Can Open Fracture Debridement Improve Postoperative Wound Infection?

Ghada Barakat1*, Masrour Abdel latief2, Mohamed Mostafa2 and Mohamed Morsy2

1Department of Medical Microbiology and Immunology, Mansoura Faculty of Medicine, Egypt.
2Department of Orthopedic Surgery, Mansoura Faculty of Medicine, Egypt.

Authors’ contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

ABSTRACT

Damaged soft tissues provide an ideal environment for bacterial growth and subsequent infections. This study was to evaluate the spectrum of bacterial contamination of predebridment and postdebridment measures in patients with open fractures and to study the best timing suitable for eradication of the micro-organism in a tertiary hospital. These studies was conducted over 112 patients open fracture wound episodes with or without overt signs of infection were included in this study. A patient is considered to have an open fracture wound infection when clinical signs and symptoms of infection were present. Four swabs were taken for each patient, the first was taken as pre debridement swab, the second was post debridement swab, the third swab was after 3 days after debridement and the fourth was 7 days after debridement. Specimens were examined aerobically and anaerobically. Of the 112 wound specimens examined by Gram stain, 66.96% were positive for the presence of bacteria. The Gram-positive and Gram-negative bacteria accounted for 58.66% and 41.33%, respectively. S. aureus (44.2%) was the dominant isolate. The most effective drugs against the tested Gram-positive were amoxicillin/clavulonic acid, erythromycin, vancomycin, cefuroxime and ampicillin. Whereas, the most effective drugs against the tested Gram-negative bacteria were gentamicin, ciprofloxacin, tazocin, imipenem and...
aztreonam. Postoperative bacterial infection can be decreased if debridement was done at optimum time.

Keywords: Bacterial infection; open fracture; debridement; postoperative infection.

1. INTRODUCTION

Damaged soft tissues provide suitable medium for bacterial growth. Bacterial growth is correlated to the severity of the soft tissue injury. It is favored by long tissue ischemia and poor perfusion of muscles and periosteum that lead to tissue necrosis [1].

Open fractures were classified by Gustilo and Anderson [2] into Grade I, Grade II and Grade III. Grade III was sub classified into a, b, c. Infections in Grade I and Grade II open fractures are quite infrequent which was demonstrated by Gustilo et al. [3] but in Grade III open fractures, the overall infection rate was about 50%.

The debridement of wounds was described first by Desault [4] in the 18th century. It has since evolved to include the thorough irrigation of the fracture site by a number of different means. Irrigation and debridement is believed to be the most important factor in reducing the prevalence of infection following an open fracture [5].

Lee [6] postulated that bacterial cultures were of no predictive value regarding later infection and even in positive post debridement bacterial cultures only 42% resulted in infections. However, Kreder and Armstrong [7] reported that predebridement bacterial culture were highly sensitive (88%) in identifying wounds developing infection but their specificity was as low as 42%.

Treatment for open fractures is controversy. It usually involves wound debridement with irrigation, intravenous antibiotics, good coverage for the bone and soft tissue, and adequate rigid stabilization [8-10].

This study aimed to evaluate the spectrum of bacterial contamination pre and post debridement in patients with open fractures in a tertiary hospital and to study the best timing suitable for eradication of the micro-organism and if it is effective to decrease the postoperative infections or of no value.

2. PATIENTS AND METHODS

A cross-sectional prospective study was conducted in the Medical Microbiology and Infection Control Unit (MMICU) for patients admitted to the Orthopedic Surgery Department at Mansoura University Hospital and Mansoura Emergency Hospital (MEH), Egypt. MEH represented the highest tertiary level for referred patients in the region. It was conducted in the period from December 2012 to December 2013. One hundred and twelve patients with open fracture wound episodes with or without overt signs of infection were enrolled in this study. A patient was considered to have an open fracture wound infection when clinical signs and symptoms of infection, such as fever >38.5°C, erythema, tenderness, pain, and wound drainage were present along with either a positive Gram stain or a positive culture [11-13]. Delay in wound healing and offensive odor was also associated with the infected wounds [14]. There were 104 (92.9%) males and 8 (7.1%) females. Their age ranged from 9 to 83 years (Mean±SD was 32.35±16.44).

Regarding time of arrival to MEH, 41 cases (36.6%) arrived within the golden period 2-4 hours, 26 cases (23.2%) arrived after 2 hours of their injury, 24 cases (21.4%) arrived after 4-6 hours, 16 cases (14.3%) arrived after 6-8 hours and 5 cases (4.5%) arrived after 8 hours (Mean±SD was 3.83±2.05). Single open fracture occurred in 104 patients. Seven patients had two open fracture wounds and only one patient had three open fractures. According to Gustilo and Anderson (G-A) Grading of Open Fractures, there were 16 patients were with (14.3%) grade I, 33 (29.5%) patients were with grade II, 42 (37.5%) patients were with grade IIIa, 18 (16.1%) patients were with grade IIIb and 3 (2.7%) grade IIIc. Most fractures occurred in tibia/fibula (52.7%), followed by upper extremity fractures (25.9%) and the femur fractures were 21.4%.

Plain radiographs images were taken for each patient. Wound beds were prepared before specimen collection by using Levine's technique [15], where the wound surface is cleansed with moistened sterile gauze. Dressed wounds were cleansed with non-bacteriostatic sterile normal saline after removing the dressing. This technique is believed to be the best technique for swabbing open wounds and more reflective of tissue bioburden than swabs of exudates or
swabs by other techniques [16]. A sterile cotton-tipped applicator was rotated over a 1 cm² area for 5 seconds with sufficient pressure to express fluid and bacteria to surface from within the wound tissue. The applicators were applied deep into the wounds in order to avoid contaminants that are usually found on the surface of the wounds [15,16].

In this study, there were four swabs taken for each patient, the first swab was taken as pre debridement swab, the second was post debridement swab, the third swab was after 3 days from the debridement and the fourth swab was 7 days from the debridement. Specimens were transported in Amies transport medium (Oxoid Ltd, UK) to the bacteriological laboratory within an hour. The specimens that were collected during night were kept at 4°C overnight until staining and culture. Gram staining was performed for the wound swabs according to standard procedures. All wound swabs were cultured aerobically, anaerobically and for mycological culture. For aerobic cultures, the swabs were cultured on the ordinary media (blood, chocolate and MacConkey’s agars). Plates were incubated at 37°C for 48 hours. For anaerobic culture, the swabs were cultured on blood agar plate and incubated anaerobically at 37°C for 48 hours. Mycological analysis was done by direct examination and culture on Sabouraud Dextrose Agar with and without cyclohexamide and incubated at 37°C and 25°C. For positive bacterial isolates, routine biochemical reactions were done using the API system (Fig. 1). The bacterial isolates were subjected to susceptibility testing by standard Kirby Bauer disc diffusion methods. The susceptibility patterns of the bacterial isolates were detected following the antimicrobial agents panel recommended by Clinical Laboratory Standard Institute (CLSI), 2010. The diameter of the inhibition zone was measured in millimeters and interpreted according to CLSI guidelines [17] (Fig. 2).

Gram-positive bacteria were tested against amoxicillin (AML) (25 µg), amoxicillin-clavulonic acid (AMC) (30 µg), ampicillin (AMP) (10 µg), ceftriaxone (CRO) (30 µg), chloramphenicol (C) (30 µg), ciprofloxacin (CIP) (5 µg), clindamycin (DA) (2 µg), cloxacillin (OB) (5 µg), doxycycline (Do) (30 µg), erythromycin (E) (15 µg), gentamicin (CN) (10 µg), kanamycin (K) (30 µg), methicillin (MET) (5 µg), norfloxacin (NOR) (10 µg), penicillin (P) (10 units), tetracycline (TE) (30 µg), and trimethoprim-sulphamethoxazole (SXT) (25 µg).

Gram-negative bacteria were tested against amoxicillin (AML) (25 µg), amoxicillin-clavulonic acid (AMC) (30 µg), ampicillin (AMP) (10 µg), ceftriaxone (CRO) (30 µg), chloramphenicol (C) (30 µg), ciprofloxacin (CIP) (5 µg), gentamicin (CN) (10 µg), norfloxacin (NOR) (10 µg), tetracycline (TE) (30 µg), and trimethoprim-sulphamethoxazole (SXT) (25 µg).

3. DATA ENTRY AND ANALYSIS

Data entry was done by using Epilinfo-2002 software and analysis was done using both Epilinfo-2002 software and SPSS version 13.0 for windows. Pearson chi-square and Fisher exact tests analysis were used to compare categorical variables. The level of significance was set at 0.05 in order to consider a p-value <0.05 as indicator of a statistically significant difference with 95% confidence.

4. RESULTS

One hundred and twelve patients were admitted into the Orthopedic Surgery Department at Mansoura University Hospital and Mansoura Emergency Hospital (MEH), Egypt. The relation between age, grade and the first and second swabs was revealed in Table 1. The samples were sent to the Medical Microbiology and Diagnostics Unit at Medical Microbiology and Immunology Department. Direct Gram stained film and culture of the swabs revealed significant relation between patient age and bacterial growth in second swab but not the first one (Table 2).

![Fig. 1. API20E of Klebsiella pneumonia](image-url)
Fig. 2. Antibiotic sensitivity test of *Klebsiella pneumoniae*

Of the 112 wound specimens cultured, 43 swabs (38.4%) were positive in the pre debridment swabs. Of these, 40 swabs (93.02%) were monomicrobial growth and 3 swabs (6.97%) were polymicrobial growth and no bacterial growth was detected in 69(61.6%) swabs. In the post debridment swabs; there was positive culture in 24 swabs (21.4%). Of these, 18 ones (75%) were monomicrobial growth and 6 swabs (25%) were polymicrobial growth and no bacterial growth in 88 swabs (78.6%). In the third swabs that were taken three days after trauma, positive growth was only in one sample (0.9%) and no growth in 111 samples (99.1%). In the fourth swabs, positive growth was in 4 swabs (3.6%) and no bacterial growth was detected in 108 samples (96.4%) (Table 3).

In the first swabs, *S. aureus* accounted for (44.2%) of the total isolates followed by *Proteus mirabilis* (16.3%), *Klebsiella pneumoniae* (7%), *Pseudomonas aeruginosa* (7%), *Proteus vulgaris* (4.7%), *MRSA* (4.7%), *E. coli* (4.7%), *Enterococci* (2.3%) and *Staph. epidermidis* (2.3%). The bacteria isolated from the 4 swabs were revealed in Table 4.

In this study, patients aged between 9 and 83 years with a median age of 27 years. The males were 104 (92.9%) and the females were 8(7.1%). Studies by Ikem et al. [22] and Fakoor and Pipelzadeh [23], reported similar findings. In this study, 59 patients (52.7%) that were from 16- 60 years gave no bacterial growth in the first swabs and 35 patients (31.54%) were with positive bacterial growth. This might be explained by the fact that traditionally, in this country, males mainly are involved in some occupations such as the transportation, industry and construction works. Farmers and daily laborers are mostly men with very few exceptions. Males are commonly involved in assault or interpersonal violence. Consequently, more than 40% of the injury caused by road traffic accident (RTA) and interpersonal violence affected mainly males particularly those involved in economically important occupations in agriculture, transport, construction and other industries.

was changed according to culture and sensitivity testing after the second swab in 29 (25.89%) cases (Table 5).

In general, the most effective drugs against Gram-positive bacteria were amoxicillin/clavulonic acid, erythromycin, vancomycin, cefuroxime and ampicillin. The most effective drugs against Gram-negative bacteria were gentamicin, ciprofloxacin, tazocin, imipenem and aztreonam. Cefadol, ofloxacin, cefotaxime, cefepime and amoxicillin antibiotics were completely resistant to different microorganisms.

5. DISCUSSION

Open fractures are always associated with soft-tissue injury [18,19]. Wound and bone infections mainly occur in higher G-A grades of open fractures [12,18,20]. The complications of open fractures increase with increasing age of the patient [19-21]. There is no previous published report concerning the bacteriology of open fracture wounds in Mansoura Emergency Hospital (MEH). To address the problem, this study was undertaken to isolate and identify the bacterial etiologic agents in compound fracture wounds and their antimicrobial susceptibility pattern from orthopedic patients admitted to MEH, Egypt. Also we purposed to study if debridement can reduce the probability of later infection.
Table 1. Relation between age, grade and first and second swabs results

| Grade   | First swab positive growth | First swab No growth |
|---------|---------------------------|-----------------------|
|         | <16y | 16<40y | 40<60y | ≥60y | <16y | 16<40y | 40<60y | ≥60y |
|         | No   | %     | No   | %     | No   | %     | No   | %     | No   | %     | No   | %     | No   | %     |
| Grade1  | 0    | 0     | 3    | 12.0  | 0    | 0     | 3    | 60.0  | 6    | 13.0  | 4    | 30.8  | 0    | 0     |
| Grade 2 | 2    | 50.0  | 8    | 32.0  | 4    | 40.0  | 2    | 50.0  | 1    | 20.0  | 12   | 26.1  | 3    | 23.1  |
| Grade 3a| 1    | 25.0  | 7    | 28.0  | 5    | 50.0  | 1    | 25.0  | 1    | 20.0  | 21   | 45.7  | 3    | 23.1  |
| Grade 3b| 1    | 25.0  | 5    | 20.0  | 1    | 10.0  | 1    | 25.0  | 0    | 0     | 7    | 15.2  | 3    | 23.1  |
| Grade 3c| 0    | 0     | 2    | 8.0   | 0    | 0     | 0    | 0     | 0    | 0     | 0    | 0     | 1    | 20.0  |

Test of sig. p-value

\[ X^2 = 5.989 \]
\[ P = .917 \]

| Grade | Second swab positive growth | Second swab No growth |
|-------|-----------------------------|------------------------|
|       | <16y | 16<40y | 40<60y | ≥60y | <16y | 16<40y | 40<60y | ≥60y |
|       | No   | %     | No   | %     | No   | %     | No   | %     | No   | %     | No   | %     |
| Grade1 | 0    | 0     | 1    | 12.5  | 1    | 9.1   | 0    | 0     | 3    | 42.9  | 8    | 12.7  | 3    | 25.0  |
| Grade 2 | 1    | 50.0  | 4    | 50.0  | 4    | 36.4  | 1    | 33.3  | 2    | 28.6  | 16   | 25.4  | 3    | 25.0  |
| Grade 3a | 1    | 50.0  | 2    | 25.0  | 5    | 45.5  | 1    | 33.3  | 1    | 14.3  | 26   | 41.3  | 3    | 25.0  |
| Grade 3b | 0    | 0     | 1    | 12.5  | 1    | 9.1   | 1    | 33.3  | 1    | 14.3  | 11   | 17.5  | 3    | 25.0  |
| Grade 3c | 0    | 0     | 0    | 0     | 0    | 0     | 0    | 0     | 2    | 3.2   | 0    | 0     | 1    | 16.7  |

Test of sig. p-value

\[ X^2 = 2.892 \]
\[ P = .968 \]

\[ X^2 = 12.587 \]
\[ P = 0.4 \]
Table 2. Relation between patient age and bacterial growth in first and second swabs

| First swab | <16 y (9) | 16-60 y (94) | ≥60 y (9) | Test of sig. p-value |
|------------|-----------|--------------|-----------|----------------------|
|            | No %      | No %         | No %      |                       |
| No growth  | 5 55.6    | 59 52.67     | 5 55.6    | X²=.834 P=.841        |
| Positive growth | 4 44.4 | 35 31.25 | 4 44.4 |

| Second swab | <16 y (9) | 16-60 y (94) | ≥60 y (9) | Test of sig. p-value |
|-------------|-----------|--------------|-----------|----------------------|
|             | No %      | No %         | No %      |                       |
| No growth   | 7 77.8    | 75 80.90     | 6 66.7    | X²=14.634 P=.002*     |
| Positive growth | 2 22.2 | 19 16.96 | 3 33.3 |

Table 3. Types of bacterial growth from the four positive swabs

| Type of bacteria | First swab | Second swab | Third swab | Fourth swab |
|------------------|------------|-------------|------------|-------------|
|                  | Single growth | Mixed growth | Single growth | Mixed growth |
| Gram positive bacteria | 23 58.97 1 33.33 | 11 61.11 2 33.33 | 1 4 |
| Gram negative bacteria | 17 43.58 2 66.66 | 7 38.88 4 66.66 | -- -- |
| Total            | 40 100 3 100 | 18 100 6 100 | 1 4 |

Table 4. Bacterial growth results of positive swabs

| Items                        | First swab | Second swab | Third swab | Fourth swab |
|------------------------------|------------|-------------|------------|-------------|
| Pseudomonas aeruginosa       | 3 7        |             |            |             |
| Proteus mirabilis            | 7 16.3     |             |            |             |
| Staph. aureus                | 19 44.2    |             |            |             |
| Enterococci                  | 1 2.3      |             |            |             |
| Proteus vulgaris             | 2 4.7      |             |            |             |
| MRSA                         | 2 4.7      |             |            |             |
| E. coli                     | 2 4.7      |             |            |             |
| Klebsiella pneumoniae        | 3 7.0      |             |            |             |
| Staph. epidermidis           | 1 2.3      |             |            |             |
| Staph+ proteus mirabilis     | 2 4.7      |             |            |             |
| Pseudomonas aeruginosa+ staph. aureus | 1 2.3 |

In the present study, 74.1% of the fractures occurred in lower extremities. A study conducted in Iran also showed that 89.2% of patients with open fracture wounds had suffered from injury of lower extremities [23].

The Gustilo and Anderson grades II, IIIA and IIIB were the predominant types of the open fractures in our study. The most dominant open fracture was grade IIIA (37.5%). This is similar to a study reported by Ikem et al. [22] in Nigeria.

In this study, wounds were simply washed with sterile normal saline and iodine or H₂O₂ solutions and dressed during fracture stabilization. Meticulous wound management and irrigation with copious fluid were essential for the care of all patients with open fracture wounds. Necrotic tissue and other contaminating materials from the wound site were debrided. The aim was to reduce the bacterial load and to increase the chance of early wound closure [3].

The total bacterial isolation rate from the open fracture wounds was 38.4% in the first swabs. This is slightly lower than that reported in Chandigarh, India by Sen et al. [24] which was 45% and 45.8% was reported in Ile-ife, Nigeria by Ikem et al. [22]. Different factors related to wound bed preparation; sample collection, sample transportation and culturing technique might have an effect in the reduction of the bacterial isolation rate.
Table 5. Antibiotic sensitivity patterns

| No | Antibiotic      | Bacteria                  | No of isolates | No (%) of sensitivity |
|----|-----------------|---------------------------|----------------|-----------------------|
| 1  | Tobramycin      | *Pseudomonas aeruginosa*  | 9              | 4 (44.4)              |
|    |                 | *Klebsiella pneumoniae*  | 6              | 2 (33.3)              |
| 2  | Imipenem        | *Pseudomonas aeruginosa*  | 9              | 5 (55.6)              |
|    |                 | MRSA                      | 5              | 2 (40)                |
|    |                 | *Proteus mirabilis*       | 14             | 6 (42.9)              |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
| 3  | Gentamicin      | *Pseudomonas aeruginosa*  | 9              | 2 (22.2)              |
|    |                 | *Proteus mirabilis*       | 14             | 1 (7.1)               |
|    |                 | *Klebsiella pneumoniae*   | 6              | 1 (16.7)              |
|    |                 | *Staph aureus*            | 32             | 5 (15.6)              |
|    |                 | *Staph epidermidis*       | 5              | 1 (20)                |
|    |                 | Enterococci               | 1              | 1 (100)               |
|    |                 | *Proteus vulgaris*        | 3              | 1 (33.3)              |
| 4  | Amikacin        | *Pseudomonas aeruginosa*  | 9              | 2 (22.2)              |
|    |                 | *Proteus mirabilis*       | 14             | 2 (14.3)              |
|    |                 | *Klebsiella pneumoniae*   | 6              | 1 (16.7)              |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
| 5  | Cotrimoxazol    | *Staph aureus*            | 32             | 20 (62.5)             |
|    |                 | *Staph epidermidis*       | 5              | 2 (40)                |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
| 6  | Aztreonam       | *Proteus mirabilis*       | 14             | 4 (28.6)              |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
| 7  | Cefuroxime      | *Klebsiella pneumoniae*   | 6              | 4 (66.7)              |
|    |                 | *Staph aureus*            | 32             | 11 (34.4)             |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
| 8  | Tazocin         | Enterococci               | 1              | 1 (100)               |
|    |                 | *Proteus vulgaris*        | 3              | 1 (33.3)              |
| 9  | Pipracillin     | *E. coli*                 | 2              | 1 (50)                |
| 10 | Ciprofloxacin   | *Proteus mirabilis*       | 14             | 10 (71.4)             |
|    |                 | *Staph aureus*            | 32             | 23 (71.9)             |
|    |                 | MRSA                      | 5              | 3 (60)                |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
|    |                 | *Proteus vulgaris*        | 3              | 2 (66.7)              |
| 11 | Ampicillin      | *Staph epidermidis*       | 5              | 2 (40)                |
|    |                 | Enterococci               | 1              | 1 (100)               |
|    |                 | *Streptococcus group D*   | 1              | 1 (100)               |
| 12 | Amp./sulbactam  | *Pseudomonas aeruginosa*  | 9              | 2 (22.2)              |
|    |                 | Enterococci               | 1              | 1 (100)               |
|    |                 | *Streptococcus group D*   | 1              | 1 (100)               |
| 13 | Erythromycin    | *Staph aureus*            | 32             | 9 (28.1)              |
|    |                 | MRSA                      | 5              | 0 (0)                 |
|    |                 | *Staph epidermidis*       | 5              | 2 (40)                |
|    |                 | *Streptococcus group D*   | 1              | 1 (100)               |
| 14 | Vancomycin      | *Staph aureus*            | 32             | 32 (100)              |
|    |                 | MRSA                      | 5              | 5 (100)               |
|    |                 | *Streptococcus group D*   | 1              | 1 (100)               |
| 15 | Amoxicillin/clavulnic acid | *Staph aureus*       | 32             | 27 (84.4)             |
|    |                 | *Staph epidermidis*       | 5              | 2 (40)                |
|    |                 | *E. coli*                 | 2              | 1 (50)                |
| 16 | Levofloxacin    | *Pseudomonas aeruginosa*  | 9              | 4 (44.4)              |
|    |                 | *Streptococcus group D*   | 1              | 1 (100)               |
No Antibiotic Bacteria No of isolates No (%) of sensitivity

| No |  |  |  |
|----|---|---|---|
| 17 | Cephradine | E. coli | 2 | 2 (100) |
| 18 | Clindamycin | Enterococci | 1 | 1 (100) |
| 19 | Fucidic acid | Streptococcus group D | 1 | 1 (100) |
| 20 | Meropenem | Streptococcus group D | 1 | 1 (100) |
| 21 | Cefoperazone | MRSA | 5 | 2 (40) |

In this study colonial counts were considered to differentiate pathogens from contaminants. Colony count interpretation was as follows; <5 CFUs (contamination), 5-15 CFUs (colonization), 16-30 CFUs (‘critical’ colonization), and >30 CFUs (infection). Cultures with <5 CFUs were ignored being considered as simple contaminants with the exception of S. aureus and Gram-negative rods. The finding of small number of colonies in these organisms may be due to inadequate or recent antibiotic treatment and the presence of high level of inhibitory substance in the culture media [25,26].

In general, quantitative bacterial counts were useful in managing open fractures. If the quantitative bacterial count is greater than 10 at any one time, it should be taken as a predictor of infection. Then, further medical intervention should be considered prior to definitive fracture care and soft tissue coverage.

The most common bacterial isolate in open fracture wounds was S. aureus (44.2%). This is in agreement with previous studies conducted at different places in Ethiopia [27-33].

The predominating prevalence of S. aureus in open fracture wounds have been also reported in other developing and developed countries like USA [2,34], France [18], UK [35-37], Ile-Ife, Nigeria [38], Lagos, Nigeria [39], Belgrade [40], India [41], Brazil [42], Davos, Switzerland [43], Romania [44], and Iran [45]. Proteus mirabilis were the second most frequently (16.3%) isolated bacteria.

The predominant isolates (58.66%) of the open fracture wounds were Gram- positive bacteria compared to Gram- negative ones (41.33%). This is in agreement with a study done in USA [11]. The Gram-negative (41.33%) to Gram-positive (58.66%) bacterial proportion in our findings agrees with reports from Minnesota, USA (40% vs. 60%) [2], Indian tertiary care hospital, India (47% vs. 53%) [41] and Gondar teaching hospital, Ethiopia (29% vs.71%) [33]. The observed difference can be mainly explained by the high proportion of G-A grade III open fracture wounds with some older or chronic ones due mainly to the unusually high number of bullet injury. It is also noted that bacterial prevalence differs in different environments [6].

In this study, 81.96% of culture-positive wounds showed mono-microbial growth and 10.71% showed polymicrobial growth. Similarly, Johnson et al. [46] reported that Gram-positive bacteria were less frequently recovered and 37% were polymicrobial infections. The profile of the bacterial isolates study comparatively agreed with findings that have been observed in Nigeria [39], India [41,47], Romania [44], and Iran [45].

All patients had been treated with ampicillin/subactam, metronidazole and ceftazidime before collection of samples [48]. Of these, 38.4% had positive culture results in the first swabs. The possible explanation for high culture positivity rate could be mainly due to bacterial resistance for prophylactically administered antimicrobials [11,21]. In addition, this also shows the rational use of some antibiotics alone or in combination, requires periodic evaluation and the establishment of antimicrobial policy for prophylaxis and treatment in Mansoura Emergency Hospital. The study provided insights into the susceptibility profile of bacteria isolated from open fracture wounds. In our study, the most effective drugs against the Gram-positive bacteria were amoxicillin/clavulonic acid, erythromycin, vancomycin, ceftazidime and ampicillin. In the other hand the most effective drugs against the Gram-negative bacteria were gentamicin, ciprofloxacin, tazocin, imipenem and aztreonam. This is in agreement with reports from Ile-Ife, Nigeria [22], Lagos, Nigeria [39], and Ahwaz University of Medical Sciences teaching hospitals, Iran [45]. In the study, the antibiotic regimen was changed in 29 patients according to the culture and sensitivity after second swabs.

Many factors have contributed to such level of bacterial resistance, including antimicrobial misuse by health professionals and unskilled practitioners. In Egypt, it is a common practice
that antimicrobials can be purchased without prescription, which leads to misuse of antimicrobials by the public thus contributing to the emergence and spread of antimicrobial resistance. Other causal factors can be poor drug quality, poor hospital hygienic conditions accounting for the spread of resistant bacteria, and inadequate surveillance, i.e. lack of information from routine antimicrobial susceptibility testing of bacterial isolates and surveillance testing of bacterial isolates and surveillance of antibiotic resistance, all of which are crucial for good clinical practice and for rational policies against antibiotic resistance [49].

Serious infections caused by Gram-positive bacteria are increasingly difficult to treat because of pathogens such as methicillin-resistant Staphylococcus aureus (MRSA), vancomycin resistant enterococci (VRE) and penicillin-resistant Streptococcus pneumoniae. The more recent emergence of vancomycin intermediate and resistant MRSA (VISA and VRSA) has further compromised treatment options [50]. The detection of multidrug resistant isolates may further limit therapeutic options.

6. CONCLUSION

Open fractures is an important issue for good management. Debridement should be done especially in the presence of clinical signs of infection in open fracture wounds. Bacterial culture before and after debridement may be worthy to avoid the postoperative infections. Guidelines have to be developed to standardize the care of orthopedic patients with open fractures.

COMPLIANCE WITH ETHICAL REQUIREMENTS

The protocol of the study was reviewed and approved by our institutional review board and a written informed consent was obtained from all studied patients.

COMPETING INTERESTS

Authors declare that they have no conflict of interest. No funding resources were used.

REFERENCES

1. Craig J, Fuchs T, Jenks M, Fleetwood K, Franz D, Iff J, Raschke M. Systematic review and meta-analysis of the additional benefit of local prophylactic antibiotic therapy for infection rates in open tibia fractures treated with intramedullary nailing. Int Orthop. 2014;38(5):1025-30.
2. Gustilo RB, Anderson JT. Prevention of infection in the treatment of one thousand and twenty-five open fractures of long bones: Retrospective and prospective analyses. J Bone Joint Surg. Am. 1976; 58:453-458.
3. Gustilo RB, Merkow RL, Templeman D. Current concepts review. The management of open fractures. J Bone Joint Surg. 1990;72(A):299-304.
4. Helling TS, Daon E. In Flanders fields: The great war. Antoine depage, the resurgence of debridement. Ann Surg. 1998;228:173-81.
5. Anglen JO. Comparison of soap and antibiotic solutions for irrigation of lower-limb open fracture wounds: A prospective, randomized study. J Bone Joint Surg [Am]. 2005;87-A:1415-22.
6. Lee J. Efficacy of cultures in the management of open fractures. Clin Orthop Relat Res. 1997;339:71-5.
7. Kreder HJ, Armstrong P. The significance of perioperative cultures in open pediatric lower-extremity fractures. Clin Orthop Relat Res. 1994;302:206-12.
8. Olson SA. Open fractures of the tibial shaft. Instr Course Lect. 1997;46:293-302.
9. Turen CH, Di Stasio AJ. Treatment of grade III B and grade III C open tibia fractures. Orthop Clin North Am. 1994;25:561-71.
10. Esterhai JL Jr, Queenan J. Management of soft tissue wounds associated with type III open fractures. Orthop Clin North Am. 1991;22:427-32.
11. Patzakis MJ, Harvey JP, Iver D. The Role of antibiotics in the management of open fractures. J Bone Joint Surg. Am. 1974; 56:532-41.
12. Heier KA, Infante AF, Walling AK, Sanders RW. Open fractures of the calcaneus: Soft-tissue injury determines outcome. J. Bone Joint Surg. Am. 2003;85:2276-82.
13. Mansell ID. Procedure for taking a wound swab; 2005. Available:http://www.wirralpct.nhs
14. RDNS Research Unit. Promoting evidence-based nursing practice wounds wabbing; 2002. Available:http://www.rdns.org.au/research_unit/Newsletters/11_Wound_Sep02.pdf
15. Levine NS, Lindberg RB, Mason AD Jr, Pruitt BA Jr. The quantitative swab culture and smear: A quick, simple method for determining the number of viable aerobic bacteria on open wounds. J Trauma. 1976;16:89-94.

16. Gardner SE, Frantz R, Hillis SL, Park H, Scherubel M. Diagnostic validity of semiquantitative swab cultures. Wounds. 2007;19:31-8.

17. Cheesbrough M. Medical laboratory manual for tropical countries II. 2004;255-75.

18. Carsenti-Etesse H, Doyon F, Desplaces N, Gagey O, Tancrede C, Pradier C, Dunais B, Dellamonica P. Epidemiology of bacterial infection during management of open leg fractures. Eur J Clin Microbiol Infect Dis. 1999;18:315-23.

19. Zalavras CG, Marcus RE, Levin LS, Patzakis MJ. Management of open fractures and subsequent complications. J. Bone Joint Surg. Am. 2007;89:884-95.

20. Stewart DG Jr, Kay RM, Skaggs DL. Open fractures in children. Principles of evaluation and management. J. Bone Joint Surg. Am. 2005;87:2784-98.

21. Hauser CJ, Adams CA Jr, Eachempati SR, Council of the Surgical Infection Society. Surgical infection society guideline: Prophylactic antibiotic use in open fractures: An evidence-based guideline. Surg Infect (Larchmt). 2006;7:379-405.

22. Ikem IC, Oginni LM, Bamgboyie EA, Ako-Nai AK, Onipade AO. The bacteriology of open fractures in Ile-Ife, Nigeria. Niger J Med. 2004;13:359-65.

23. Fakoor M, Pipelzadeh MH. A study on the healing effect of honey on infected open fracture wounds. Pak J MedSci. 2007;23:327-9.

24. Sen RK, Murthy NRS, Gill SS, Nagi ON. Bacterial load in tissues and its predictive value for infection in open fractures. J Orthop Surg. 2000;8:1-5.

25. Dietz FR, Koontz FP, Found EM, Marsh JL. The importance of positive bacterial cultures of specimens obtained during clean orthopaedic operations. J. Bone Joint Surg. Am. 1991;73:1200-7.

26. Silletti RP, Alley E, Sun S, Tang D. Microbiologic and clinical value of primary broth cultures of wound specimens collected with swabs. J Clin Microbiol. 1997;35:2003-6.
Bone infections and antibiotics use in orthopaedics. Acta Fac. Med. Naiss. 2004;21:245-52.

41. Dhawan B, Mohanty S, Das BK, Kapil A. Bacteriology of orthopaedic wound infections in an Indian Tertiary Care Hospital. Indian J Med Res. 2005;121:784-5.

42. Fontes CO, Carvalho MAR, Nicoli JR, Hamdan JS, Mayrink W, Genaro O, Carmo LS, Farias LM. Identification and antimicrobial susceptibility of microorganisms recovered from cutaneous lesions of human American tegumentary leishmaniasis in Minas Gerais, Brazil. J Med Microbiol. 2005;54:1071-6.

43. Harris LG, Richards RG. Staphylococci and implant surfaces: A review. Injury. 2006;37:S3-S14.

44. Purghel F, Badea R, Ciuvica R, Anastasiu A. The use of antibiotics in traumatology and orthopaedic surgery. Clin Med. 2006;1:58-65.

45. Khosravi AD, Ahmadi F, Salmanzadeh S, Dashtbozorg A, Abasi Montazeri E. Study of bacteria isolated from orthopedic implant infections and their antimicrobial susceptibility pattern. Res J Microbiol. 2009;4:158-63.

46. Johnson EN, Burns TC, Hayda RA, Hospenthal DR, Murray CK. Infectious complications of open type III tibial fractures among combat casualties. Clin Infect Dis. 2007;45:409-15.

47. Saini S, Gupta N, Aparna, Lokveer, Griwan MS. Surgical infections: A microbiological study. Braz J Infect Dis. 2004;8:118-25.

48. Patzakis MJ, Bains RS, Lee J, et al. Prospective, randomized, double-blind study comparing single-agent antibiotic therapy, ciprofloxacin, to combination antibiotic therapy in open fracture wounds. J Orthop Trauma. 2000;14(8):529–533.

49. Okeke IN, Lamikanra A, Edelman R. Socioeconomic and behavioral factors leading to acquired bacterial resistance to antibiotics in developing countries. Emerg Infect Dis. 1999;5:18-27.

50. Menichetti F. Current and emerging serious gram-positive infections. Clin Microbiol Infect. 2005;Suppl 3:22.

© 2016 Barakat et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14998