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Evaluation of bacteriological contamination pattern of open fractures of extremities in tertiary care hospital

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ABSTRACT

Background: Open fractures and associated complications like infection are fairly common in developing countries due to rising incidence of high velocity trauma. Primary goal of study is to evaluate the pattern of bacteriological contamination of open fractures of extremities in tertiary care hospital.
Methods: A total of 316 patients of all the age group, both the sexes with open fractures of extremities presented within 6 hours were taken in to study. 1st swab taken at the time of primary wound examination followed by 2nd culture swab on just after debridement followed by 3rd culture swab on the day of 1st aseptic dressing followed by 4th culture swab if infection continues or asepsis score is more than 20 till the duration of 4 days. Culture and sensitivity reports were collected for studying pattern of bacterial isolates and their sensitivity.
Results: Infection developed in 22.5% of the patients with open fractures of extremities in whom most of bacterial infections were caused by gram-negative organisms (80.3%). Cultures on admission were positive in 41 patients, out of which 11 patients had developed infection in the final cultures but with different flora. While cultures taken at 1st aseptic dressing were found to be positive in 51 cases, out of which 31 had developed infection with prognostic value of 57%.
Conclusions: We concluded that cultures obtained at 1st aseptic dressing are far more predictive than pre and post-debridement cultures in management of patients with open fractures of extremities and are important in formulating an antibiotic policy.

Keywords: Open fractures, Debridement, Infection, Antibiotics

INTRODUCTION

Open fractures are fairly common in developing countries due to rising incidence of high velocity trauma. Infection at a site of traumatic wounds is a common complication of open fractures. Chronic osteomyelitis, non-union, loss of function are serious outcomes of deep fracture site infection. Primary goal in management of open fracture is prevention of infection of bones and soft tissue by early debridement, irrigation of wound and administration of antibiotics with stabilization of fractures.[1]

This serious nature of open fracture has been understood since antiquity. Fractures are classified as open when they communicate with the outside environment through a wound and are usually caused by high energy trauma. According to Gustilo-Anderson (G-A), open fractures are classified into three major types, based on the mechanism of injury, the degree of soft-tissue damage, the configuration of the fracture, and the level of contamination (G-A). The bacterial contamination of bones and soft tissue in open fracture leads to an infection rate of up to 50%.[2-5]

Table 1: Modified Gustilo and Anderson classification of open fractures (adapted from Okike and Bhattacharyya, 2006).[6]

Grade	Definition	Historical infection rate (%)
I	Wound <1 cm; minimal contamination, comminution, and soft-tissue damage	0-2
II	Wound >1 cm; moderate soft-tissue damage, minimal periosteal stripping	2-5
IIIA	Severe soft-tissue damage and substantial contamination; coverage adequate	5-10
IIIB	Severe soft-tissue damage and substantial contamination; coverage inadequate	10-50
IIIC	Arterial injury requiring repair	25-50

Up to 70% of open fractures are contaminated at the time of injury mostly by organisms from the skin and the environment. Several large series from multiple centres have identified the most common organisms present and have led to the acceptance of using broad spectrum antibiotics; cephalosporins augmented by aminoglycosides in grade III open fractures and penicillin in farmyard injuries.

Contamination may also occur in the course of treatment. Pathogens and their resistance against therapeutic agents change with time and vary in different regions. The selection of antibiotics to treat the contaminating organisms and coverage against the infection is still controversial. These bacterial patterns are important in developing antibiotic protocols for prophylaxis and empirical treatment.[7]

The aim of our study was to describe the pattern of bacterial contamination and antibiotic susceptibility and possible resistance to antibiotic agents from open fractures coming to our institute within 6 hours of injury. Local studies on these patterns are lacking in our area. This specific prophylactic antibiotic treatment based on prevalent microbes in our region will be helpful in preventing dreadful chronic complications associated with deep tissue infection in open fractures. There would be also a decline in cost of treatment to patient and antibiotic resistance as a proper regimen will be formed for management of patients.

METHODS

Study design

Following approval from institutional review board, a prospective study was conducted on a total of 316 patients with open fractures of extremities admitted in accident and emergency department of Maharaja Agrasen Medical College, Agroha, Hisar between 1st January 2019 to 31st March 2020. Patients were informed about the study in all respects and informed consent was obtained from each patient.

Statistical testing was conducted with the statistical package for the social science system version statistical package for the social sciences (SPSS) 20.0.

Inclusion criteria

All patients with open fractures of extremities due to road traffic accident, household fall, sports injury, crush injury, fall from height, assault and others (burn, electric shock) with time of injury less than 6 hours were included in the study.

Exclusion criteria

Patients having diabetes mellitus and peripheral vascular disease; patients with open fracture primarily treated somewhere else; patients who had received oral or parenteral antibiotics before presentation; patients who did not have definitive treatment at our institution; and patients not willing to be part of this study were excluded.

All the patients meeting the inclusion criteria were selected to study bacterial flora in open fractures of extremities and their antibiotic sensitivity was done on isolation of bacteria. On arrival in emergency, wounds were examined, pre and post debridement wound swabs for aerobic culture in type I to type IIIA, aerobic and anaerobic culture in type IIIB and IIIC were taken.

Swab collection times

Swabs were collected: at the time of admission on first inspection of wound, after wound debridement, at time of first aseptic dressing, and in patients with asepsis score is more than 20 till duration of 4 days.

All the swab samples were sent to microbiology department. Preliminary gram staining was performed to determine the likely organism present. The samples were inoculated on blood agar, MacConkey agar, Robertson's cooked meat and glucose broth, which were incubated for 24-48 hours at 37° C. All the isolates were identified by colony morphology, gram stain and biochemical tests using the standard procedures. Each isolates were screened for antibiotic sensitivity testing by the Kirby–Bauer disc diffusion method including–ampicillin, ampicillin-sulbactam, amoxicillin-clavulanic acid, piperacillin-tazobactam, ceftazidime, cefitaxime, gentamicin, amikacin, clindamycin, erythromycin, chloramphenicol, linezolid, vancomycin, clotrimazole, cefepime, imipenem,

meropenem, cefoperazone-sulbactam, tetracyclin, ciprofloxacin and aztreonam.

RESULTS

The present study was done at Department of Orthopaedic Surgery, Maharaja Agrasen Medical College, Agroha, on a total of 316 patients of open fractures of extremities who met the inclusion criteria attended accident and emergency department from 1st January 2019 to 31st March 2020 and these were analyzed for overall results.

Most of the patients in the present study were males (84.5%) with male to female ratio are 5.4:1. The gender wise distribution is shown in Table 2.

Table 2: Gender wise distribution.

Sex	No. of patients	Percentage (%)
Female	49	15.5
Male	267	84.5
Total	316	100.0

In our study, most of patients were found in the age group of 21-50 years as shown in Table 3. This is due to the fact that this age group belongs to the middle age and they are more involved in outdoor activities and road traffic accident than young and old age people.

Table 3: Age wise distribution.

Age group	No. of patients	Percentage (%)
1-20	57	17.9
21-50	219	68.6
>51	40	12.5
Total	316	100.0

In our study, the most common cause of open fractures of extremities was found to be road traffic accident, accounting for 204 cases (65%). We found maximum cases 226 (72%) of open fractures in lower limb, among which tibia was the most common fractured bone with 121 (38%) cases with right sided predominance (58.5%). Out of 316 patients, most of cases 124 (39%) of open fractures were Gustilo II followed by type IIIA (33%).

On admission, pre-debridement swabs were collected from all 316 patients of open fractures of extremities. Out of which, 41 (13%) cases were found to be culture positive. Most of the cultures showed gram-positive growth (58.5%). Among which, *Staphylococcus aureus* was found to be predominant contaminant. Post-debridement swabs showed growth in only 3 (0.9%) patients, in whom *Staphylococcus aureus*, *E. coli* and *Pseudomonas* were found to be in equal proportion.

1st aseptic dressing cultures showed growth in 51 (16.1%) cases. Out of 51, only 3 patients were those who also showed growth in pre-debridement cultures but with different organisms. All positive post-debridement culture patients became negative at this stage. Most of the positive 1st aseptic dressing cultures showed gram-negative growth (84.3%) as compared to gram-positive (15.7%). Among which, *Pseudomonas* was found to be most common isolate.

In our study, we had 91 patients in whom the discharge continued and asepsis score was found over 20. Out of which, infection developed in 71 patients and most of bacterial infections were caused by gram-negative organisms (80%). Among gram-negative, *Pseudomonas* (35.1%) was the most common infecting organism while *Staphylococcus aureus* (100%) was the predominant culprit among gram-positive isolates. The distribution pattern of bacterial flora at different stage of wound management is shown in Table 4.

On analysis, we found that cultures on admission (pre-debridement cultures) were positive in only 41 (13%) of the patients. Out of which, 11 patients had developed infection in the final cultures but with different flora. Similarly, negative initial cultures did not rule out the probability of infection later on, as many cases (60) negative for the growth in initial cultures showed growth in final cultures. While cultures taken at 1st aseptic dressing day was found to be more sensitive as 31 (61%) out of 51 cases had developed infection in the final cultures and in 57% of the cases, similar type of organisms were isolated. Thus cultures obtained at 1st aseptic dressing had a better prognostic value (57%) as compared to initial cultures. The predictive value of pre- and post-debridement cultures for development of infection in the final cultures was found to be statistically insignificant as p value was >0.05 as compared to that of 1st aseptic dressing cultures which had p value <0.05.

Figure 1: Pre-debridement wound.

In the present study, all gram-positive organisms showed high susceptibility to linezolid, vancomycin and cefotaxime over 90%, 85.7% and 78.8% respectively. Other antibiotics were less susceptible (<50%) and showed high resistance to gram-positive isolates. Antimicrobial susceptibility pattern of gram-positive isolates is shown in Table 5 and 6.

Table 4: Bacterial flora at different stages of wound management.

Cultures at different stages of wound management	No growth	Growth seen	Gram-positive growth (%)	Gram-negative growth (%)
Pre-debridement cultures (n=316)	275	41	58.5	41.5
Post-debridement cultures (n=316)	313	3	34	66
1st aseptic dressing cultures (n=316)	265	51	16	84
Final cultures (n=91)	20	71	19.7	80.3

Table 5: Antibiotic susceptibility pattern of gram-positive isolates.

Gram-positive organism	Antimicrobial agents (%)						
	SAM	AMK	AMC	FEP	CFP	CTX	CIP
***Staphylococcus aureus* (n=14)**	71.4	71.4	21.4	14.2	28.5	78.8	64.2

Table 6: Antibiotic susceptibility pattern of gram-positive isolates.

Gram-positive organism	Antimicrobial agents (%)						
	VAN	LZD	GEN	IMP	CLI	CHL	TET
Staphylococcus aureus	85.7	92.8	21.4	-	21.4	42.8	42.8

Table 7: Antibiotic susceptibility pattern of gram-negative isolates.

Gram-negative organisms	Antimicrobial agents (%)						
	IMP	AMK	CIP	CEP	AMP	SAM	CHL
***Acinetobacterbaumanni* (n=7)**	85.7	85.7	71.4	42.8	-	-	-
***Escherichia coli* (n=7)**	28.5	71.4	71.4	-	14.3	57.1	57.1
***Pseudomonas aeruginosa* (n=20)**	90	85	85	70	-	10	-
***Klebsiella* (n=12)**	-	75	75	58.3	-	-	-
***Citrobacter* (n=11)**	54.5	36.3	27.2	45.5	-	36.3	-

Table 8: Antibiotic susceptibility pattern of gram-negative isolates.

Gram-negative organisms	Antimicrobial agents (%)							
	GEN	AMC	ATM	MEM	TZP	TET	CTX	CAZ
***Acinetobacterbaumanni* (n=7)**	-	-	-	-	-	-	-	
***Escherichia coli* (n=7)**	57.1	28.2	-	14.3	14.3	28.5	-	
***Pseudomonas aeruginosa* (n=20)**	45	35	20	-	80	-	15	75
***Klebsiella* (n=12)**	-	-	-	58.3	-	-	-	-
***Citrobacter* (n=11)**	-	9.1	-	18.2	36.3	45.5	-	-

Figure 2: X-ray image.

Figure 3: Post-debridement wound.

Figure 4: Pseudomonas growth.

In the present study, all gram-negative isolates except *Citrobacter* showed high susceptibility to amikacin and ciprofloxacin. Antimicrobial susceptibility pattern of gram-negative isolates is shown in Table 7 and 8.

DISCUSSION

The present study was conducted on a total of 316 patients of open fractures of extremities who were brought to A and E department of our institution from 1st January 2019 to 31st March 2020.

In the present study, maximum numbers of patients were found in the age group of 21-50 years. The study conducted by Agarwal et al and Mangala et al also shows the same finding.[9,12]

In our study, out of 316 patients there were 267 males and 49 females with male to female ratio is 5.4:1. The study conducted by Lingaraj et al and Yishak et al also shows male preponderance.[10,14]

In the present study, road traffic accident (RTA) was found to be most common cause of open fractures, accounting for 204 (65%) cases. The study conducted by Agarwal et al and Bhatty et al also noticed the same thing.[9,13]

In our study, we found maximum number of cases 226 (72%) of open fractures in lower limbs. Agarwal, et al, Yishak et al and Mangala et al also shows the same finding.[9,12,14]

In the present study, right side was found to be affected more commonly, accounting for 185 (58.5%) cases which is comparable to study conducted by Faisham et al.[8]

In the present study, tibia and fibula was the most common fractured bone, accounting for 38% cases. Agarwal et al and Mangala et al also noticed same finding.[9,12]

In the present study, cultures obtained at the time of admission (pre and post-debridement) were found to be of no value in predicting and treating the infections as none of the organisms grown on these cultures eventually caused infection. These findings are consistent with those found by Mangala et al and Bhatty et al.[12,13]

In the present study, cultures obtained at 1st aseptic dressing were found to be more representative in predicting the infecting organisms as 31 (61%) out of 51 cases had developed infection in the final cultures and in 57% of the cases, similar type of organisms were isolated. These findings are consistent with those found by Agarwal et al, who also noticed that the infecting organisms were the same as that in the 1st aseptic dressing swabs in 80% of the cases.[9]

In our study, most of bacterial infections in open fracture wounds were caused by gram-negative organisms (80.3%) with *Pseudomonas* and *Klebsiella* were the most predominant gram negative isolates. These findings are consistent with those found by Sitati et al.[11]

In the present study, *Staphylococcus aureus* was found to be predominant gram-positive isolates. Mangala et al and Bhatty et al noticed the same thing.[12,13]

In the present study, linezolid (92.8%) and vancomycin (85.7%) were found to be the most effective antibiotics against the tested gram-positive organisms. However, these drugs are costly and not to be recommended for prophylaxis to protect their efficacy. In our study, gram-positive organisms also showed high susceptibility to 3rd generation cephalosporins (cefotaxime 78.8%) and these findings are consistent with those found by Sitati et al.[11]

In the present study, amikacin and ciprofloxacin were found to be the most effective antibiotics against the tested gram-negative organisms except *Citrobacter* and these findings are consistent with those found by Sitati et al and Agarwal et al.[9,11]

CONCLUSION

In our study, we concluded that cultures obtained at 1st aseptic dressing are far more predictive than pre- and post-debridement cultures in management of patients with open fractures of extremities and are important in formulating an antibiotic policy. It is therefore recommended that cultures obtained at 1st aseptic dressing will provide guidance regarding the choice of antimicrobial therapy, which when combined with a thorough wound debridement will enable an early wound closure and lesser complications.

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