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For further information about this article or if you need reprints, please contact:

Dr. R. Yousefi-Mashouf
Department of
Medical Microbiology,
Faculty of Medicine,
Hamedan University
of Medical Sciences,
Shahid Fahmideh Street,
Hamedan, Iran

Tel: +98 811 8223109
Fax: +98 811 8246299

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The Epidemiology of Burn Wound Infections in Patients Hospitalized in Burn Center of Hamedan, Western Iran

¹Rasoul Yousefi-Mashouf and ²Seyyed Hamid Hashemi

A total of 465 burned patients with wound infections who admitted to referral burns center of Hamedan Imam Khomeiny hospital from July 1998 to June 2001 were retrospectively studied. The required data including age, sex, season, causes of burns, burn size of wounds and types of organisms isolated from patients (wounds and blood), was recorded in a questionnaire. The susceptibility of the isolates to eight routine antibiotics was tested by disc diffusion method. The data was analyzed by SPSS and EP16 software package. Out of 465 burn wound infections 73.1% of isolates were Gram-negative bacilli and 26.9% were Gram-positive cocci. *Pseudomonas aeruginosa* (32.7%), *Klebsiella pneumoniae* (21.8%) and *Staphylococcus aureus* (21.2%) were the most common isolates. In 28.7% of patients, blood culture became positive, *Klebsiella pneumoniae* (30.4%), *Pseudomonas aeruginosa* (26.9%), were predominant isolates. 57.3% of patients were males and the most frequency of burn patients belonged to age group 0-9 years old (28.6%), most of the burns occurred during summer. Boiled water, fuel oil flames and firewood flames were the commonest causative agent for burns, respectively. The most effective antibiotics against isolates were ciprofloxacin, ceftizoxime, amikacin and gentamicin, while most of isolates showed high resistance to ampicillin, tetracycline and carbenicillin. Present results indicated that *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Staphylococcus aureus* were predominant isolates with high resistance to tested antibiotics. These data can be used to evaluate the effects of changes in burn treatment and antimicrobial resistance development in relation to antibiotic usage.

Key words: Burns, epidemiology, bacteriology, wound infections, drug-resistance

¹Department of Medical Microbiology,
Hamedan University of Medical Sciences, Hamedan, Iran

²Department of Infectious Disease, Sina Hospital,
Hamedan University of Medical Sciences, Hamedan, Iran

INTRODUCTION

Burn is one of the most common incidents that hurts skin and create different types of wound infections. In addition to loss of the natural cutaneous barrier to infection, coagulated proteins and other microbial nutrients in the burn wound lead to microbial colonization. Infection is the major complication in burns and it has been estimated that about 75% of the mortality associated with burn injuries is related to infection (Heimbach, 1999). The wounds can become infected with different types of the organisms and these are increasing in their resistance to antibiotics. The treatment of these infections is one of the most difficult processes to help recovery of patients (Deitch, 1990).

Understanding the epidemiology of the infecting organisms in these patients with burn wound infection is important because of immunosuppression and resultant severe complications such as septicemia and pneumonia (Pruitt *et al.*, 1998; O'Sullivan and O'Connor, 1997).

Nosocomial infections and cross-infections caused by multi-drugs resistant bacteria such as *Pseudomonas aeruginosa* and *Staphylococcus aureus* in patients who hospitalized in burns units are the other problems of the patients (Prasanna and Thomas, 1998; Shanson, 1981; Pavillard *et al.*, 1982; Karimi *et al.*, 2002). In a study, *Pseudomonas aeruginosa* (52.9%) and *Staphylococcus aureus* (25.5%) were most prevalent isolates (Shankowsky *et al.*, 1994). In another research, tissue biopsy specimens were examined histopathologically and 231 *Pseudomonas aeruginosa* were isolated from hospitalized patients. The results showed that the most patients were infected by 1-3 different serotypes of *Pseudomonas* (Schlenger *et al.*, 1994). *Pseudomonas aeruginosa* is the most common isolated organism from blood of patients with burn wound infection (Karimi, 2002; Tredget *et al.*, 1992). *Staphylococcus aureus* is other organism that causes septicemia especially because of intravenous colonization of organism (Prasanna and Thomas, 1998; Pavillard *et al.*, 1982; Pegg, 1992). The incidence of burn wound sepsis has been related to burn size, burn depth and patient age.

Regarding to importance of burn wound infections and causes of burns, the aims of the present study were to assess the causes of burns, epidemiological factors of burn patients, determination of frequency of the organisms isolated from infected burn wounds and blood cultures and effectiveness of current antibiotics against isolates, during a 3 years period in a main referral burn center of Hamedan, the west of Iran.

MATERIALS AND METHODS

A total of 465 burned patients with wound infections who admitted to referral burns center of Hamedan Imam

Khomeiny hospital during a 36-month period from July 1998 to June 2001 were retrospectively studied. This burn-center had followed strictly all measures of infection control and allowed access to only the required numbers of medical and paramedical staffs. The required data of the burn patients including age, sex, season, causes of burns, burn size of wounds, manner (way) of burning based on intentional (on purpose) or unintentional (casually), places of burning on body and types of microorganisms isolated from burn wounds discharge and blood cultures, were recorded in a special questionnaire and then analyzed using EP1 INFO 6 software package.

The sampling of wound discharge of each patient was done to culture at two times to make sure of growing any pathogenic microorganisms. Blood cultures were also taken immediately after getting positive culture of wounds infections. Cultivation and isolation of organisms were performed according to the methods outlined in the Bailey and Scott's Diagnostic Microbiology (Baron and Finegold, 1990). Specimens were cultured on appropriated culture media including Chocolate agar, Blood agar (Merck, Germany) and Eosin Methylene Blue (EMB) agar (ANTEC, ATD, Germany). The cultures were incubated in 37°C for 24-48 h and then the colonies were removed for further studying. Biochemical and antigenic properties of isolates were verified for identification purposes (Koneman *et al.*, 1997). In essential cases, specific antiserum against bacteria was used for precise identification of bacteria type. In order to detection of the susceptibility of isolates to routine antimicrobial drugs, the all isolates were tested by disc diffusion (Kirby-Bauer) method (Bauer *et al.*, 1966). Eight antibiotics including carbenicillin (100 µg), tetracycline (30 µg), ciprofloxacin (5 µg), amikacin (30 µg), ceftizoxime (30 µg), gentamicin (10 µg), ampicillin (10 µg) and cephalixin (30 µg) were used.

RESULTS

During this study, 465 patients with suspected burn wound infections had their wounds sampled twice. In total, 538 pathogenic and opportunistic bacteria were identified. Single isolates were found in 82.3% of specimens and 17.3% of specimens also yielded double and triple isolates, respectively. In all, 393 isolates (73.1%) were Gram-negative bacilli and 145 (26.9%) were Gram-positive cocci, respectively. *Pseudomonas aeruginosa* (32.7%) and *Klebsiella pneumoniae* (21.8%) were the most predominant bacteria, which isolated from burn wound infections (Table 1).

In 133 patients (28.7%), their blood culture became positive for single isolates only. Frequency distribution of organisms that isolated from bloods of burned patients is shown in Table 2. The most important isolates were

Table 1: Frequency distribution of isolated microorganisms from burned patient with wound discharges

Isolates	Frequency of isolates	Percentage
<i>Pseudomonas aeruginosa</i>	176	32.7
<i>Klebsiella pneumoniae</i>	117	21.8
<i>Staphylococcus aureus</i>	114	21.2
<i>Staphylococcus epidermidis</i>	27	5.1
<i>Proteus mirabilis</i>	25	4.7
<i>Escherichia coli</i>	21	3.9
<i>Klebsiella oxytoca</i>	19	3.6
<i>Citrobacter freundii</i>	13	2.4
<i>Enterobacter agglomerans</i>	10	1.6
<i>Proteus vulgaris</i>	6	1.1
<i>Enterococci</i> spp.	3	0.6
Other isolates	7	1.3
Total	538	100.0

Table 2: Frequency distribution of organisms that were isolated from bloods of burned patients with wound infections

Isolates	Frequency of isolates	Percentage
<i>Klebsiella pneumoniae</i>	40	30.4
<i>Pseudomonas aeruginosa</i>	36	26.9
<i>Escherichia coli</i>	22	16.5
<i>Staphylococcus epidermidis</i>	16	12.1
<i>Staphylococcus aureus</i>	8	6.2
Other isolates	10	7.6
Total	133	100.0

Table 3: The frequency distribution of age groups of burned patients

Age groups	Frequency	Percentage
0-9	133	28.6
10-19	71	15.3
20-29	92	19.7
30-39	42	9.1
40-49	24	5.1
> 50	103	22.1
Total	465	100.0

Table 4 : The frequency distribution of the causes of burns in patients

Causes of burns	Frequency	Percentage
Boiled water	109	23.4
Oil fuel flames	67	14.5
Firewood flames	52	11.1
Fire by gas flames	51	10.9
Fire by gasoline flames	45	9.6
Burned chemical agents	41	8.9
Fire by cloths	17	3.6
Hot liquids	14	3.1
Explosive agents	8	1.7
Electrical shock	4	0.9
Hot tar	3	0.7
Bread oven	2	0.4
Other cases	52	11.1
Total	465	100.0

Table 5 : Antibiotic susceptibility patterns of isolates that were isolated from wound infections

Isolate	Frequency of susceptibility to antibiotics (%)							
	CP*	AN	GM	CT	CB	CF	TE	AM
<i>Pseudomonas aeruginosa</i>	88	68	21	79	12	38	14	0
<i>Klebsiella</i> spp.	92	70	28	87	16	47	25	7
<i>Staphylococcus aureus</i>	89	62	68	82	47	22	6	4
<i>Staphylococcus epidermidis</i>	88	59	71	78	32	31	9	9
<i>Proteus</i> spp.	92	49	58	96	8	17	21	11
<i>Escherichia coli</i>	91	36	61	86	32	42	19	18
<i>Citrobacter freundii</i>	94	72	87	92	12	52	28	39
<i>Enterobacter agglomerans</i>	89	78	82	74	19	48	32	19
<i>Enterococci</i> spp.	88	42	58	89	17	49	23	4

*: CP = Ciprofloxacin, AN = Amikacin, GM = Gentamicin, CT = Ceftizoxime, CB = Carbenicillin, CF = Cephalexin, TE = Tetracycline, AM = Ampicillin

Klebsiella pneumoniae (30.4%) and followed by *Pseudomonas aeruginosa* (26.8%).

Out of 465 infected patients, 57.3% were males and 42.7% were females. The most frequent patients were belonged to the 0-9 years old (28.6%). Present results showed that the most frequent burning (29.8%) was occurred during summer and then fall with frequency of 25.1% and spring 23.7%. The lowest frequency (21.4%) was belonged to winter. So, the most common time of burning of persons was during summer (Table 3).

As it is shown in Table 4, boiled water (23.4%), fuel oil flames (14.5%) and firewood flames (11.1%), were the most frequency agents of burns, respectively. Frequency of the manners of burning based on intentional or accidentally was as follow: 73.6% (342 cases) of patients were burned accidentally and 26.4% (123 cases) were intentional. Concerning to the places of burning on body, 49.3% patients had burning only in their hands or feet area or along with body and 47.4% patients in head, neck and face or along with other parts of body, in 3.3% only body was burned. In respect of burning size, in 19.4% patients, burning size was 1-10% of their bodies, 38.8, 11-30 and 41.8% over 30%.

As it is observed from Table 5, the most effective antibiotics against both gram-negative bacilli and gram-positive cocci were ciprofloxacin, ceftizoxime, amikacin and gentamicin while most of isolates showed high resistance to ampicillin, tetracycline and carbenicillin. All *Pseudomonas aeruginosa* isolated from wound infections were resistant to ampicillin. *Staphylococcus aureus* (96%) and *Klebsiella pneumoniae* (93%) were also resistant to this antibiotic.

DISCUSSION

Burn wound infections are a serious complication of thermal injury that requiring care in specialized units. In the past 2 decades, important changes in burn wound treatment have been occurred, however, the causative microorganisms of burn wound infections have been changed little (MayHall, 2003,1999). In at least

one health care center with very effective infection control, the rate of burn wound infections has markedly decreased and bacteria are less often the cause than fungi (Pruitt and McManus, 1992).

The results of this research showed that although the health special care in burn units has been developed, but the rate of secondary infections in hospitalized patients is still high. According to obtained results, 73.1% of microorganisms that causing wound infections were Gram-negative bacilli and 26.9% Gram-positive cocci, respectively, which is in contrast to the findings of Komolafe *et al.* (2003), they found 55.9% Gram-positive cocci and 44.1% of Gram-negative bacilli out of 317 specimens obtained of burns unit at the Queen Elizabeth Central Hospital, Malawi. Among Gram-negative bacilli, *Pseudomonas aeruginosa* (32.7%) was the predominant species that isolated from wounds discharges, which is in agreement with other studies (Prasanna and Thomas, 1998; Karimi *et al.*, 2002; Rastegar *et al.*, 1998; Ghanaat and Rashed, 1992). In two different studies that were performed in a main referral burn center in Tehran (in 1975 and 1999), *Pseudomonas aeruginosa* (73.9 and 57%) was the most isolate (Karimi *et al.*, 2002; Rastegar *et al.*, 1998). In other similar study that carried out in Mashhad (east of Iran), *Pseudomonas aeruginosa* and *Klebsiella pneumoniae* (34.7% and 27.6%) were reported as main causes of burn wound infections (Ghanaat and Rashed, 1992). *Klebsiella pneumoniae* (21.8%) was the second predominant species that isolated from wound infections, which is not supported by Karimi *et al.* (2002), MayHall, (2003), Komolafe *et al.* (2003) and Manson *et al.* (1992). These findings showed that Gram-negative bacilli in particular *Pseudomonas aeruginosa* plays an important role in creating burn wound infections in this region. On a general note, the time-related changes in the predominant flora of the burn wound usually from Gram-positive to Gram-negative bacteria organisms recapitulate the history of burn wound infections.

Among Gram-positive bacteria, *Staphylococcus aureus* (21.2%) was the most common species that isolated from wounds discharges, in agreement with many other investigations (Prasanna and Thomas, 1998; Schlarger *et al.*, 1994; Komolafe *et al.*, 2003; Zhang *et al.*, 1995). During three years (1989-1991) research in a burn center in China, 1116 pathogenic microorganisms were isolated that *Staphylococcus aureus* (208 isolates) and *Pseudomonas aeruginosa* (119 isolates) were most prevalent isolates, respectively (Zhang *et al.*, 1995).

One of the most important complication of burn injury is septicemia that usually leading to death (Pruitt *et al.*, 1998; Cartotto *et al.*, 1998; Manson *et al.*, 1992). In this study, 28.7% of patients had positive blood culture that

the most prevalent isolates were *Klebsiella pneumoniae* (30.4%) and *Pseudomonas aeruginosa* (26.9%), respectively. These results were compatible with the results obtained of their wound cultures. In some cases, *E. coli* was isolated from blood cultures, while other bacteria were isolated from the wound discharges of same patient.

Cartotto *et al.* (1998) compared the results of blood cultures of burn patients with results of burn wound cultures and found same isolate of *Staphylococcus aureus* that was caused bacterial acute endocarditic. Pruitt *et al.* (1998) also reported that bacterial septicemia was the most common complication in burn patients that mostly leading to death.

Present results also showed that children under 10 years old were the most age groups of burning victims (28.6%). Since most of these children are accidentally exposed to burns factors, they needed to be looked after carefully. In a retrospective survey, the effects of several factors on the time of being hospitalized of patients with extensive burning (at least 24% of body) have been investigated (Manson *et al.*, 1992). Seventy one patients with mean age of 23 years old and burn size average 40% have been studied. The length of being in hospital; has had direct relationship with burn size and patient age. Most wound infections have been created by Enterobacteriaceae sp. or accompanied with *pseudomonas* species.

The other finding of this study was the causes of burns, the most common causes of burning of patients were boiled water (23.4%) followed by fuel oil flames and firewood flames. Most of victims (73.6%) were accidentally burned and 41.8% of them also had more than 30% burn lesions on their bodies. In these conditions, drugs resistant organisms such as *Pseudomonas aeruginosa* and methicillin resistant *Staphylococcus aureus* (MRSA) are probably transferred to the burn wound surfaces and provide serious cross-infections.

Antibiotic susceptibility patterns of isolates that were isolated from wound infections showed, the most effective antibiotics were ciprofloxacin, ceftizoxime, amikacin and gentamicin. *Pseudomonas aeruginosa* and *Staphylococcus aureus* showed high resistance to many antibiotics such as tetracycline, carbenicillin, ampicillin and cephalixin. These two species mentioned above are versatile human pathogen that continues to be an important cause of nosocomial infections especially in burns units. The emergence and spread multidrug-resistance among species of *Pseudomonas aeruginosa* and *Staphylococcus aureus* has become a major concern worldwide and is seriously challenging current treatment

strategies (Karimi *et al.*, 2002; Tredget *et al.*, 1992; MayHall, 2003; Appelgren *et al.*, 2002). In agreement with many other studies (Prasanna and Thomas, 1998; Karimi *et al.*, 2002; Komolafe *et al.*, 2003; Agnihotri *et al.*, 2004), present results reveal a broad-spectrum resistance of isolates, both Gram-positive and Gram-negative organisms to majority of antibiotics used. Most isolates showed high resistance to ampicillin, tetracycline and carbenicillin.

In conclusion, the results of this study can be used to evaluate the effects of changes in burn treatment and antimicrobial resistance development in relation to antibiotic usage. Careful surveillance of infection, good isolation techniques and procedure routines and a restrictive antimicrobial policy can keep antimicrobial resistance rates and infection rates low in burn patients. We also emphasize the need to pay more attention to taking care of patients who are hospitalized in burn centers. It is therefore important to control the flow of human traffic in the burn units as well as strictly enforcing hand washing both before and after handling a patient so as to curtail the risk of cross-infections and spread of multidrug-resistant bacteria such as *Pseudomonas aeruginosa* and MRSA in patients hospitalized in burn units.

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