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Research Article

Impact of Exposure Keratitis on Length of ICU Stay in Critically Ill Patients: A Study in a Tertiary Care Centre

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ABSTRACT

Introduction- Critically ill ICU patients are highly susceptible to exposure keratitis due to impaired eyelid closure, sedation, and mechanical ventilation. Despite its high prevalence and preventable nature, EK remains under-recognized. Its association with prolonged ICU stay has been inadequately explored, particularly in resource-limited tertiary care settings.

Material and Method- A one-year prospective observational study was conducted in medical and surgical ICUs of a tertiary care hospital. Adults aged ≥18 years with ICU stay ≥72 hours were enrolled (n=254). Alternate-day ocular examinations assessed exposure keratitis. ICU stay was compared between groups using appropriate statistical tests and multivariable regression analysis.

Result- Exposure keratitis occurred in 102 of 254 ICU patients (40.2%). It was significantly associated with mechanical ventilation, sedative use, chemosis, age group, and reason for ICU admission. Patients with exposure keratitis had longer ICU stays than those without (10.47 vs 6.60 days, $p<0.0001$), with ICU stay increasing progressively with disease severity. Multivariable analysis identified exposure keratitis as an independent predictor of prolonged ICU stay.

Conclusion- Exposure keratitis is a frequent ICU-acquired complication and an independent predictor of prolonged ICU stay. Its severity shows a direct association with increased hospitalization duration. Early identification and implementation of preventive eye care protocols may reduce ICU stay and improve outcomes in critically ill patients.

Keywords*: Exposure keratitis Intensive care unit, critically ill patients, ICU stay etc.*

INTRODUCTION

Critically ill patients admitted to intensive care units (ICUs) are vulnerable to a wide range of complications that extend beyond the primary systemic illness. Among these, ocular surface disorders—particularly exposure keratitis (EK)—remain under-recognized despite their high prevalence and preventable nature. Exposure keratitis refers to corneal epithelial damage caused by inadequate eyelid closure and tear film instability, leading to desiccation of the ocular surface and subsequent epithelial breakdown [1]. In the ICU setting, factors such as depressed consciousness, sedation, neuromuscular blockade, mechanical ventilation, facial edema, and impaired blink reflex significantly compromise the natural protective mechanisms of the eye [2]. The reported prevalence of exposure keratitis among critically ill patients varies widely, ranging from 20% to over 60%, depending on patient characteristics, duration of ICU stay, and the presence or absence of standardized eye care protocols [3,4]. Mechanically ventilated patients are particularly susceptible, as positive pressure ventilation and deep sedation further reduce eyelid tone and blinking frequency [5]. Although EK may initially present as mild punctate epithelial erosions, delayed diagnosis can lead to serious complications including corneal ulceration, secondary infection, scarring, and irreversible visual impairment [6].

While the ocular consequences of exposure keratitis are well documented, its potential impact on broader clinical outcomes has received comparatively less attention. The development of EK may reflect greater illness severity, prolonged

immobilization, and extended exposure to ICU-related risk factors. Moreover, EK often necessitates ophthalmology consultations, additional medications, and enhanced nursing care, which may indirectly contribute to prolonged ICU stays and increased healthcare utilization [7]. Previous studies have identified longer ICU duration as a risk factor for EK; however, limited evidence is available examining the reverse relationship—namely, whether the occurrence of exposure keratitis itself influences the length of ICU stay [8]. In resource-limited tertiary care settings, where ICU overcrowding and workforce constraints are common, preventable complications such as exposure keratitis assume greater clinical and economic significance. Despite the simplicity and low cost of preventive eye care measures, EK continues to be underdiagnosed, partly due to the absence of routine ocular assessment protocols in many ICUs [9]. Understanding the relationship between exposure keratitis and ICU length of stay could provide valuable insights into patient outcomes and reinforce the importance of integrating eye care into standard critical care practice. Therefore, the present study aims to evaluate the impact of exposure keratitis on the length of ICU stay among critically ill patients admitted to a tertiary care centre. By quantifying this association, the study seeks to highlight the clinical relevance of early detection and prevention of EK, thereby contributing evidence to support the incorporation of structured ocular care protocols in intensive care units.

MATERIAL AND METHOD-

A prospective observational study was conducted in the Medical and Surgical Intensive Care Units of GMERS Medical College and Hospital, Valsad, Gujarat, a tertiary care teaching hospital. The study was carried out over a period of one year from March 2023 to March 2024. Prior approval was obtained from the Institutional Ethics Committee before initiation of the study, and the study adhered to ethical principles outlined in the Declaration of Helsinki. The study population consisted of critically ill adult patients aged ≥18 years admitted to the Medical and Surgical ICUs during the study period. Sample size was calculated using Daniel's formula for prevalence studies, taking an expected prevalence of exposure keratitis of 21%, a 95% confidence level (Z = 1.96), and a precision of 5%. Based on this calculation, and to account for possible exclusions and incomplete data, a total of 254 patients were included in the study using a convenient sampling technique. Confidentiality and privacy of patient data were strictly maintained, and participation did not influence patient management or incur additional costs. Patients aged 18 years and above of either sex who had an ICU stay of 72 hours or more were included in the study. Patients with pre-existing external ocular diseases, history of ocular trauma or surgery, those who refused consent (patient or legally authorized representative), or incomplete clinical records were excluded. After obtaining informed consent, eligible patients were enrolled consecutively. Baseline demographic data, primary diagnosis, ICU admission details, reason for ICU admission and clinical parameters were recorded using a predesigned proforma. Clinical variables such as type of ICU, duration of mechanical ventilation, use of sedatives, and presence of facial edema were documented. Severity of EK was classified based on ocular surface findings observed on eye examination.

Ocular examinations were conducted by a single trained investigator to minimize inter-observer variability. Eye assessments were performed at the bedside on alternate days throughout the ICU stay. Ophthalmic evaluation included examination of eyelids for position and closure, conjunctiva, and corneal surface using a portable slit lamp. Fluorescein dye was instilled when indicated to assess corneal epithelial integrity. Exposure keratitis was diagnosed based on the presence of incomplete eyelid closure associated with corneal epithelial changes such as punctate erosions or epithelial defects. The primary outcome variable was length of ICU stay, defined as the total number of days from ICU admission to discharge or death. Patients were categorized into two groups based on the presence or absence of exposure keratitis, and ICU stay duration was compared between these groups. Data were entered into Microsoft Excel and analyzed using SPSS version 26.0. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, while categorical variables were presented as frequencies and percentages. The length of ICU stay between groups was compared using the independent t-test or Mann–Whitney U test as appropriate. Multivariate regression analysis was performed to identify the independent effect of exposure keratitis on ICU stay. A p-value <0.05 was considered statistically significant.

RESULT-

Among the 254 patients included in the study, exposure keratitis was identified in 102 patients (40.2%), while 152 patients (59.8%) did not develop the condition. As seen in Table 1, the mean age of patients with exposure keratitis was marginally higher compared to those without exposure keratitis (53.8 ± 14.2 years versus 50.6 ± 15.0 years), though this difference did not reach statistical significance (p = 0.11). A significantly greater proportion of patients in the exposure keratitis group required mechanical ventilation when compared to the non-exposure keratitis group (31.4% vs 21.7%, p = 0.042). In addition, the use of sedative medications was significantly more frequent among patients who developed exposure keratitis (15.7%) than among those who did not (6.6%), with this difference being statistically significant (p = 0.013). Facial edema manifested as chemosis was observed only in patients with exposure keratitis (21.6%) and was absent in the non-exposure keratitis group, demonstrating a strong association with the occurrence of exposure keratitis (p < 0.001). There was no statistically significant association between sex and exposure keratitis, despite a male predominance in both groups (p = 0.42). Likewise, the distribution of patients between medical and surgical intensive care units was comparable between the two groups, with no significant difference observed (p = 0.29).

Table 1- Baseline demographic and clinical characteristics of the study population (n = 254)

Parameter	EK Patients (n = 102)	Non-EK Patients (n = 152)	Total (n = 254)	p-value
Number of patients, n (%)	102 (40.2%)	152 (59.8%)	254 (100.0%)	—

Mean age (years), Mean ± SD		53.8 ± 14.2	50.6 ± 15.0	51.8 ± 14.7	0.11
Mechanical ventilation, n (%)		32 (31.4%)	33 (21.7%)	65 (25.6%)	**0.042**
Sedative use, n (%)		16 (15.7%)	10 (6.6%)	26 (10.2%)	**0.013**
Facial edema (chemosis), n (%)		22 (21.6%)	0 (0.0%)	22 (8.7%)	**<0.001**
Sex	Female	36 (35.3%)	61 (40.1%)	97 (38.2%)	0.42
	Male	66 (64.7%)	91 (59.9%)	157 (61.8%)	
ICU type, n (%)	Medical ICU	54 (52.9%)	92 (60.5%)	146 (57.5%)	0.29
	Surgical ICU	48 (47.1%)	60 (39.5%)	108 (42.5%)	

Figure 1 illustrates the age-wise distribution of the study population stratified by the presence or absence of exposure keratitis. The majority of patients in both groups belonged to the middle and older age categories. Among patients who developed exposure keratitis, the highest proportion was observed in the 41–60 years age group (40.2%), followed by those aged 61–80 years (37.3%). A similar pattern was seen in the non-exposure keratitis group, with 34.9% of patients aged 41–60 years and 33.6% aged 61–80 years. Younger patients aged ≤20 years constituted a very small proportion of the study population in both groups (2.0%). Patients aged more than 80 years were more frequently represented in the non-exposure keratitis group (11.2%) compared to the exposure keratitis group (1.0%). Statistical analysis revealed a significant association between age group and the occurrence of exposure keratitis (p = 0.044), indicating that the distribution of exposure keratitis varied significantly across different age categories.

Figure 1- Age wise distribution of study population

Table 2 demonstrates the distribution of exposure keratitis according to the underlying reason for ICU admission. A statistically significant association was observed between the reason for ICU admission and the occurrence of exposure keratitis (χ^2 test, $p < 0.001$). Exposure keratitis was most frequently observed among patients admitted with respiratory conditions, where 72.4% developed exposure keratitis, followed by those admitted for infectious causes (62.5%), malignancy (57.1%), hemodynamic instability (47.9%), trauma (48.3%), and central nervous system disorders (39.5%). All patients admitted due to poisoning developed exposure keratitis; however, the number of patients in this category was small. In contrast, exposure keratitis was relatively uncommon among patients admitted for renal (5.6%), gastrointestinal (21.4%), and cardiac causes (16.7%), and no cases were observed among patients admitted for metabolic disorders or autoimmune conditions. Overall, these findings indicate that certain categories of ICU admission—particularly respiratory, infectious, neurological, and hemodynamic causes—are associated with a higher occurrence of exposure keratitis.

Table 2- Association between **reason for ICU admission** and exposure keratitis **(n = 254)**

Reason for ICU admission	**EK patients n (%)**	**Non-EK patients n (%)**	**Total Patients n (%)**	**p-value**
Autoimmune	0 (0.0%)	1 (0.7%)	1 (0.4%)	**< 0.001**
Cardiac	2 (16.7%)	10 (83.3%)	12 (4.7%)	
CNS	17 (39.5%)	26 (60.5%)	43 (16.9%)	
Endocrinal	3 (42.9%)	4 (57.1%)	7 (2.8%)	
GIT	9 (21.4%)	33 (78.6%)	42 (16.5%)	

Hemodynamic	23 (47.9%)	25 (52.1%)	48 (18.9%)	
Infection	5 (62.5%)	3 (37.5%)	8 (3.1%)	
Malignancy	4 (57.1%)	3 (42.9%)	7 (2.8%)	
Metabolic	0 (0.0%)	7 (100.0%)	7 (2.8%)	
Poisoning	3 (100.0%)	0 (0.0%)	3 (1.2%)	
Renal	1 (5.6%)	17 (94.4%)	18 (7.1%)	
Respiratory	21 (72.4%)	8 (27.6%)	29 (11.4%)	
Trauma	14 (48.3%)	15 (51.7%)	29 (11.4%)	

Figure 2 depicts the distribution of exposure keratitis severity among the 102 affected patients. The majority of patients presented with moderate exposure keratitis, characterized by coalescent epithelial erosions, accounting for 64 cases (62.7%). Mild exposure keratitis, identified by punctate epithelial erosions, was observed in 28 patients (27.5%). Severe exposure keratitis, manifesting as corneal epithelial defects or ulcers, was relatively uncommon and was noted in 11 patients (10.8%). Overall, most cases of exposure keratitis in the study population were of moderate severity, with fewer patients progressing to severe corneal involvement.

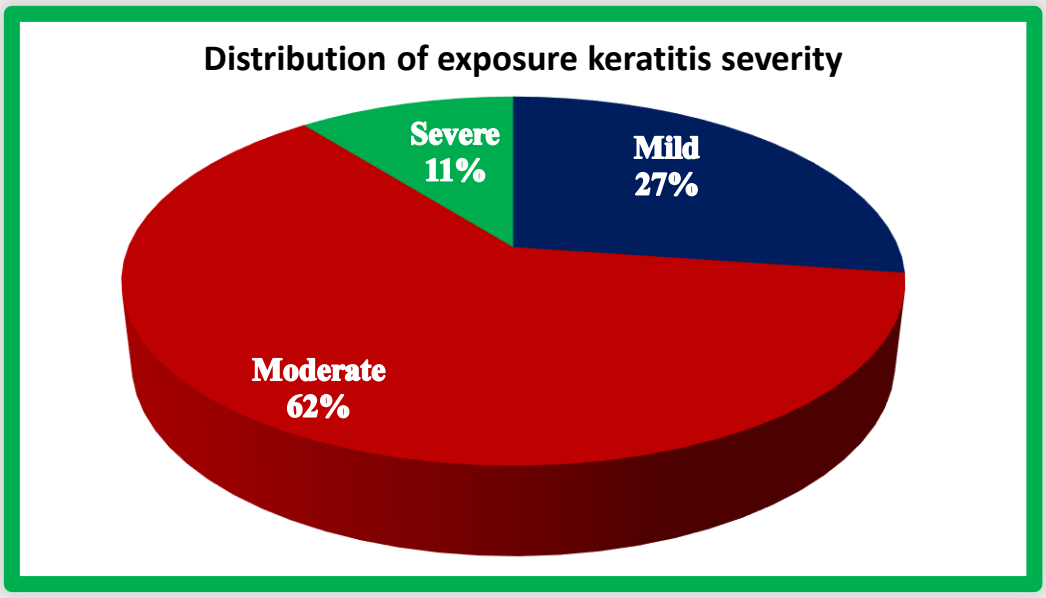

Figure 2- Distribution of exposure keratitis severity (n = 102)

Table 3 shows the relationship between the severity of exposure keratitis and the duration of ICU stay. A progressive increase in mean ICU stay was observed with increasing severity of exposure keratitis. Patients with mild exposure keratitis had a mean ICU stay of 9.4 ± 1.2 days, while those with moderate exposure keratitis had a longer mean ICU stay of 10.9 ± 1.4 days. The longest ICU stay was noted among patients with severe exposure keratitis, with a mean duration of 12.8 ± 1.7 days. The differences in ICU stay across severity grades were statistically significant ($p < 0.001$), indicating a strong association between increasing severity of exposure keratitis and prolonged ICU stay.

Table 3- ICU Stay According to Severity of Exposure Keratitis

Severity Grade	Mean ICU Stay (days) ± SD	p-value
Mild	9.4 ± 1.2	**<0.001**
Moderate	10.9 ± 1.4	**<0.001**
Severe	12.8 ± 1.7	**<0.001**

Table 4 compares ICU stay between patients with and without exposure keratitis. Patients who developed exposure keratitis had a significantly longer mean ICU stay compared to those without exposure keratitis (10.47 ± 1.76 days versus 6.60 ± 1.97 days), and this difference was highly statistically significant ($p < 0.0001$). When ICU stay was analyzed categorically, a markedly higher proportion of patients with exposure keratitis experienced prolonged ICU stay of more than 7 days (82.4%) compared to patients without exposure keratitis (18.4%). Conversely, shorter ICU stays of 7 days or less were predominantly observed among patients without exposure keratitis (81.6%). The association between exposure keratitis and prolonged ICU stay was statistically significant ($p < 0.001$). These findings indicate that exposure keratitis is strongly associated with increased duration of ICU hospitalization.

Table 4- Association Between Exposure Keratitis and ICU Stay

ICU Stay		EK Present n (%)	EK Absent n (%)	p-value
Mean ICU Stay in days (Mean ± SD)		10.47±1.76	6.60±1.97	**<0.001**
ICU Stay Duration n (%)	≤ 7 days	18 (17.6%)	124 (81.6%)	**<0.001**
	> 7 days	84 (82.4%)	28 (18.4%)	

As clear in Table 5, multivariable linear regression analysis was performed to identify factors independently associated with ICU stay among critically ill patients. Exposure keratitis was strongly associated with prolonged ICU stay, with an adjusted increase of 3.84 days (95% CI: 3.41–4.27, $p < 0.001$). Increasing age was also significantly associated with longer ICU stay, with each additional year contributing 0.03 days (95% CI: 0.01–0.05, $p = 0.004$). Mechanical ventilation was an independent predictor of prolonged ICU stay, increasing duration by 1.62 days (95% CI: 1.11–2.13, $p < 0.001$). Similarly, sedative use was associated with a modest but significant increase in ICU stay (+0.85 days; 95% CI: 0.18–1.52, $p = 0.013$). Sex and ICU type (surgical or medical) were not significantly associated with ICU stay in the adjusted model (male sex: $\beta = +0.21$, $p = 0.29$; surgical ICU: $\beta = +0.42$, $p = 0.29$; medical ICU: $\beta = -0.21$, $p = 0.38$). These results indicate that exposure keratitis, along with age, mechanical ventilation, and sedative use, independently contribute to longer ICU hospitalization among critically ill patients.

Table 5- Multivariable Linear Regression Analysis for ICU Stay (n = 254)

Variable	β coefficient (days)	95% CI	p-value
Exposure keratitis (Yes vs No)	+3.84	3.41 – 4.27	**<0.001**
Age (per year increase)	+0.03	0.01 – 0.05	**0.004**
Male sex	+0.21	−0.18 – 0.60	0.29
Mechanical ventilation	+1.62	1.11 – 2.13	**<0.001**
Sedative use	+0.85	0.18 – 1.52	**0.013**
Surgical ICU admission	+0.42	−0.18 – 1.02	0.29
Medical ICU admission	−0.21	−0.68 – 0.26	0.38

DISCUSSION-

In the present study, exposure keratitis (EK) was identified in 40.2% of critically ill patients admitted to the intensive care unit. This high prevalence highlights EK as a common ICU-acquired complication. Our finding is supported by the studies of Kousha et al. and Grixti et al., who reported EK prevalence ranging from 34% to 44% in critically ill patients [10,11]. Similarly, Hartford et al. observed exposure keratopathy in approximately one-third of ICU patients across multiple centers [12]. In contrast, Ezra et al. reported a comparatively lower prevalence, possibly due to routine implementation of structured eye care protocols in their ICU setting [13]. Mechanical ventilation emerged as a significant risk factor for EK in our study. This observation is supported by Hartford et al. and McHugh et al., who demonstrated a strong association between ventilatory support and ocular surface damage [12,14]. The reduced blink reflex and impaired eyelid closure during mechanical ventilation have been well documented. However, our findings contrast with those of Hearne et al., who did not find mechanical ventilation to be an independent predictor, suggesting that variations in sedation depth and eye care practices may influence outcomes [15]. Sedative use was significantly more frequent among patients who developed EK. This finding aligns with the study by Chen et al., which identified sedation as an independent contributor to exposure keratopathy [16]. Sedatives reduce corneal protective mechanisms, thereby increasing vulnerability to epithelial injury. In contrast, Grixti et al. reported sedation as a secondary rather than primary risk factor, emphasizing illness severity over medication effects [11]. Facial edema in the form of chemosis showed a strong association with EK and was observed exclusively in affected patients. Our result is supported by Kousha et al. and Pavlovic et al., who highlighted chemosis as a major mechanical factor preventing complete eyelid closure [10,17]. Few studies have contradicted this finding, underscoring the consistency of chemosis as a critical risk factor.

The age-wise distribution in our study demonstrated a higher occurrence of EK among middle-aged and elderly patients. This finding is supported by Pavlovic et al., who reported increased susceptibility to ocular surface disease with advancing age [17]. In contrast, Hartford et al. did not observe a significant age-related association, suggesting that ICU-related factors may outweigh demographic influences [12]. Severity analysis revealed that most patients had moderate EK, with increasing severity being associated with progressively longer ICU stay. This trend is supported by Chen et al. and Kumar et al., who reported worse outcomes and prolonged hospitalization among patients with severe ocular surface involvement [16,18]. In contrast, earlier studies such as that by Ezra et al. focused primarily on prevention and did not stratify outcomes by EK severity, limiting direct comparison [13]. A key finding of the present study was the significantly longer ICU stay among patients with EK compared to those without EK. This observation is supported by recent studies by Chen et al. and Kumar et al., which demonstrated that ICU-acquired ocular complications are associated with prolonged hospitalization [16,18]. In contrast, Hearne et al. suggested that EK may be a marker rather than a cause of prolonged ICU stay, though their study did not adjust for multiple confounders [15]. Multivariable linear regression analysis in our study confirmed EK as an independent predictor of prolonged ICU stay, even after adjusting for age, mechanical ventilation, and sedative use. These findings are supported by Chen et al., who reported similar independent associations between EK and adverse ICU outcomes [16]. In contrast, Hartford et al. reported attenuation of this association after adjustment, highlighting variability

across ICU settings [12]. Overall, the present study reinforces the clinical importance of early recognition and prevention of exposure keratitis in critically ill patients. The consistent association between EK and prolonged ICU stay underscores the need for standardized eye care protocols as an integral component of critical care practice.

CONCLUSION-

Exposure keratitis is a common and clinically significant complication among critically ill patients in the intensive care unit, affecting nearly two-fifths of the study population. Its presence and increasing severity were associated with prolonged ICU stay, with patients having moderate to severe exposure keratitis experiencing substantially longer hospitalization. Significant associations with mechanical ventilation, sedative use, and facial edema highlight the contribution of modifiable ICU-related risk factors to its development. These findings emphasize that exposure keratitis is an important yet preventable complication in critically ill patients. Routine ocular assessment and implementation of standardized eye care protocols in the ICU may reduce its incidence and severity, potentially improve patient outcomes and optimize ICU resource utilization.

Source of finding- Nil
Conflict of interest- None

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