to 1992 exceeded 7 days (Table 1). Our ICU, a six-bed general unit, accepted 170–260 patients a year. The average stay was 8.2 days, and mortality was 11.2%. The eyes of each patient had been examined once a day by ICU staff, who determined the presence of conjunctivitis and corneal erosion. Conjunctivitis was diagnosed when copious exudate, chemosis (edema), and injection (redness) were apparent in the conjunctiva. Corneal erosion was diagnosed when defects or punctate changes were observed in the corneal epithelium. We also noted the following variables: age, prognosis, continuous intravenous (IV) administration of sedatives or muscle relaxants, and air conditioner settings. Air conditioner settings were obtained from the records in an administrative office that controls the air conditioning for the whole building. Other notes were recorded on the ICU flowsheets, medical charts, and nurse summary sheets. Standard eye care included ocular lubrication with ofloxacin eyedrops and erythromycin ointment every 8 h.

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Table 1. Patients' Demographics in Retrospective and Prospective Studies

	Retrospective study (ICU stay ≥7 days)	Prospective study (ICU stay ≥7 days and continuous sedation/muscle relaxation)
n	143	15
Age	33 ± 31 (3 mo to 77 yr)	27 ± 27 (5 mo to 65 yr)
Male/female	87/56	12/3
Duration of ICU stay (days)	21 ± 22	22 ± 29
Mortality [*n* (%)]	39/143 (27)	6/15 (40)
Primary disease		
Congenital heart disease	44	7
Coronary artery disease	9	3
Valvular heart disease	9	1
Great vessel disease	15	1
Esophageal cancer	28	
Pneumonia	9	1
Congenital tracheal stenosis	7	
Congenital diaphragmatic hernia	5	
Miscellaneous	17	2

ICU = Intensive Care Unit.

Prospective Study

Subjects were 15 consecutive patients who had IV sedatives (morphine 15–40 $\mu g \cdot kg^{-1} \cdot h^{-1}$ and/or midazolam 0.1–0.2 $mg \cdot kg^{-1} \cdot h^{-1}$) or muscle relaxants (vecuronium 40–150 $\mu g \cdot kg^{-1} \cdot h^{-1}$) administered continuously for longer than 48 h (Table 1). All patients were intubated and mechanically ventilated before their entry into this study. They were admitted to the ICU between October 1992, and May 1993. During this period, a total of 127 patients were admitted to the ICU, and 42 stayed for longer than 7 days.

When continuous administration of sedatives and muscle relaxants had commenced, the cornea surface was examined once a day (1) by instillation of fluorescein dye (Fluores test paper; Showa Medical, Osaka, Japan) into the inferior cul-de-sac of both eyes, followed by gentle manual lid closure and examination by slit lamp biomicroscopy (Kowa portable slit lamp SL-5; Kowa Corp., Tokyo, Japan) with a cobalt blue filter (1). The filter and magnification (×10) revealed pathologic changes in keratitis. Epithelial cell loss and punctate staining pattern were defined as corneal erosion. The area and distribution of corneal erosion were estimated by 5% increments under magnification and were recorded on each case card. Room temperature, relative humidity, eyelid status, and severity of illness were recorded. Room temperature and relative humidity were measured at the head of each patient with a thermohygrometer (Shinyei Corp., Tokyo, Japan). Eyelid status was classified as either incomplete or complete eyelid closure. Incomplete closure was diagnosed when a part of the conjunctiva or cornea was visible. Severity of illness was evaluated from clinical prognosis and organ failure. The APACHE III score was not evaluated because children (<6 yr of age) were included. Organ failure was determined according to modified Fry's criteria (7) as follows: central nervous system—organic brain damage; heart—hypotension (systolic blood pressure <80 mm Hg in adults and <50 mm Hg in children) and need for catecholamines; lung—need for 5 days of mechanical ventilation; liver—aspartate aminotransferase and alanine aminotransferase >100 U/L and total-bilirubin >5 mg/dL for 3 days; kidney—serum creatinine >2 mg/dL; digestive organ—gastrointestinal bleeding requiring transfusion; and disseminated intravascular coagulopathy—platelet count <50,000 mm^3 or platelet decrease >50,000 mm^3/day.

The patients were divided into two groups: the "erosion group" who developed corneal erosion and the "intact group" whose corneas remained intact throughout the study period.

Eye care in the prospective study was similar to that given during the retrospective study. We applied eyelid taping (Nichiban Corp., Tokyo, Japan) in four patients when the area of corneal erosion was still increasing even with this eye care.

Statistical analysis used χ^2 test, Fisher's exact probability test, and Student's *t*-test. Data are shown as mean ± SD. $P < 0.05$ was considered significant.

Results

Retrospective Study

Ocular surface disorders were apparent in 28 (20%) of 143 patients and included 23 cases of conjunctivitis (16 injection and 13 chemosis) and 5 cases of corneal erosion. Duration of ICU stay was longer for patients with ocular surface disorders than for those without the disorders (47 ± 39 vs 16 ± 10 days, $P < 0.01$).

Risk factors for ocular surface disorders are shown in Table 2. The patients under continuous sedation showed a significantly higher incidence of ocular surface disorders (35% vs 15%, $P < 0.05$). The incidence under continuous paralysis was also higher (39% vs 11%, $P < 0.01$). Nonsurvivors showed a significantly higher incidence of ocular surface disorders than survivors (56% vs 6%, $P < 0.01$). Use of an electric fan or air conditioning settings did not affect the incidence.

Prospective Study

Corneal erosion developed in 9 (60%) of 15 sedated or immobilized patients, 8 in the right and 8 in the left

Table 2. Risk Factors for Ocular Surface Disorders in a Chart Review

Continuous sedation	
Yes	35 (11/31)
No	15 (17/112)†
Continuous muscle relaxation	
Yes	39 (17/44)
No	11 (11/99)*
Prognosis	
Survivor	6 (6/104)
Nonsurvivor	56 (22/39)*
Electric fan	
Yes	19 (6/32)
No	20 (22/111)
Air conditioning	
Cooling	22 (11/50)
Heating	17 (12/69)
No	21 (5/24)
Age (yr)	
>65	23 (7/31)
<65	19 (21/112)
Gender	
Male	16 (14/87)
Female	25 (14/56)

Values are expressed as % (*n*).
* $P < 0.01$, † $P < 0.05$.

Table 3. Comparison of Demographics Between the Erosion Group and the Intact Group

	Erosion group	Intact group
n	9	6
Age (yr)	38 ± 26	12 ± 22
Male/female	7/2	5/1
ICU stay (days) (median)	25 ± 24 (12)	11 ± 9 (8)
Failed organs	5.0 ± 2.7	2.7 ± 3.5†
Central nervous system	7	0*
Heart	8	6
Respiratory	7	4
Hepatic	9	2*
Renal	6	2
GI bleeding	2	0
DIC	6	2
Mortality [*n* (%)]	5/9 (56)	1/6 (17)
Inability to fully close eyes [*n* (%)]	9/9 (100)	0/6 (0)*
Room temperature (°C)	25.6 ± 1.1	25.6 ± 0.7
Relative humidity (%)	28.6 ± 7.8	25.6 ± 9.8

ICU = Intensive Care Unit, GI = gastrointestinal, DIC = disseminated intravascular coagulopathy.
* $P < 0.01$, † $P < 0.05$.

eye (Table 3). The area of corneal erosion was 0%–25% (mean 17%) of the right cornea and 0%–40% (mean 18%) of the left. In all cases, corneal erosion developed within 1 or 2 days of the commencement of continuous sedation or immobilization. There was no significant difference in room temperature or relative humidity between the two groups. Duration of ICU stay tended to be longer in the erosion group, but this trend did not reach statistical significance.

The erosion group had a significantly larger number of failed organs and a greater incidence of central nervous system disorder and hepatic failure. Mortality tended to be higher in the erosion group, but this trend did not reach statistical significance. There was a high correlation between corneal erosion and inability to fully close the eyes. None of patients in the erosion group could completely close their eyelids, whereas those in the intact group could. The distribution of corneal erosion was coincident with the area of corneal exposure, mainly in the inferior portion. In the erosion group, four patients were treated with eyelid taping and the other five patients were treated with conventional eye lubrication. All patients treated with eyelid taping completely recovered from corneal erosion, but it took at least 1 wk. The five patients with conventional lubrication showed no improvement in the established corneal erosion during the study period. Follow-up data were obtained for nine survivors (four in the erosion group and five in the intact group). Two patients in the erosion group showed superficial corneal scarring without visual distortion or sense loss, whereas all survivors in the intact group showed intact corneas during 6-wk follow-up.

Discussion

This study demonstrates that ocular surface disorders are not uncommon in the critically ill, occurring in 20% of patients with long ICU stays and in 60% of sedated or immobilized patients. The incidence increased with sedation, paralysis, severity of illness, and longer ICU stay. In a prospective study, we chose sedated or immobilized patients as a high-risk group and found a close correlation between inability to close one's eyes and corneal erosion.

Hilton et al. (4) described 10 nosocomial eye infections in obtunded ICU patients with pulmonary infection, and speculated on the relationship between suctioning procedures and the eye infection. Wincek and Ruttom (5) and Ommeslag et al. (6) reported four exposure keratitis and four pseudomonas eye infections during mechanical ventilation, respectively. They speculated that incomplete eyelid closure and respiratory pathogens increased the occurrence of the corneal ulcer. Eye complications are common during general anesthesia (8–11), and prevention with eyelid taping (9–11) and ointment (8, 10) is recommended.

In our ICU, the atmosphere is dry (relative humidity <30%), and filtered air blows from the ceiling toward the patient's face. If the patients cannot blink or are unable to close their eyes, drying of the ocular surface can easily develop. Meanwhile, fluid imbalance and increased permeability, which are common in the critically ill, cause conjunctival edema and hinder eye

closure. Sedation, muscle relaxation, and impaired consciousness suppress blinking activity, which accelerates the exposure of the ocular surface. It has been suggested that inadequate eyelid function and constant corneal exposure lead to corneal epithelial desiccation, which impairs the defense system of the eye and results in corneal ulceration (5, 12). In our study, the distribution of the corneal erosion was coincident with the exposed corneal area.

Patients with multiple organ failure and nonsurvivors showed a high incidence of ocular disorders. They often needed sedation or immobilization to maintain their circulatory or respiratory conditions. Moreover, it is probable that edema due to increased permeability appears in the conjunctiva, and that organ dysfunction impairs restoration of cells in the damaged eye. Positive pressure ventilation raises the patient's venous pressure, reduces drainage of blood from the ocular tissue, and causes conjunctival or ocular edema (12).

Corneal erosion can develop surprisingly quickly. Because the ocular morbidity of corneal ulcer and related perforation is high (4–6), prompt diagnosis and treatment are critical. Ocular lubrication with antibiotic ointment is reported to be effective for bacterial keratitis (13, 14), but no improvement was observed in our study. Care with eyelid taping was effective.

Our study has several limitations. First, a retrospective and macroscopic observation may result in an underestimation of the occurrence of eye complications. In the patients who stayed in the ICU longer than one week, the incidence was 20% in the retrospective study and 21% (9 of 42) in the prospective study. Second, the patient population was small in the prospective study. We found a high incidence of these complications in sedated or immobilized patients and decided to start routine eyelid taping for them. Third, flash-aided inspection of the eye with fluorescein was not routinely used in the ICU, but it revealed the early pathologic changes in the corneal surface. Fourth, we defined conjunctivitis and corneal erosion as ocular surface disorders. Exposure keratitis is defined as an inflammation caused by the failure of the eyelids to cover the globe (1) and is most commonly associated with facial nerve disorders, blepharoptosis, and severe proptosis (1, 2). Although such disorders were not noticed in any of our patients, the term might be appropriate to describe the complications observed in this study. Finally, the complications observed in this study might be mild or moderate because none of the patients developed corneal perforation or vision impairment after their recovery.

In conclusion, the critically ill show a high incidence of ocular surface disorders, especially when sedated and immobilized. Severity of illness and mortality affect the incidence, but environmental factors do not. There is a close correlation between the disorders and lack of eye closure.

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