JCN Journal of Clinical Nursing

Journal of
Clinical Nursing

CLINICAL ISSUES

Effectiveness of polyethylene covers versus carbomer drops (Viscotears®) to prevent dry eye syndrome in the critically ill

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Aim. The purpose of this study was to compare the effectiveness of the polyethylene covers versus carbomer eye drops to prevent dry eye syndrome in intensive care unit patients.

Background. Concerns about eye care for critically ill patients remain an issue. Few studies have focused on the effect of polyethylene covers and eye drops. In addition, there are no studies comparing polyethylene covers and carbomer eye drops for critically ill patients.

Design. A prospective, randomised and contralateral eye study was conducted.

Methods. The study took place in an intensive care unit in 2007. Thirty-six eyes of 18 patients, who were under mechanical ventilation or unconscious for more than 24 hours in the intensive care unit, were studied. After examining the eyes of the patients with the Schirmer 1 test and fluorescein dye test, suitable patients were included in the study. One eye of the patient was randomly covered with a polyethylene cover every 12 hours, and carbomer drops were instilled on the other eye every six hours. All eyes were checked for an ocular surface abnormality by the same ophthalmologist everyday. The study interventions were continued until a defect was detected or for five days. Patients with a defect detected completed the study and were recorded as positive for the primary endpoint.

Results. Carbomer drop was effective in prophylaxis of dry eye syndrome in only three of 18 patients, whereas polyethylene cover showed greater effect in 18 of 18 eyes at the end of the study (SD 0·3835, $Z = -3{\cdot}873$, $p < 0{\cdot}001$). A negative effect of greater rima palpebra in the resting position was observed in the efficacy of carbomer drop ($r = -0{\cdot}476$, $p < 0{\cdot}05$).

Conclusion. This study suggests that a polyethylene cover is significantly effective in prevention of dry eye syndrome in intensive care patients. As an eye care intervention, the effectiveness of polyethylene cover should be supported by further studies.

Relevance to clinical practice. This study, which is an initial step in preventing dry eye syndrome in critically ill patients, also offers a new and effective eye care method in these patients.

Key words: cornea, dry eye syndrome, eye care, intensive care units, nursing, prevention

Accepted for publication: 17 August 2010

Introduction

Critically ill patients are at risk for eye dryness because of lack of tear film production, poor eyelid position and loss of blink reflex. Therefore, eye care as a preventive nursing approach is vital for intensive care unit (ICU) patients. From a review of the literature, there are various eye care measures to prevent dry eye syndrome (DES) in the ICU patients. Cortese *et al.* (1995) and Joyce (2002) indicate that polyethylene cover (PC) provides a greater protection than other eye instillations against corneal epithelial breakdown.

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doi: 10.1111/j.1365-2702.2010.03559.x

Background

ICU patients are often vulnerable to numerous ocular abnormalities related to factors such as impaired mental status, mechanical ventilation therapy or neuromuscular blockage destroying defensive mechanisms (Lenart & Garrity 2000, Joyce 2002, Kocaçal & Eşer 2008, Rosenberg & Eisen 2008). Poor eyelid closure (lagophthalmos), reduced ability to use blink reflex and decreased tear production can cause the development of ocular complications (Kocaçal & Eşer 2008). For instance, DES, conjunctival chemosis (Dawson 2005), corneal exposure and microbial keratitis (Hutton & Sexton 1972, Hilton 1983) can occur. DES caused by tear film abnormalities can lead to serious ocular complications such as permanent corneal scarring and visual loss, if it is not prevented. In spite of few published studies on the incidence of further complications of DES, there is no study reporting the incidence of DES in ICU patients. Corneal abrasions can occur within a short time, ranging from 48 hours to one week in ICU patients (Joyce 2002, Ezra *et al.* 2005, 2009, So *et al.* 2008). The results of a study conducted by Germano *et al.* (2009) are consistent with this knowledge: they found that most corneal epithelial defects (69%) were detected within the first week of mechanical ventilation therapy and many were detected within the first 48 hours. Recent studies have also shown that 75% of patients under heavy sedation or taking muscle relaxants have poor eyelid closure (Mercieca *et al.* 1999). Imanaka *et al.* (1997) point out that 60% of such patients have superficial keratopathy.

DES is a preventable condition in ICU patients. Prevention, early diagnosis, urgent treatment and high-quality care underpinned by evidence are significantly essential components of the management of DES in critically ill patients (Dua 1998). Prevention is cheaper, more practical and more beneficial than cure whilst being acceptable to both ICU team and patients; unfortunately, anticipating and preventing eye problems in the ICU population is not common amongst the health care team compared with other approaches including protection of vital functions (Parkin & Cook 2000, Joyce 2002, Rosenberg & Eisen 2008).

Some eye care measures for prevention of DES include passive eye closure, hypoallergenic tape (micropore), moisture chamber (PC, swimming goggles, polyacrylamide hydrogel dressings), saline soaked gauze, lubricants, tarsorrhaphy (suturing the eyelids) to maintain eye closure and the integrity of the ocular surface (Suresh *et al.* 2000, Joyce 2002, Rosenberg & Eisen 2008). However, eye care regimes are not always evidence based, and there is no clear consensus defining the best form of eye care intervention (Laight 1996, Cunningham & Gould 1998, Rosenberg & Eisen 2008). More studies with high-quality evidence are needed to guide eye care practices for critically ill patients. This study aims to compare the effectiveness of two preventive measures to preclude DES in ICU patients who do not have spontaneous blink reflex: PC versus carbomer drops (CD).

Materials and methods

Design

This prospective, randomised and contralateral eye study was carried out between March–July 2007 in the Anesthesiology and Reanimation Unit at Ege University Medical Faculty. The unit has a 30-bed capacity.

Subjects

Thirty-six eyes of 18 patients, who were over three years old and who had been mechanically ventilated or unconscious (Glascow Coma Score <7) for more than 24 hours in the ICU, formed the sample of the study. The patients' age, admission diagnosis, administration of muscle relaxants and sedatives, the frequency of eye blinking, eyelid position (Table 1), length of stay in the ICU and the humidity of the ICU environment were also recorded daily by using a patient observation form prepared by the researchers.

Having a pre-existing eye problem (ocular trauma, chronic lagophthalmos, etc.), a previous admission to the ICU within a month of enrolment and eye treatment with topical agents other than ocular lubrication before the study were exclusion criteria. Patients who died or had a corneal staining were excluded from the study.

Procedure and ethical considerations

Approval was obtained from the Institutional Ethics Committee of Ege University Medical Faculty prior to study initiation. Informed written consent was also received from each patient's family.

After a detailed eye examination performed at the bedside

Table 1 Eye lid position

Grade	Eye lid position
Grade 1	Lids closed
Grade 2	Only conjunctival exposure
Grade 3	1/3 or less of the cornea exposed
Grade 4	1/2 or more of the cornea exposed

by the researchers to assess eye blinking reflex, eye lid position, amount of tear (Schirmer 1 test: 5 mm and over) and corneal staining (fluorescein test: no staining), suitable patients were included in the study. Each patient received both PC and CD, which were allocated at random to either the left or the right eye using a block envelope-based randomisation method. The sequence was hidden until the intervention was assigned. A simple randomisation method (drawing lots) was used to select eyes of the patients for the groups (experiment group: application of PC or control group: application of CD). The researchers were responsible for the randomisation of the study groups.

After randomisation, standard eye care with sterile gauze soaked with 0·9% saline solution was performed twice a day. Then, one eye of the patient was covered with PC (Fig. 1) every 12 hours and CD was applied to the other eye every six hours by the researcher. All of the interventions were carried out in accordance with the guidelines prepared by the researchers.

PC is an eye protector that prevents tears from evaporating away from the eye surface. It is also a natural protector that is applied to the front of the eye. There is a transparent film containing 100% polyethylene in the middle of the cover and double-sided and adhesive drape forms the edges of the cover (Fig. 2). The preparation of PC is required medical aseptic technique. CD is a sterile, translucent and colourless liquid artificial eye gel, which is used for management of DES conditions for unstable tear film. It is also used for prophylaxis of DES in critically ill patients in our unit.

All eyes were checked for ocular surface abnormality using fluorescein dye under pen light illumination and 20 diopter lens magnification by the same ophthalmologist. Before the corneal evaluation, the PC was removed from the eye and all eyes were cleaned by the researcher to ensure objectivity. The fluorescein dye test was performed daily. When any corneal surface abnormalities appeared as a green stain with the fluorescein dye, the patient was excluded from the study and treated. If there was no corneal staining, the study was carried on for five days.

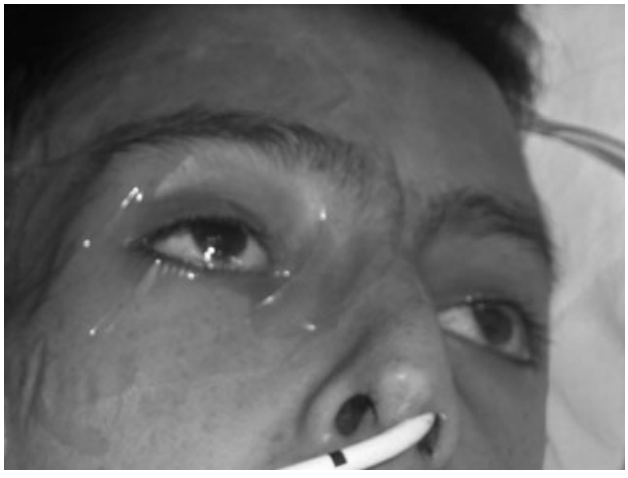

Figure 1 Application of polyethylene cover.

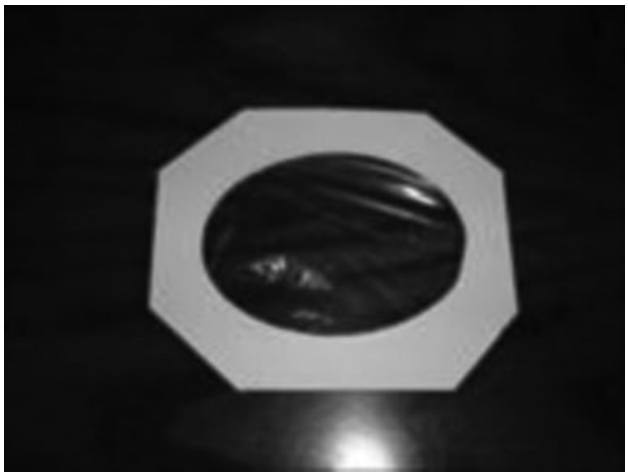

Figure 2 Polyethylene cover.

Data analysis

Descriptive and potentially confounding variables derived from the study were tabulated by groups and are shown by percentage. The Wilcoxon signed-rank test was used to compare the eyes covered with PC with those lubricated with CD in terms of corneal damage. Mann–Whitney *U* test and Chi-square test were used to evaluate the effect of independent variables, and Spearman Correlation Analysis was used to determine the relation between the grade of the eyelid position and the severity of corneal damage in the eyes lubricated by CD.

Results

Participants' profiles

A total of 36 eyes of 18 patients were recruited over the six months. Five (23·5%) of the patients were women and 13 (76·5%) were men. Ages ranged from 8–80 (mean 45, SD 23·4). Duration of ICU stay varied from 1–18 days. Because of the exclusion criteria of the study, baseline Schirmer test 1 for all the eyes was higher than 5 mm/five minutes, none of the patients had spontaneous blink reflex and no eyes had a corneal staining. Fifteen patients were under sedation and

nine were receiving muscle relaxants. The Glasgow Coma Scale score was < 7 in 16 patients. The humidity of the ICU measured with a hygrometer (*Pakkens*) was found to be between 28–58% during the study.

Comparison of the test results in the groups

At the end of the five-day follow-up period, there was a statistical significance between the PC group and the CD group in terms of results of fluorescein dye test (SD 0·38 $Z = -3{\cdot}87$, $p < 0{\cdot}001$), and 15 eyes lubricated with CD had positive fluorescein stains compared with none of the eyes covered with PC (Fig. 3). There was no corneal damage in the 18 eyes covered with PC throughout the five days of the follow-up period, but CD was effective for 2·94 days on average. The effect of CD decreased day by day (Table 2).

Because PC was effective in all eyes, descriptive and potentially confounding variables (for example, age, gender, ICU lenght of stay, Glasgow Coma Scale score, the presence of sedation) were not significant in PC group. Independent variables which could also have an impact on the success of the CD were analysed by Mann–Whitney *U* test and were not statistically significant ($p > 0{\cdot}05$). However, the difference between the eyes of patients taking muscle relaxants was close to statistical significance level ($p = 0{\cdot}065$) in the study (Table 3). The negative effect of greater rima palpebra in resting position was observed in the effectiveness of CD ($r = -0{\cdot}476$ $p < 0{\cdot}05$) (Fig. 4). On the other hand, eye lid position did not affect the efficacy of PC.

Figure 3 Corneal staining on the left eye protected by carbomer drop.

Table 2 Percentage effectiveness of polyethylene cover and carbomer drop (CD) protection

	PC effectiveness		CD effectiveness	
Follow-up period	*n*	%	*n*	%
1st day	18	100	18	100
2nd day	18	100	10	55·5
3rd day	18	100	4	22·2
4th day	18	100	3	16·7
5th day	18	100	–	–

Table 3 Significance of some descriptive and potentially confounding variables in development of corneal surface abnormality in carbomer drops group

Variable	Fluorescein dye test positive, %	Fluorescein dye test negative, %	M–*U**	*p*
Age				
< 50	80	20	22·000	0·953
More than 50	87·5	12·5		
Gender				
Male	61·1	11·1	21·000	0·819
Female	22·2	5·6		
Glasgow Coma Score				
More than 7 point	5·6	5·6	16·500	0·192
< 7 point	77·7	11·1		
ICU length of stay				
More than 7 days	71·42	28·57	31·000	0·293
< 7 days	90·9	9·09		
Sedation	76·5	11·1	18·000	0·410
Muscle relaxant	44·4	5·6	9·000	0·065

*Mann–Whitney *U* test.

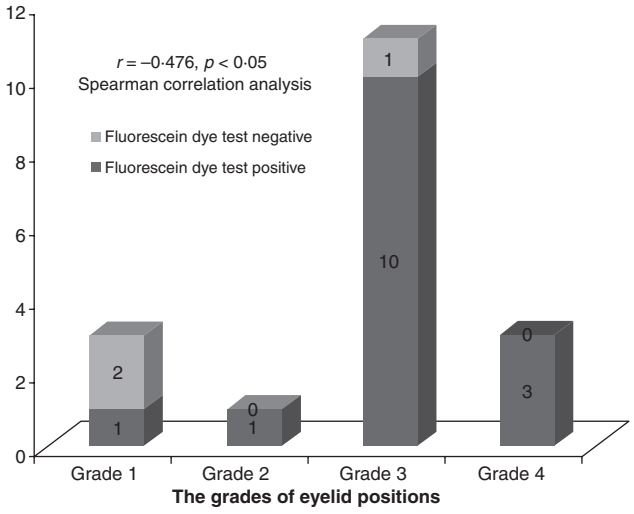

Figure 4 The relationship between the eye lid position and the results of the fluorescein dye test in carbomer drop group.

Discussion

Despite the fact that a healthy epithelium of the cornea is a barrier against most infectious agents, dryness-related epithelial breakdown in ICU patients can lead to numerous corneal infections (Kanski 2007, Rosenberg & Eisen 2008, Ezra *et al.* 2009). Thus, protection of the cornea is very important to avoid infections. In the current study, application of routine CD was found fairly ineffective (16·7%) in the prevention of corneal drying and further damage. The effectiveness of CD application decreased day by day during the study period. Thus, it can be seen that the use of CD is not an effective method for protecting the eyes of patients in the ICU. On the other hand, the moisture chamber created by the PC was completely effective in protecting the cornea throughout the five-day study period (Table 2). Similarly, Cortese *et al.* (1995) found that PC was more effective than methylcellulose drops. However, Koroloff *et al.* (2004) indicated that PC and hypromellose drops and lacrilube combination were not statistically different, but that PC had more advantages in use. A prospective randomised controlled study carried out by So *et al.* (2008) showed that the ocular surface could be kept moist, when PC was used despite chemosis and the results of that study are similar to the study by Koroloff *et al.* (2004) Additionally, So *et al.* (2008) reported an eye infection in the lanolin eye ointment group, but none were reported in the polyethylene group. The current study confirms these results. In our study, PC had no side effects or disadvantages when compared with application of CD and it confirms the results of Koroloff *et al.* (2004), Cortese *et al.* (1995) and So *et al.* (2008). According to another study by Sivasankar *et al.* (2006), swimming goggles as a moisture chamber are more effective than the open chamber method, but they also reported in the study that 6·5% of eyes had significant lid oedema because of the pressure of the goggles on the eyelids. Polyacrylamide hydrogel dressing (Geliperm) is another popular form of eye protection in ICUs (Ezra *et al.* 2005, 2009). Ezra *et al.* (2009) suggested that Geliperm is as effective as ocular lubricants (Lacrilube) in the prevention of exposure keratopathy in the critically ill, if nurses are trained in its application for eye care because misplacement or drying of the Geliperm can increase the risk of exposure keratopathy (Ezra *et al.* 2009).

No demonstrable difference between eyes treated with CD and independent variables (age, sex, diagnosis, length of stay in ICU, etc.) was noted in our study. We think that this was related to the limited nature of the study sample. Our results are consistent with other studies (Cortese *et al.* 1995, Koroloff *et al.* 2004). For instance, in the study carried out by Koroloff *et al.* (2004), the confounding variables showed no statistically significant difference between the PC and hypromellose groups. Lenart and Garrity (2000) also reported that differences in sex and age were not significant. On the other hand, Germano *et al.* (2009) found that 55% of the mechanically ventilated children with sepsis in the ICU developed corneal defects.

Mechanically ventilated patients receiving neuromuscular blocking agents or sedatives are at risk for corneal defects because of impaired defensive mechanisms (Lenart & Garrity 2000). The difference between the eyes of patients taking muscle relaxants was close to statistical significance ($p = 0{\cdot}065$) in the current study. This might have reached statistical significance, if our study had been performed with a larger sample. There are some studies showing the relation between these medications and corneal defects. For example, Sivasankar *et al.* (2006) reported a significant difference between muscle relaxants and corneal disorders. In a study conducted by Lenart and Garrity (2000), continuous sedation and neuromuscular blockage increased the rate of corneal abrasions to 35 and 39%.

Impaired consciousness and lenght of time under mechanical ventilation also increase the exposure of the ocular surface (Wincek & Ruttum 1989), but the most important relationship is the lagophthalmos (Baum 1997). Mercieca *et al.* (1999) detected that in 75% of patients who were under heavy sedation and were taking muscle relaxants, lagophthalmos had developed. Imanaka *et al.* (1997) also highlighted that superficial keratopathy was seen in 60% of this kind of patients. Additionally, in the current study, the negative effect of eyelid position was observed in the effectiveness of CD. Our study showed that incomplete lid closure and the use of muscle relaxants are the most important predictive factors of DES.

Polyethylene can provide various benefits for the ocular surface. For instance, it provides a natural protection against nasocomial infection agents and the corneal epithelium remains intact when it is used. Polyethylene is also very easy and convenient to use. In our study, the PC was replaced with a new one, twice a day. Thus, the frequency of application of PC was lower than CD. Cortese *et al.* (1995), Koroloff *et al.* (2004) and So *et al.* (2008) specified also some advantages of PC in their research and following their studies; PC started to be used as a standard care in ICUs where the studies had taken place. We also intend to use the PC as a routine prophylactic care in our ICUs, as well.

It is very important for the corneas of ICU patients to be protected for different reasons. For a patient with a good survival rate, ocular surface protection prevents further dryness-related damage and maintains visual potential. It is also for respecting patient as a whole. On the other hand, for

patients with a poor survival rate, these corneas should be considered as potential donor corneas that must be protected. Because of the poor life prognosis of ICU patients, these units are important sources of cornea donors.

In this study, cost-effectiveness was not considered in relation to PC, but Koroloff *et al.* (2004) and So *et al.* (2008) indicated that PC was cheaper than drops or ointments. PC is also more advantageous when we consider the frequency of the use of these methods. We did not only compare two different protective eye measures with this study but also looked over the effect of present standard eye care (CD). In the light of current and related studies, we intend to change the current intervention (CD) with PC near by.

Limitations of the study

The small study sample and financial problems for the procurement of the components (polyethylene film and adhesive drapes) of the PC and for the carbomer eye drops are the limitations of this study.

Conclusions

Preventive approaches for eye care are vital for ICU patient, as most of them are susceptible to eye complications related to multiple factors. Therefore, health care providers should take precautions to guard against DES and further disorders. ICU team must be aware of this issue and must identify and intervene for ICU patients at risk of dryness and ocular surface damage. The moist chamber formed using a PC provides more effective dryness protection than carbomer lubrication for unconscious ICU patients. There is a need for more evidence-based studies comparing different eye care methods. And the best effective measures should be put into practice in the all ICUs.

Relevance to clinical practice

This study, which is an initial step in preventing DES in critically ill patients, also offers a new and effective eye care method in these patients. Critical care nurses should be consistent with the scope of practice for eye care of the ICU patients, and they should incorporate the evidence-based practice related to eye care into the nursing care. In addition, eye problems should be handled with a multidisciplinary approach.

Acknowledgements

We thank all responsible and instructor physicians and clinical nurses in Intensive Care Unit: Ali Reşat Moral, Mehmet Uyar and Kubilay Demirağ, Gülin Dinçaraslan, Dilek Suakar and Seda Ilgın; we also thank Ayşe Yağcı, Melis Palamar and Esat Çınar in Opthalmology Department. We also thank all the patients participating in this study. The work was performed in Anesthesiology and Reanimation Unit at Ege University School of Medicine, İzmir, Turkey. The study was awarded in a national project competition, Post-graduate Competition Applicable to Manufacturing Trade, by Ege University and Elginkan Charitable Fund at 3–5th June 2008, İzmir, TURKEY. The study was previously presented at 3rd EfCCNa & 27th Aniarti Congress, 09 October 2008/11 October 2008 Florence, Italy. A patent application for polythylene cover as a new design, which was used in this study, was accepted by Turkish Patent Institute. Additionally, TÜBİTAK (The Scientific and Technological Research Council of Turkey) provided financial support for this patent application.

Contributions

Study design: EKG, İE, SE; data collection and analysis: EKG, SE and manuscript preparation: EKG, İE, SE.

Conflict of interest

There is no any financial relationship or other set of circumstances that might affect or might reasonably be thought by others to affect, an author's judgment, conduct or manuscript.

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