Bacterial keratitis in the critically ill

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Abstract

***Background*—In the 4 year period (1988–91) there were nine cases of bacterial keratitis in five critically ill patients on an intensive care unit ('unit A'), all except one due to *Pseudomonas aeruginosa*. Many of these patients had serious ocular complications requiring surgery and all surviving patients were left with significant visual deficits. One further case of keratitis due to *P aeruginosa* occurred on unit A in April 1993. The problem of keratitis in ventilated patients is not unique to this unit as a further four cases in three patients from additional units in this area have been treated.**

***Methods*—Predisposing factors in unit A were established through subsequent investigations. It was found, in particular, that all the ocular infections were preceded by colonisation of the respiratory tract with the pathogenic organism. Recommendations concerning eye care and tracheal suctioning were adopted by unit A in 1991.**

***Results*—In the subsequent 4 years (1991–5), the frequency of isolation of pseudomonas from the respiratory tract per patient treated in unit A remained relatively high at 3.8% (153/4032). However, the conjunctival pseudomonas isolation rate has decreased significantly ($p < 0.001$) from 0.8% (19/2430) to 0.05% (2/4032).**

***Conclusions*—Ventilated patients may be at risk from inoculation of pathogens into the eyes. The principal risk factor for bacterial keratitis in this series was corneal exposure secondary to conjunctival chemosis or lid damage. The adoption of simple preventative measures on unit A had a significant impact on the incidence of eye infections due to pseudomonas, despite the high proportion of patients whose respiratory tracts were colonised with the same organism. There is a need for additional research into the most effective method of eye care for ventilated patients in order to reduce the frequency of this avoidable condition.**

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In the past few years a total of 13 cases of bacterial keratitis in nine critically ill patients have been referred to Bristol Eye Hospital from a number of high dependency units in the region. Initially, a cluster of eight cases in two adults and three children were referred from one intensive care unit ('unit A'). The effectiveness of revised eye care guidelines subsequently adopted by this unit was assessed by analysis of microbiological data. Since then there has been a further case on this unit. In addition we have treated two cases from a burns unit ('unit B'), and another two cases from a paediatric intensive care unit ('unit C'). Despite previous reports of similar cases,[1–3] the problem persists and is not unique to this region, as there has been a report of five cases in other units this year.[4]

Methods

The first five patients from unit A were treated between 1988 and 1991 (period 1) and a review of the eye care procedures resulted in recommendations which were adopted in the subsequent period 1991 to 1995 (period 2). Specimens were sent to the microbiology department for investigation when clinically indicated and were processed following the same protocols throughout the period 1988 to 1995. Data were collected and analysed retrospectively for the two periods from the database of routine microbiology stored on the pathology department computer system. Microbiological data have not been obtained from the other units where recent isolated cases have occurred.

Results

The surgical and ophthalmological details of the nine patients are summarised in Tables 1 and 2. All were in a critical condition, the majority requiring prolonged ventilation, and three did not survive their illness. The visual acuity of the six surviving patients was significantly impaired as a consequence of the ulceration and four required penetrating keratoplasty for corneal perforation.

A summary of the microbiological results for unit A in the two periods before and after the introduction of the revised guidelines (Table 3) is displayed in Table 4. There were only two patients with positive conjunctival swabs for pseudomonas in the second period.

Table 1 Surgical aspects of cases

Case	*Unit*	*Risk factors*	*Total duration of ventilation (days)*	*Outcome*
1	A	Acute renal failure	7	Surviving
2	A	Cardiac failure	9	Death
3	A	Acute renal failure	28	Surviving
4	A	Cardiac failure Severe Parkinson's disease	5	Surviving
5	A	Cardiac failure	14	Death
6	A	Cardiac failure Acute renal failure	8	Death
7	B	Severe burns	Not ventilated	Surviving
8	B	Severe burns	Not ventilated	Surviving
9	C	Cardiac failure, renal failure	43+	Surviving

Table 2 Ophthalmological and microbiological aspects of cases

Case	*Unit*	*Colonising organism* (day post admission)*	*Time between colonisation* and corneal ulceration (days)*	*Ocular isolate*	*Ocular pathology*	*Ocular outcome*
1	A	*P aeruginosa* (3)	3	*P aeruginosa*	Bilateral corneal ulcers R corneal perforation requiring graft	R clear graft amblyopia VA 2/60 corrected L scar below visual axis VA 6/4 uncorrected
2	A	*P aeruginosa* (5)	3	*P aeruginosa*	L corneal ulcer and abscess	L corneal ulcer at death
3	A	*P aeruginosa* (6)	2	*P aeruginosa*	Bilateral corneal ulcers R corneal perforation requiring graft	R clear graft cataract VA 6/60 corrected L corneal scar VA 6/6 uncorrected
4	A	*P aeruginosa* (4)	1	Culture negative†	Bilateral corneal ulcers	R epithelial changes VA 6/18 corrected L corneal scar VA 6/18 corrected
5	A	*Streptococcus viridans* (1)	1	*Streptococcus viridans*	R epithelial defect L corneal ulcer	Bilateral epithelial defects at death
6	A	*P aeruginosa* (11)	2	*P aeruginosa*	L corneal ulcer and abscess	L corneal ulcer at death
7	B	*P aeruginosa* (6)	11	*P aeruginosa*	R corneal ulcer and perforation requiring graft	R clear graft VA 6/24 corrected
8	B	*P aeruginosa* (18)	4	*P aeruginosa*	R corneal ulcer and perforation R corneal graft	R failed graft and implant VA HM
9	C	*Streptococcus aureus* (4)	7	*Streptococcus aureus*	Bilateral corneal ulcers	Bilateral corneal scars NPL (occipital infarcts)

*Colonisation of respiratory tract, except cases 7 and 8 where wounds became colonised.
†Topical antibiotics commenced before swabs taken.
VA = visual acuity; HM = hard movements; NPL = no perception of light.

The overall proportion of patients treated on the unit who had a positive conjunctival pseudomonas isolate decreased by a factor of 16, from 0.8% in the first period to 0.05% in the second ($p < 0.001$, Fisher's exact test). There was also a significant reduction from 3% to 0.97% ($p < 0.001$, χ^2 test) in the proportion of patients who required conjunctival swabs, and the pseudomonas isolation rate in these patients has significantly decreased from 26% to 5.1% ($p = 0.015$, Fisher's exact test).

These differences are not due to a reduction in the time patients stayed on the unit, as there was an increase in the length of stay in days in the second period (Mann-Whitney U test: mean difference 9.9 days, $p = 0.029$). Equally, the background incidence of pseudomonas infection does not account for the differences, as there is no significant difference in the overall isolation rate of pseudomonas per specimen sent for analysis between the two periods (613/18 230 in period 1, 409/12 706 in period 2; χ^2 test, $p=0.5$).

The respiratory tract pseudomonas isolation rate in period 2 per patient treated on unit A was 3.8% (153/4032). This is lower than other studies, which have found colonisation rates between 6.5% and 7.8%.[5 6] The isolation rate in period 1 is not known with certainty, as 1093 respiratory tract samples out of a total of 1698 did not specify their ward of origin accurately.

Table 3 Revised guidelines for the ocular care of unconscious patients

	Eye care recommendations
1	Unconscious patients with no ocular infection should have eye care 2 hourly
2	The eyes should be regularly inspected for lid swelling, conjunctival hyperaemia, corneal clouding, or epithelial loss
3	If there is corneal exposure lubricating ointment should be applied to the eyes 2 hourly
4	Patients at risk of corneal exposure should have their lids mechanically apposed with adhesive tape
5	Tracheal suctioning should take place from the side of the bed with the eyes covered
6	Daily conjunctival swabs should be taken if there is a positive respiratory isolate of *Pseudomonas aeruginosa*. An urgent conjunctival Gram stain should be performed if there is a clinical suspicion of ocular infection
7	Topical gentamicin should be started if pseudomonas is isolated from the conjunctiva and an ophthalmic opinion sought

Discussion

Bacterial keratitis is a preventable sight threatening complication in the critically ill. Eye care should be a high priority even when the survival of the patient is in doubt, as poor vision can have a devastating effect on quality of life in those who recover. Thirteen cases in nine patients are reported in this series which occurred in three different units in this region.

There are many potential causative organisms of bacterial keratitis and it is important to prevent infection with any pathogen. The organism responsible both for the majority and for the most serious infections in this and other series,[1–4] however, was *Pseudomonas aeruginosa*. This characteristically causes a devastating and rapid keratitis,[7 8] that may lead to corneal thinning and perforation (Table 2). For this reason microbiological data on pseudomonas were analysed from unit A, on which most cases occurred.

To confirm a statistically significant reduction in bacterial keratitis rates before and after the adoption of the revised guidelines, a very large sample analysed over a long period

Table 4 Results for unit A

Source	*Pseudomonas isolates per total no of patients* treated on unit*			*No of patients who had swab tested per total no of patients* treated on unit*			*Pseudomonas isolates per no of patients who had swab tested*		
	Period 1	*Period 2*	*Fisher's exact test*	*Period 1*	*Period 2*	*χ^2 test*	*Period 1*	*Period 2*	*Fisher's exact test*
Conjunctiva	0.8% (19/2430)	0.050% (2/4032)	p<0.001	3% (73/2430)	0.97% (39/4032)	p=<0.001	26% (19/73)	5.1% (2/39)	p=0.015
Respiratory tract†		3.8% (153/4032)							

*Figures for total number of patients treated calculated from weekly totals.
†Samples did not specify location of patients accurately in period 1; location of all conjunctival samples verified from clinical notes.

would be necessary as bacterial keratitis as a proportion of patients treated is rare. However, in common with the other series,[1–4] the majority of patients were colonised with the pathogenic organism in the period immediately before the keratitis developed (Table 2). Consequently, a comparison of the background incidence, colonisation, and ocular isolation rates between the two periods does give an indication of the effectiveness of eye care in preventing the spread of the organism from exogenous and endogenous sources to the eyes. After the introduction of the revised guidelines, despite a relatively high proportion of patients with respiratory tract pseudomonas isolates, there were fewer conjunctival isolates in all patients treated on unit A. Additionally, fewer patients had the clinical requirement for microbiological testing of conjunctival swabs, and of those analysed, fewer were positive for pseudomonas. All these differences are statistically significant (Table 4).

The elimination of the source of the pathogenic organisms is not realistic as long term critically ill patients have in common many risk factors for colonisation with such organisms[9–11] (Table 1). The investigation of unit A revealed that suction of the trachea had been carried out over the patients' heads. It has been shown in a prospective study that inoculation of respiratory pathogens into the eyes may occur when tracheal suctioning is carried out in such a manner.[2] As all patients with pseudomonas keratitis on this unit had prior colonisation of the oropharynx, it is logical to advise that such therapy should be carried out from the side of the bed.

The most important risk factor for bacterial keratitis in this series was corneal exposure. The resulting desiccation and corneal epithelial damage allows bacteria to adhere to damaged epithelial cells before migration into the stroma.[12 13] Ventilatory support leads to fluid retention exacerbated in these patients by cardiac or renal failure (Table 1) resulting in gross peripheral oedema and conjunctival chemosis. In patients from the burns unit, the corneal exposure resulted from eyelid damage and poor lid closure.

The application of a polyacrylamide gel substance such as Geliperm was the most common method of maintaining eyelid closure in a recent survey of intensive care units,[14] and was the method used by unit A in period 1. The manufacturers suggest that its high water content helps prevent evaporation of the tear film, that it acts as a bacterial barrier, and is heavy enough for maintaining lid closure. However, it is not sufficient alone to adequately maintain lid closure when there is marked conjunctival chemosis, and it is possible for the gauze to cause a corneal abrasion if the gel is allowed to dry. There is as yet no published clinical trial on the use of Geliperm for eye care in intensive care units.

Another method of maintaining lid closure is by placing securing tape in a horizontal position over the closed eyelids.[15] This was the recommended procedure on unit A for period 2. However, this may cause irritation to the skin and it may be difficult to obtain adequate lid closure, particularly if there is any lubricating ointment on the lids. Other methods include the use of Frost sutures or cling wrap. The authors have no experience with cling wrap, but a possible advantage may be that it forms a moist chamber and so protects the cornea even when marked exposure is present. There is an urgent need for a prospective study on the most effective method of preventing corneal exposure on intensive care units.

The recommendations made to unit A are given in Table 3, and these have been effective in reducing the spread of pseudomonas to the eyes. These are not, however, intended to be definitive. In particular, although the early use of gentamicin should prevent the infection becoming established, resistance may be encouraged. There is a need for other units to be made aware of the risk to eyesight particularly in the presence of corneal exposure, and for evidence based nationally agreed guidelines for the eye care of critically ill patients to prevent further cases of this potentially serious problem.

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