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Aerobic, anaerobic and fungal burn wound infections

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Summary: One hundred and twenty-seven patients were studied prospectively for aerobic, anaerobic and fungal burn wound infections. All cases yielded organisms on culture. A total of 377 isolates were recovered (239 aerobes, 116 anaerobes and 22 fungi). Aerobic bacteria alone were present in 49 patients (38·6%). Anaerobic bacteria alone were present in four patients (3·2%). *Candida* sp. alone was present in one patient (0·8%). Mixed aerobic and/or anaerobic bacteria and/or fungi were present in 73 patients (57·5%). Fungi were isolated from 21 patients (23·9%) of 88 patients having fungal cultures. The predominant isolates recovered in descending order of frequency were: *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Bacteroides* sp., *Klebsiella* sp. and *Peptostreptococcus* sp. There were 70 patients (55·1%) infected with anaerobic bacteria. The rate of recovery of anaerobes was higher in patients with open wound dressings (72·7%) than in patients with occlusive wound dressings (41·7%), ($P<0·01$). Seventeen patients presented with septic shock, 15 of them (88·2%) yielding positive anaerobic cultures. *Bacteroides* sp. were isolated from 14 patients with septic shock, and were recovered from the four patients who had anaerobic infection alone. These results indicate a significant role of *Bacteroides* sp. in burn wound sepsis.

Keywords: Burns; burns microbiology; burn infections; anaerobic infection; fungal infection.

Introduction

Wound sepsis remains one of the major causes of morbidity and mortality in patients with burns.[1] The surface of every burn wound is contaminated to some degree by bacteria.[2] Because of this, surface bacterial growth is routinely monitored in most centres to facilitate management and treatment. It has been found by many investigators that the distribution of various species of bacteria from burn wound surfaces is similar to that from blood specimens or from biopsy cultures.[3,4] There are multiple factors that render burn wounds susceptible to infection with anaerobic organisms. The wounds themselves are composed of necrotic, relatively avascular tissue from which

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anaerobes are frequently encountered in other clinical settings.[5] The aim of this study was to investigate the prevalence and role of anaerobes in patients with burn wound infection.

Patients and methods

A prospective study was conducted of 127 patients admitted to the burn units at three medical centres between 15 March 1996 and 20 November 1996. The mean age was 20 years (range 1–67 years); 58 were males and 69 were females. The burn accidents happened in the home (107), at work (11) and in the street (9). The burns were caused by various agents: fire (94), hot liquid (22) and electricity (11). The mean total body surface area burned was 45% (range 7–80%). Only cases with clinical signs of burn wound sepsis were included in this study. Complications included 64 patients who had fever at the time of specimen collection and 17 had septic shock. Other cases had marked subeschar suppuration, black or dark brown discolouration of the wound, or a violaceous and oedematous wound margin. Seventy-two patients were treated by occlusive dressing and 55 patients were treated by open dressing. Topical antimicrobial agents were used in 108 patients, and systemic agents in 114. The specimens were collected by cotton swabs from subeschar exudates. At the bedside, these specimens were immediately inoculated on pre-reduced selective and non-selective culture media and incubated under anaerobic conditions in a 'GasPak' anaerobic jar (BBL). This procedure avoided the use of transport media and prevented delayed inoculation. The following media were used for isolation of anaerobes: sheep blood (5%) agar, vitamin K1-enriched brucella laked blood agar, *Bacteroides* bile esculin agar and phenylethanol sheep blood agar. The following media were used for isolation of aerobes: sheep blood (5%) agar, chocolate agar (incubated in 5–10% CO_2), MacConkey's agar and phenylethanol agar (for inhibition of aerobic Gram-negative bacilli). Sabouraud's agar supplemented with gentamicin and chloramphenicol was used for isolation of fungi. The specimens for fungal culture were collected either as a piece of tissue (nearly 0·5 g in weight) or from subeschar exudate by a cotton swab. Microbial growth was determined semi-quantitatively. Moderate or heavy growth was regarded as a positive culture, whereas sparse growth (few colonies) was regarded as a negative culture. Aerobes, anaerobes and fungi were identified using conventional methods.[6,7]

Results

Organisms were recovered from all 127 patients. A total of 377 isolates were isolated (239 aerobes, 116 anaerobes and 22 fungi). Aerobic bacteria alone were present in 49 patients (38·6%), mixed aerobic and/or anaerobic bacteria and/or fungi were present in 73 patients (57·48%). Fungi were

Table I. *Organisms isolated on culture*

Organism	Number isolated (%)
Aerobic bacteria	
Pseudomonas aeruginosa	72 (19·1)
Staphylococcus aureus	71 (18·8)
Klebsiella sp.	40 (10·6)
Proteus sp.	14 (3·7)
Escherichia coli	11 (2·9)
Staphylococcus epidermidis	11 (2·9)
Streptococcus Gr. D	6 (1.6)
Enterobacteriaceae	5 (1·3)
Bacillus sp.	5 (1·3)
Streptococcus pyogenes	4 (1·1)
Anaerobic bacteria	
Pigmented *Bacteroides*	33 (8·7)
Bacteroides fragilis	27 (7·2)
Peptostreptococcus anaerobius	20 (5·3)
Peptostreptococcus micros	9 (2·4)
Propionibacterium acnes	6 (1·6)
Veillonella sp.	5 (1·3)
Bacteroides ureolyticus	4 (1·1)
Fusobacterium nucleatum	3 (0·8)
Fusobacterium mortiferum	2 (0·5)
Bacteroides sp.	2 (0·5)
Clostridium perfringens	2 (0·5)
Clostridium tetani	1 (0·3)
Lactobacillus sp.	1 (0·3)
Eubacterium sp.	1 (0·3)
Fungi	
Aspergillus niger	7 (1·8)
Candida sp.	5 (1·3)
Zygomycetes	3 (0·8)
Aspergillus flavus	2 (0·5)
Aspergillus terreus	2 (0·5)
Penicillium sp.	2 (0·5)
Aspergillus fumigatus	1 (0·3)
Total	377 (100)

isolated from 21 patients (23·86%) out of 88 patients who had fungal cultures. All the fungi were mixed with bacteria except for one patient who was infected with *Candida* sp. alone. Seventeen patients presented with septic shock; 15 of them (88·23%) had positive wound cultures of anaerobes (one or two isolates of *Bacteroides* sp. were recovered from 14 patients). Seventy patients were infected with anaerobic organisms (55·12%). Of the 72 patients managed by occlusive dressing, 30 (41·66%) were infected with anaerobic bacteria, while of the other 55 patients who were managed by open dressing, 40 (72·72%) were infected with anaerobic bacteria. This difference was statistically significant ($X^2 = 12{\cdot}16$, $P < 0{\cdot}01$). The predominant aerobic organisms recovered in descending order of frequency were (Table I): *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Klebsiella*

sp. and *Proteus* sp. The predominant anaerobes isolated were: pigmented *Bacteroides*, *Bacteroides fragilis*, *Peptostreptococcus anaerobius* and *Peptostreptococcus micros*. The predominant fungi were *Aspergillus* sp. The infection was monomicrobial in 17 patients (13·4%), while the remaining cases yielded polymicrobial infection. *Pseudomonas aeruginosa* was the most common isolate (72), followed by *Staphylococcus aureus* (71), *Bacteroides* sp. (66), *Klebsiella* sp. (40) and *Peptostreptococcus* sp. (29). Four patients (3.2%) were infected with anaerobic organisms alone. All of them were infected with *B. fragilis*. Three patients were also infected with pigmented *Bacteroides* and two with *P. anaerobius* (Table II).

Discussion

The most common aerobic organisms isolated from burn wounds in this study were *Ps. aeruginosa* and *S. aureus*. This is similar to results from previous studies.[3,8–10] *Aspergillus* sp. were the most common fungal isolates, and this concurs with previous reports.[11,12] In this study, anaerobic bacteria were isolated from 70 patients (55·1%). This high rate of recovery of anaerobes was related to the care taken during the collection and cultivation of the specimens. The specimens were taken from subeschar exudate rather than from the superficial pus. This was because the superficial pus is exposed to the lethal effect of oxygen on anaerobes. In addition, the specimens were inoculated immediately, by the bedside, on pre-reduced media and then placed in anaerobic incubation jars. This avoided the usual problems of transport delay which might lead to loss of anaerobic isolates. *Bacteroides* sp. were found to be the third most frequent isolates (following *Ps. aruginosa* and *S. aureus*). They were isolated from 14 patients with septic shock. In addition, all of the four patients who had anaerobic bacteria alone in their burn wounds were infected with *Bacteroides* sp. (two of them infected with *Bacteroides* sp. only). This indicates the significant role of *Bacteroides* sp. in producing burn wound sepsis.

The isolation rate of anaerobes in the present work was higher than that found by Brook and Randolph,[13] who found anaerobes in 29% of burn wound specimens. Zhang[14] reported anaerobes in 38·7% of subeschar exudate specimens.

In several other large studies involving a total of 5379 patients with burn wound sepsis, no cases were attributed to anaerobic infection.[8–10,15–17] However, anaerobic cultivation was not performed routinely for every case in these studies, and when it was, the techniques used were generally suboptimal.

In the present study, the rate of recovery of anaerobic organisms was found to be higher in cases of open dressing method (72·7%) than in cases of occlusive dressing method (41·7%) and the difference was statistically significant ($P<0·01$). This may be because in open dressing there is drying of the burn wound which leads to progressive thrombosis of previously

Table II. *Data for four patients with anaerobic burn wound infection alone*

Case no.	Burn site	*Temp. (°C)	Burned body surface (%)	Degree of burn	Dressing	Culture
1	Trunk	38	20	1st & 2nd	Open	*Bacteroides fragilis* Pigmented *Bacteroides* *Peptostreptococcus anaerobius*
2	Trunk	38·5	30	1st & 2nd	Open	*Bacteroides fragilis* Pigmented *Bacteroides*
3	Lower limb	38·2	15	1st & 2nd	Open	*Bacteroides fragilis* Pigmented *Bacteroides* *Peptostreptococcus anaerobius*
4	Trunk	37·5	20	1st & 2nd	Closed	*Bacteroides fragilis*

* Temperature at time of specimen collection.

intact vasculature,[18] tissue dehydration, cell death and decreased breakdown of dead tissue and fibrin.[19] All these changes tend to produce an environment that will encourage the growth of anaerobes. In view of the findings of the present study, it is recommended that burn wounds should be managed by occlusive rather than open dressings. This supports the findings of many investigators who have found that occlusive dressings are beneficial in speeding the rate and quality of wound healing.[19–23] It is concluded from the present study that anaerobic bacteria play an important role in burn wound infection and their prevalence is higher than was previously recognized. Anaerobic infections should be taken into account in the management of burned patients.

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