ORIGINAL ARTICLE

Culture-Proven Bacterial Keratitis in a Malaysian General Hospital

S H Hooi, FRCS*, S T Hooi, FRCS**

*Department of Ophthalmology, Hospital Sultanah Aminah, Johor Bahru, **Department of Ophthalmology, Hospital Sultan Ismail, Jalan Persiaran Mutiara Emas Utama, Taman Mount Austin, 81100 Johor Bahru

Summary

One hundred patients (101 eyes) with culture-proven bacterial keratitis were treated in the Department of Ophthalmology, Hospital Sultanah Aminah, Johor Bahru, over a 4-year period. The majority of patients was male (63%), Malay (60%), from the Johor Bahru district (62%) and aged between 41 to 50 years (20%). The ocular predisposing factors were ocular trauma (41 eyes), ocular surface disease (28 eyes) and contact lens wear (26 eyes). The corneal ulcers were mainly large (50.5%), central (59.4%) and colonized by Gram-negative bacteria (78.1%). The most frequently isolated microorganisms were *Pseudomonas aeruginosa* (67 eyes), *Staphylococcus aureus* (12 eyes), *Acinetobacter baumanii* (6 eyes), *Klebsiella pneumoniae* (5 eyes), *Corynebacterium* sp. (3 eyes) and *Streptococcus pneumoniae* (3 eyes). Twelve eyes (11.8%) had polymicrobial infection. A good visual outcome occurred in 52.5% of eyes analysed. Prognostic factors for visual outcome include presenting Snellen visual acuity, time to presentation after onset of ocular symptoms, ocular predisposing factor, corneal ulcer location and corneal ulcer size.

Key Words: Corneal Ulcer, Infective Keratitis, Bacterial Keratitis, Aetiology, Malaysia

Introduction

Corneal ulcers are an important worldwide cause of visual morbidity. Studies on corneal ulcers in developed and developing countries show considerable differences in the types and frequency of causative microorganisms in their respective communities.

Little published data is currently available on bacterial corneal ulcers (bacterial keratitis) in Malaysia. This study investigates the aetiology of bacterial keratitis and the pattern of microorganisms causing bacterial keratitis in patients seen in the Department of Ophthalmology in Hospital Sultanah Aminah, Johor Bahru (HSAJB), over a 4-year period, in order to improve upon empirical therapy for the condition. Hospital Sultanah Aminah is a 989-bed general hospital[1] and the tertiary referral centre for Johor state (population 2.74 million[2]). The Ophthalmology Department is the second largest in the government sector in Malaysia.

Materials and Methods

A retrospective study was done on all patients treated for culture-proven bacterial keratitis in the Department of Ophthalmology in Hospital Sultanah Aminah, Johor Bahru, between 1st January 1999 and 31st December 2002. A corneal ulcer was defined as a corneal epithelial defect associated with an underlying stromal infiltrate. The corneal ulcer was deemed to be culture-proven bacterial keratitis if scrapings taken from the ulcer yielded bacterial colonies when cultured.

Patients with culture-proven bacterial keratitis were identified from the outpatient and inpatient records in

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Corresponding Author: Hooi Siew Tong, Department of Ophthalmology, Hospital Sultan Ismail, Jalan Persiaran Mutiara Emas Utama, Taman Mount Austin, 81100 Johor Bahru

the Department of Ophthalmology and from patient records in the Department of Microbiology in HSAJB and their case notes were retrieved.

Patients with culture-proven bacterial keratitis had details recorded including sex, race, age, district of origin, referral source, duration of inpatient stay, outpatient attendance, time to presentation after the onset of ocular symptoms (time to presentation), ocular and non-ocular predisposing factors, presenting Snellen visual acuity, ulcer location and size, treatment regime, causative microorganism(s) and visual outcome.

The patient's Snellen visual acuity was graded as good (6/6 to 6/12), moderately impaired (6/18 to 6/60) or severely impaired (5/60 or worse). The corneal ulcer was deemed to be central if the corneal visual axis was within the ulcer margin, and peripheral if the corneal visual axis was outside it's margin. The maximum ulcer diameter was measured prior to scraping and treatment to determine it's size; a small ulcer was defined as one with a maximum diameter of less than 2 millimetres, a medium ulcer was defined as one with a maximum diameter of between 2 and 4 millimetres and a large ulcer was defined as one with a diameter of greater than 4 millimetres.

The corneal ulcers were scraped and the scrapings were sent for Gram-stain and wet mount microscopy; the scrapings were also directly plated onto blood agar and Sabouraud's agar plates for culture and antibiotic sensitivity testing.

Patients were commenced on intensive topical ceftazidime 5% eyedrops and topical fortified gentamicin 1.5% eyedrops. Other antibiotic eyedrops used during the course of treatment included chloramphenicol 1% eyedrops, ciprofloxacin 0.3% eyedrops and penicillin G 5% eyedrops depending on the attending ophthalmologist. The treatment regime was modified as necessary depending on the culture results and the clinical response to the antibiotics.

Patients followed up for a minimum of 30 days were analysed for factors affecting visual outcome. A good visual outcome was defined as a Snellen visual acuity of 6/60 or better while a poor visual outcome was defined as a Snellen visual acuity of 5/60 or worse.

Discontinuous variables were tested using the chi-square test or the Fisher exact test. Non-parametric medians were compared using the MannWhitney U test or the Kruskal-Wallis test where appropriate. Statistical significance was defined as a probability (p) value of less than 0.05.

Results

A total of 100 patients (101 eyes) were included in the study. There were 63 males and 37 females. The ethnic distribution of the patients was 60 Malays, 32 Chinese, 2 Indians, 1 Iban and 5 Indonesians. The left eye alone was involved in 50 patients, the right eye alone was involved in 49 patients and one patient had bilateral ocular involvement secondary to thyroid exophthalmopathy.

Figure 1 illustrates the age distribution of the patients. The peak age range was 41 to 50 years (20%) and the mean age was 41.4 years (range 28 days to 86 years). Seventy-five patients were in the economically active 15 to 64 years old age range. Five patients were under 12 years old.

Figure 2 illustrates the district of origin of the patients. The majority (62%) of patients were from the Johor Bahru district. All 8 districts of Johor state were represented with the exception of Muar district.

Seventy-seven patients were referred from government medical practitioners while the rest were referred by private practitioners. Two patients refused hospital admission and were treated as outpatients; all other patients were treated as inpatients. The 98 inpatients were responsible for a total of 1724 inpatient days (mean 17.6 days, median 15 days, mode 5 days, range 1 to 89 days). Patients with contact lens-related bacterial keratitis had a significantly shorter median duration of hospital stay compared to patients with ocular trauma-related bacterial keratitis and patients with ocular surface disease-related bacterial keratitis (8 days versus 16 days and 22 days respectively, p=0.001). The patients made a total of 418 outpatient clinic visits (median 3 visits, mode 1 visit, range 1 to 15 visits).

Figure 3 illustrates the time to presentation after onset of ocular symptoms of the patients. The patients had a mean time to presentation of 4.7 days (median 3 days, range 1 to 30 days).

Table I lists the ocular predisposing factors for the corneal ulcers. Ninety-two patients had identifiable ocular predisposing factors while 8 patients had no obvious ocular predisposing factors. Twelve eyes had more than one ocular predisposing factor. Nine patients

had diabetes mellitus and two patients were positive for the Human Immunodeficiency Virus on account of intravenous drug usage.

Table II summarises the relationship between the ocular predisposing factors and sex, median age and peak age range of incidence. Patients with ocular trauma-related bacterial keratitis tended to be middle-aged males, while contact lens-related bacterial keratitis patients tended to be young females. Patients with ocular surface disease-related bacterial keratitis tended to be elderly, with a roughly equal sex distribution.

Sixty corneal ulcers (59.4%) were central in location and 41 corneal ulcers (40.6%) were peripheral in location. At presentation, 20 corneal ulcers (19.8%) measured less than 2 mm in diameter (small ulcer), 25 corneal ulcers (24.8%) measured between 2 and 4 mm in diameter (medium ulcer) and 51 corneal ulcers (50.5%) measured more than 4 mm in diameter (large ulcer). The size measurement was not available for 5 corneal ulcers. Large ulcers were more likely to be centrally located compared to small or medium sized ulcers (78.4% versus 25.0% and 48.0% respectively, p=0.001). Ulcer size at presentation was not significantly associated with time to presentation. Corneal ulcers infected with *Pseudomonas aeruginosa* were more likely to be large compared to corneal ulcers infected with other microorganisms (60.9% versus 37.5%, p=0.03). No bacteria were noted in the Gram-stain tests on 61 corneal scrapings (60.4%). Bacteria were noted in the Gram-stain tests on 40 corneal scrapings (39.6%), and of these, 36 (90%) correlated with the microbiology culture findings.

Table III summarises the 19 different bacterial species isolated from the corneal ulcers. Gram-negative bacteria comprised the majority of microorganisms isolated (78.1%). The commonest isolates were *Pseudomonas aeruginosa* (58.8%), *Staphylococcus aureus* (10.5%), *Acinetobacter baumanii* (5.3%), *Klebsiella pneumoniae* (4.4%), *Corynebacterium* sp. (2.6%) and *Streptococcus pneumoniae* (2.6%). A total of 12 eyes (11.9%) had polymicrobial infection. There were no cases of coinfection with fungi in our series.

Pseudomonas aeruginosa was the commonest isolate in bacterial keratitis secondary to workplace-related trauma (18/26 isolates, 69.2%), home-related trauma (8/15 isolates, 53.3%), motor vehicle-related trauma (2/2 isolates, 100%) and in contact lens-related keratitis (21/33 isolates, 63.6%). This microorganism was also isolated from corneal ulcers associated with all other ocular predisposing factors except blepharitis, corneal sutures, bullous keratopathy secondary to Fuch's endothelial dystrophy and thyroid exophthalmopathy. *Staphylococcus aureus* was the commonest isolate in bacterial keratitis secondary to corneal sutures (5/6 isolates, 83.3%); this microorganism was also isolated from corneal ulcers associated with workplace-related, home-related and eyelid trauma, thyroid exophthalmopathy and bullous keratopathy secondary to Fuch's endothelial dystrophy.

Acinetobacter baumanii was isolated from corneal ulcers related to contact lens wear (3/33 isolates, 9.1%), workplace-related trauma (2/26 isolates, 7.7%) and eyelid skin infection (1/3 isolates, 33.3%).

Klebsiella pneumoniae was isolated from contact lens-related corneal ulcers (3/33 isolates, 9.1%) and corneal ulcers related to home trauma (1/15 isolates, 6.7%) and neovascular glaucoma-related bullous keratopathy (1/4 isolates, 25%).

Corynebacterium sp. was isolated from bacterial keratitis secondary to home-related trauma (1/15 isolates, 6.7%) and from corneal ulcers with exposure secondary to thyroid exophthalmopathy (2/4 isolates, 50%).

Streptococcus pneumoniae was isolated from corneal suture-related bacterial keratitis (1/6 isolates, 16.7%) and from corneal ulcers secondary to home-related trauma (2/15 isolates, 13.3%).

Table IV summarises the percentages of the microorganisms sensitive to ceftazidime, gentamicin and to either antibiotic. The majority of eyes were commenced on intensive ceftazidime eyedrops and fortified gentamicin eyedrops. The majority of bacteria isolated in the study were sensitive to either ceftazidime and/or gentamicin. *Streptococcus pneumoniae*, Group A beta-haemolytic *Streptococci* and alpha-haemolytic *Streptococci* were not sensitive either to ceftazidime or gentamicin. These microorganisms were sensitive to chloramphenicol and penicillin.

A hypopyon was present in 42 eyes (41.6%) on admission. This was not associated significantly with corneal perforation or poor visual outcome. Of these 42 eyes with a hypopyon, 31 eyes had centrally-located ulcers and 11 eyes had peripherally-located ulcers. Eyes with central ulcers were more likely to have a hypopyon at presentation than eyes with peripheral

ulcers (51.7% versus 26.8%, p=0.013). Eyes with large ulcers were also more likely to have a hypopyon at presentation than eyes with medium or small ulcers (54.9% versus 40.0% and 5.0% respectively, p=0.001).

Corneal perforation occurred in 13 eyes (12.9%). All cases of corneal perforation occurred during the course of treatment apart from one case where the corneal ulcer was perforated at presentation. The peak age range was 41 to 50 years, accounting for 5 eyes (38.5%). The most common ocular predisposing factor associated with corneal perforation was workplace-related trauma, which accounted for 5 eyes. The commonest microorganism associated with corneal perforation was *Pseudomonas aeruginosa*, accounting for 8 cases (61.5%). Other microorganisms associated with corneal perforation in this study include *Acinetobacter baumanii*, coagulase-negative *Staphylococci*, Group A beta-haemolytic *Streptococci*, *Flavobacterium sp.* and *Staphylococcus aureus*, each being responsible for 1 case. Corneal perforation was more likely to occur in patients presenting at 7 days or more after the onset of ocular symptoms compared to those presenting less than 7 days after the onset of ocular symptoms (40.0% versus 4.0%, p=0.001). The median time to presentation after onset of ocular symptoms was significantly longer in patients with corneal perforation compared to those without corneal perforation (7 days versus 3 days, p=0.001). Corneal perforation occurred more frequently in patients with a presenting Snellen visual acuity of 5/60 or worse compared to patients with a presenting Snellen visual acuity of 6/60 or better (18.6% versus 0%, p=0.018). Central corneal ulcers were more likely to perforate than peripheral ones (21.7% versus 0%, p=0.001), while large corneal ulcers were more likely to perforate than medium or small ulcers (21.6% versus 4.0% and 0% respectively, p=0.015).

One eye (1.0%) with a medium-sized central *Citrobacter diversus* corneal ulcer secondary to workplace-related trauma developed endophthalmitis. Six eyes (5.9%) were eviscerated, while 3 eyes (3.0%) underwent tectonic penetrating keratoplasty.

A total of 61 eyes that had undergone 30 or more days of follow up were analysed for visual outcome. Of these 61 eyes, 32 (52.5%) had a good visual outcome while 29 (47.5%) had a poor visual outcome. Figure 4 illustrates the visual status of the 61 eyes before and after treatment. A good visual outcome was more likely in patients who presented less than 7 days after the onset of ocular symptoms than in patients who presented at 7 days or more after symptom onset (58.7% versus 28.6%, p=0.048).

Eyes with contact lens-related bacterial keratitis were more likely to have a good visual outcome compared to eyes with ocular trauma-related bacterial keratitis and eyes with ocular surface disease-related bacterial keratitis (91.7% versus 45.5% and 47.6% respectively, p=0.02). Patients with severe visual impairment at presentation were less likely to attain a good visual outcome compared to patients with good visual acuity or moderate visual impairment on presentation (41.7% versus 100% and 85.7% respectively, p=0.005). Patients with paracentral ulcers were more likely to attain a good visual outcome than those with central ulcers (80% versus 33.3%, p=0.001), while those with small or medium-sized ulcers were more likely to have a good visual outcome than those with large ulcers (83.3% and 63.6% versus 38.2% respectively, p=0.019). One-third (1/3 cases) of eyes undergoing tectonic penetrating keratoplasty had a good visual outcome.

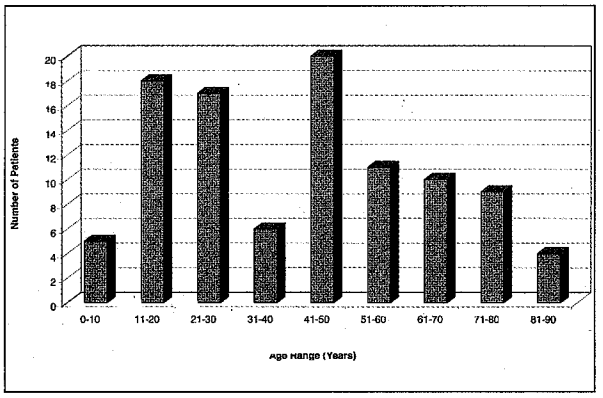

Fig. 1: Age Distribution of Patients

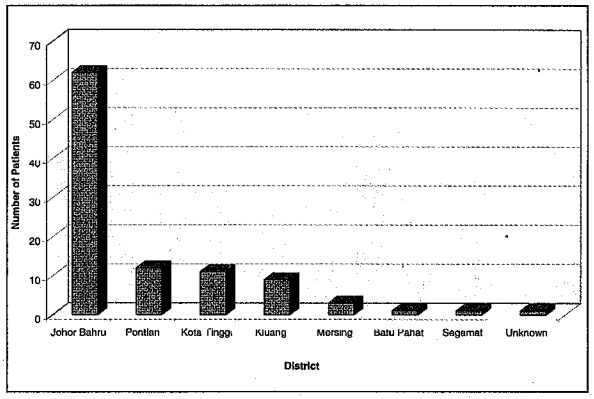

Fig. 2: District of Origin

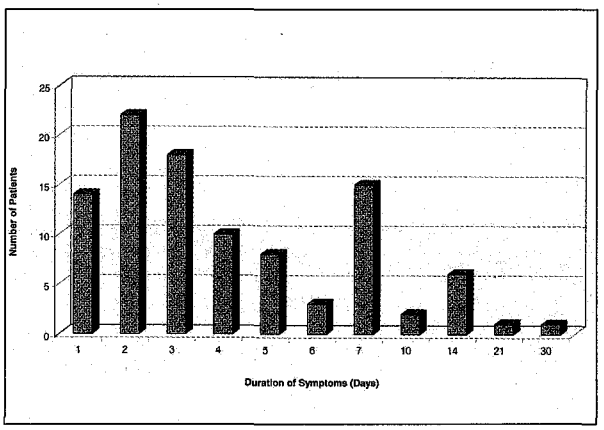

Fig. 3: Duration of Ocular Symptoms Prior to Presentation

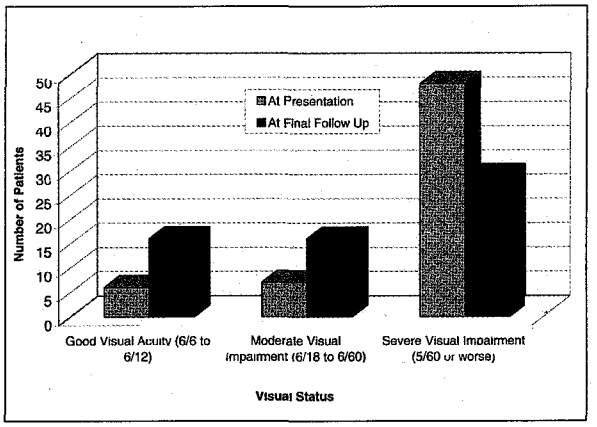

Fig. 4: Visual Status of Patient

Table I: Ocular Factors Predisposing to Culture-Proven Bacterial Keratitis

Factor	Number of Eyes
Ocular Trauma	**41**
Workplace-related Trauma	25
Home-related Trauma	14
Motor Vehicle-related Trauma	2
Ocular Surface Disease	**28**
Eyelid Pathology	
Blepharitis	5
Eyelid Skin Infection	3
Entropion	1
Trichiasis	1
Bullous Keratopathy	
Neovascular Glaucoma-related Bullous Keratopathy	4
Fuch's Endothelial Dystrophy	1
Aphakic Bullous Keratopathy	1
Pseudophakic Bullous Keratopathy	1
Corneal Sutures	
Secondary to cataract extraction	6
Exposure Keratopathy	
hyroid Exophthalmopathy	2
Eyelid Trauma	2
Facial Nerve Palsy (Leprosy)	1
Conjunctival Pathology	
Conjunctivitis	1
Contact Lens Wear	**26**
Soft contact lens wear	26

Table II: Relationship between Ocular Predisposing Factors, Sex and Age

Factor	Male/Female Ratio	Median Age (Years)	Peak Age Range (Years)
Ocular Trauma	7.2:1	44.0	41-50
Ocular Surface Disease	1.1:1	67.0	71-80
Contact Lens Wear	0.6:1	20.0	11-20

Table III: Microorganisms Cultured from the Corneal Ulcers

Microorganism	Number of Eyes
Gram-Negative Bacteria	**89**
Pseudomonas aeruginosa	67
Acinetobacter baumanii	6
Klebsiella pneumoniae	5
Klebsiella sp.	2
Enterobacter cloacae	2
Enterobacter agglomerans	1
Enterobacter gergoviae	1
Enterobacter sp.	1
Flavobacterium sp.	2
Citrobacter diversus	1
Proteus mirabilis	1
Gram-Positive Bacteria	**25**
Staphylococcus aureus	12
Coagulase-negative *Staphylococci*	2
Staphylococcus sp.	1
Corynebacterium sp.	3
Streptococcus pneumoniae	3
Group A beta-haemolytic *Streptococci*	2
Alpha-haemolytic *Streptococci*	1
Bacillus sp.	1

Table IV: Percentage of Microorganisms Isolated Sensitive to Ceftazidime, Gentamicin and to Either Antibiotic

	Percentage of Microorganisms Sensitive to:		
	Ceftazidime	Gentamicin	Either Antibiotic
Microorganism			
Pseudomonas aeruginosa	91.0	99.0	100
Acinetobacter baumanii	66.7	100	100
Klebsiella pneumoniae	100	100	100
Klebsiella sp.	50.0	100	100
Enterobacter cloacae	100	100	100
Enterobacter agglomerans	100	100	100
Enterobacter gergoviae	100	100	100
Enterobacter sp.	100	100	100
Flavobacterium sp.	100	100	100
Citrobacter diversus	100	100	100
Proteus mirabilis	100	100	100
Staphylococcus aureus	75.0	100	100
Coagulase-negative Staphylococci	100	100	100
Staphylococcus sp.	100	100	100
Corynebacterium sp.	66.7	100	100
Streptococcus pneumoniae	0	0	0
Group A beta-haemolytic Streptococci	0	0	0
Alpha haemolytic Streptococci	0	0	0
Bacillus sp.	0	100	100

Discussion

Infective keratitis is a major cause of corneal blindness resulting in significant visual morbidity in developing countries; it is estimated to cause one and a half million new cases of monocular blindness worldwide annually[3]. The annual incidence of infective keratitis has been reported to be between 11 per 100,000 population (Minnesota, United States of America[4]) and 113 per 100,000 population (Tamilnadu, India[5]). Taking into account that the population of Johor state is 2.74 million,[2] the annual incidence of corneal ulcers in the state would theoretically range between 301 and 3097 cases.

While many previous studies on infective keratitis included culture-negative cases in their analysis, this study concentrated on culture-proven bacterial keratitis in order to better quantify and qualify its characteristics. This study ascertained that the majority of patients treated for culture-proven bacterial keratitis in HSAJB between 1999 and 2002 were male, Malay, from the district of Johor Bahru and were in the 41 to 50 year old age group. The high male:female ratio of 1.7:1 in this study was probably due to the large number of males with ocular trauma-related corneal ulcers (41) seen in the study; males are, in general, more likely to sustain ocular trauma than females, an effect that starts in childhood[6-9] . The racial distribution of the patients mirrored that of the Johor state population[2]. The tendency for more patients to originate from the Johor Bahru district is due to the proximity of the hospital, the location of the majority of industrial projects in the district[10] and the fact that the majority of the population of Johor state (42%) resides in the district[2]. There are government ophthalmic clinics serving the Batu Pahat and Muar districts. The Muar Hospital ophthalmic unit also covers the Segamat district. This accounts for the lack of patients from Muar district and the small numbers from the Batu Pahat and Segamat districts. The peak in incidence of culture-positive bacterial keratitis in patients between 41 to 50 years of age was due mainly to ocular trauma-related bacterial keratitis (13/20 patients). It is uncertain why trauma-related bacterial keratitis peaked in this middle-age group, in contrast with general ocular trauma which tends to

peak earlier[11-13]; it could indicate that one's corneal immune systems may start to decline after the age of 40 years[14].

The average time to presentation was 4.7 days. This study showed that a delay in presentation had an adverse effect on visual outcome. The general public should be educated on the dangers of corneal ulcers and advised to seek medical attention urgently for ocular trauma and contact lens complications should the need arise.

Ocular trauma was the main ocular predisposing factor for bacterial keratitis in this study, the bulk of which occurred in the workplace. The provision and enforcement of the use of protective eye wear at work, particularly in vocations where fine foreign bodies are likely to enter the eye frequently such as grass cutting and motor vehicle and machinery maintenance, will help to reduce the incidence of workplace-related bacterial keratitis. The enforcement of seat belt usage[7], stricter adherence to the Highway Code and legislation requiring that all glass used in motor vehicle manufacturing be of the laminated rather than the tempered variety where possible should help to reduce the incidence of motor vehicle-related traumatic bacterial keratitis. Better supervision of children at home will also help to reduce the incidence of home-related bacterial keratitis.

Ocular surface disease was the second commonest ocular predisposing factor for bacterial keratitis. This diverse group of conditions can be better managed to reduce corneal superinfection; all patients should be counseled about the risk of infection and told to pay particular attention to personal hygiene. An ophthalmologist should supervise the use of topical corticosteroid eyedrops, if any, closely in such patients and all local and regional infections should be scrupulously treated.

A study in the United Kingdom[15] showed that 10-0 monofilament nylon corneal sutures had a rate of bacterial colonization of 38.9% when loose and a rate of 37.9% when broken compared with a rate of 6.2% when tight, intact and covered by conjunctival or corneal epithelium. As such, corneal sutures should be promptly removed when loose, broken and prior to the patient's discharge from the ophthalmic clinic.

Patients with exposure keratopathy can be treated with topical lubricants, protective eye wear, tarsorrhaphy and/or botulinum toxin-induced ptosis[16] where appropriate. Patients with eyelid malposition can be treated conservatively or surgically.

Contact lens wear was the third most common of the ocular predisposing factors in this study. In this series, all patients wore soft contact lenses. Soft contact lenses have been implicated in numerous studies in the development of bacterial keratitis, especially in the context of extended wear[17, 18], overnight wear[19] and improper care and maintenance[20] of the contact lenses. Only ophthalmologists or certified optometrists should be licensed to prescribe contact lenses to patients who should be educated on the proper care and usage of the lenses and who are willing to attend regular follow up. The problem of contact lens-related bacterial keratitis is set to grow with time, in light of the increasing incidence of myopia among younger Malaysians, especially the Chinese[21], and the increasing affluence of society in general.

Studies showed ocular trauma to be the main cause of bacterial keratitis in developing countries[22,23], comprising between 48% to 52.8% of cases seen, in contrast with studies in developed countries, which showed contact lens wear to be the main ocular predisposing factor in the development of corneal ulcers[17,24-26], comprising between 34% to 66% of cases seen . The finding that males in this study were more likely to sustain trauma-related ulcers while females in this study were more likely to sustain contact lens-related ulcers have been documented in other Asian studies[20,24]. This may reflect the tendency for Asian males as compared to Asian females to enter into vocations where the risk of trauma is increased, while Asian women may be more likely than Asian men to use contact lenses.

It is evident that a large proportion of the corneal ulcers seen were potentially preventable, especially those secondary to contact lens wear and ocular trauma. Efforts in prevention should therefore be redoubled in order to reduce the incidence of corneal ulcers and the burden they inflict on patients and on the healthcare system.

In contrast to studies in Nepal[22], Paraguay[23], France[25], Switzerland[26], the United Kingdom[27], the United States of America[28] and New Zealand[29] where Gram-positive microorganisms including *Staphylococci* and *Streptococci* tended to dominate in bacterial keratitis, comprising between 72% and 83% of isolates, our study corresponded to those done in Singapore[24] and Hong Kong[20] where Gram-negative microorganisms including

Pseudomonas aeruginosa tended to dominate in bacterial keratitis, comprising between 53% and 80.4% of isolates. This implies that treatment guidelines for bacterial keratitis produced in one location will not be applicable universally. The ubiquitous nature of *Pseudomonas aeruginosa* can be seen in its appearance in eyes with different ocular predisposing factors in this study. The predominance of Gram-negative bacilli in general and *Pseudomonas aeruginosa* in particular in contact lens-related ulcers in this study is corroborated in other studies[17,20, 24-26]. The predominance of Gram-negative bacteria in general and *Pseudomonas aeruginosa* in particular in our study population indicates that the standard ceftazidime and gentamicin eyedrops used was appropriate, as no significant resistance to this antibiotic combination in the context of bacterial keratitis had been encountered locally. Patients with *Streptococcal* ulcers had their antibiotic regimes changed to chloramphenicol and penicillin eyedrops to reflect the sensitivity of the microorganisms to those antibiotics. It is, however, important to remember that in vitro sensitivities of microorganisms to a particular antibiotic may at times not correlate with the in vivo clinical response to the antibiotic[30]; therefore therapy should be guided by clinical response as well as by antibiotic sensitivity results.

The finding that corneal perforation can occur in *Pseudomonal* and *Staphylococcal* corneal ulcers has previously been documented[31]. The tendency for the corneal ulcers of patients with a presenting Snellen visual acuity of 5/60 or worse to perforate probably reflected the degree of disruption of the corneal architecture by the offending microorganism and/or the ocular predisposing factor at the point of presentation. The healthy cornea normally has a thickness ranging from 0.5mm centrally to 1.2 mm peripherally; it is therefore not surprising that central corneal ulcers were more likely to perforate than peripherally located ones. A longer time to presentation was found to predispose to corneal perforation in this study; time to presentation was, however, not significantly associated with ulcer size. Perhaps a longer time to presentation enabled the offending microorganisms to invade to a deeper corneal depth and hence perforate the respective corneas.

Only 52.5% of patients attained a good visual outcome. The knowledge that the visual acuity at presentation, time to presentation, ocular predisposing factors, ulcer location and ulcer size affect visual outcome can be used when counseling patients with culture-proven bacterial keratitis in future. In view of the fact that three-quarters of those affected were in the economically active 15 to 64 years old age group, efforts should be made in the prevention of corneal ulcers in order to reduce the socioeconomic burden of the condition on individuals and their families.

Conclusion

In conclusion, this study in HSAJB demonstrated that culture-proven bacterial keratitis mainly affected middle-aged males who sustained ocular trauma. Gram-negative bacteria in general and *Pseudomonas aeruginosa* in particular were the most common microorganisms isolated. Public education on the prevention of corneal ulcers should be encouraged to reduce the impact of bacterial keratitis on individuals and on the healthcare system.

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