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Antibiotic susceptibility patterns of bacterial isolates in burn wound infection in a tertiary care hospital

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Abstract:

Background: Burn patients are at high risk of infection, and it has been estimated that over 75% of all deaths following burns are related to infection. It is therefore, essential to determine the specific pattern of burn wound colonization and their antibiotic susceptibility profiles. **Aim**: To study the prevalence of various aerobic bacterial isolates in burns wound infection, evaluate antibiotic susceptibility profile of these bacterial isolates and to detect multi-drug resistant (MDR) strains among these isolates. **Materials and Methods**: This descriptive cross sectional study was conducted in the Department of Microbiology of Jubilee Mission Medical College and Research Institute, Thrissur over a study period of one year and six months. 110 non-repetitive samples from burns cases were included in the study by consecutive sampling. Samples were processed as per standard microbiological methods and were identified using biochemical reactions and antibiotic susceptibility tests were done. **Results**: Cultures from burn wound revealed *Pseudomonas aeruginosa* as the most common organism isolated followed by *Acinetobacter baumannii*, *Staphylococcus aureus*, Klebsiella spp., *Escherichia coli* and *Enterobacter cloacae*. Majority of the isolates were multi-drug resistant. Multi-drug resistance was shown by 86.11% of *Acinetobacter baumanni*i followed by *E. coli* and Klebsiella spp. *Pseudomonas aeruginosa* showed differing trend (24%) in terms of multi-drug resistance when compared to many previous studies. A high proportion of ESBL and carbapenemases were detected among our study isolates. Positivity for MBL and ESBL were shown by 77.77% and 58.33% *Acinetobacter baumannii* respectively. ESBL production was positive for 50 % of *E. coli* and 42.85% of Klebsiella spp. Among *Pseudomonas aeruginosa*, 12% tested positive for ESBL and 18% for carbapenemases. Among *Staphylococcus aureus*, 42.30% were MRSA. **Conclusion**: The results of the present study will be helpful in understanding the pattern of burn wound microbial infection, the dominant bacterial flora and the antimicrobial resistance.

Key words: antimicrobial susceptibility, bacterial isolates, burns, Pseudomonas, ESBL

Introduction:

Burns are one of the most common and devastating forms of trauma. Patients with serious thermal injury require immediate specialized care in order to minimize morbidity and mortality. If patients survive the initial burn and resuscitative phase, 75 % of all deaths following thermal injuries are currently related to infection. One of the key areas about which surgeons treating burn patients are concerned is septic complications, as burn wounds are an ideal culture medium for microorganisms.[1]

Immediately following thermal injury, the burn wounds are sterile, but eventually get colonized with microorganisms. Various factors responsible are disruption of skin barrier, a large cutaneous bacterial load, the possibility of the normal bacterial flora becoming opportunistic pathogens and severe depression of the immune system. [2] The colonization and later invasion of tissues is from patient's normal flora of skin or from gastrointestinal tract or more usually by cross infection.[1, 2] Among the bacterial pathogens isolated, the most frequent cause of burn wound infections was found to be *Pseudomonas aeruginosa* and Acinetobacter spp. followed by

Staphylococcus aureus, *E.coli*, Klebsiella spp.[1, 3.]

Emerging antimicrobial resistance trends in burn wound bacterial pathogens represent a serious therapeutic challenge for clinicians caring for burns patients. Antibiotic resistant organisms like Methicillin Resistant *Staphylococcus aureus* (MRSA), Vancomycin-resistant enterococci (VRE) and β-lactamase producing Gram-negative rods including *Pseudomonas aeruginosa*, Acinetobacter spp., and members of Enterobacteriaceae have been associated.[4] Risk factors for acquisition of resistant organisms include antibiotic use prior to development of infection, extended duration of hospitalization, invasive procedures and advancing age. Strict infection control practices and appropriate empirical antimicrobial therapy are essential to help reduce the incidence of infections due to these antibiotic resistant organisms. [5]

In this study carried out at Jubilee Mission Medical College & Research Institute, Thrissur from January 2016 to June 2017, we attempted to find out the antimicrobial susceptibility profile and emerging resistance mechanisms of various bacterial isolates in infected burn wounds in the burns unit of our institution which will help in instituting empirical antimicrobial therapy, modify existing antibiotic policies and minimize irrational use of antimicrobial agents.

Materials and Methods:

This descriptive cross sectional study was conducted in the Department of Microbiology of Jubilee Mission Medical College and Research Institute, Thrissur over a study period of one year and six months. A total of 196 cases of burn wound swabs were received in the Department of Microbiology for culture and sensitivity testing during the study period, of which 37 yielded no growth and 14 yielded mixed growth of more than 2 types of bacteria. Of the remaining, 110 non-repetitive samples were included in the study by consecutive sampling. The specimen collected was pus using a swab on the 3rd post-burn day. Specimens were collected by sampling clinically deep area of the burn wound site after removal of dressings and topical antibacterial agents and cleansing the wound surface with sterile saline. The swabs were placed immediately in sterile test tubes and transported to microbiology laboratory as soon as possible as per standard protocols.

Samples were processed as per standard microbiological methods and were identified using biochemical reactions. Antimicrobial susceptibility testing was done by Kirby Bauer disc diffusion method according to M-100 CLSI (Clinical Laboratory Standards Institute), January 2017 guidelines (27thedition) [6]. Phenotypic screening tests for detection of ESBL and carbapenemases were done on isolates which showed resistance to 3rd generation cephalosporins and carbapenems. Confirmatory tests used were Combined disc method for ESBL (Extended Spectrum Beta lactamase) and Modified Hodge Test (MHT) and Imipenem-Imipenem/EDTA Combined Disc Diffusion Test for Carbapenemases/ Metallo-betalactamases (MBL). Results were analysed using descriptive statistics, Baseline characters were summarised in means and proportions. Prevalence expressed in %, Mean, +/- SD, Frequency in %.

Table I: ESBL screening test as per CLSI guidelines[6]

Cefpodoxime 10µg or	≤ 17mm
Ceftazidime 30µg or	≤ 22mm
Aztreonam 30µg or	≤ 27mm
Cefotaxime 30µg or	≤ 27mm
Ceftriaxone 30µg	≤ 25mm

Table II: ESBL confirmatory test as per CLSI[6]

Antimicrobial concentration	Test interpretation
Ceftazidime 30µg Ceftazidime/Clavulanic acid 30/ 10µg and Cefotaxime 30µg Cefotaxime/Clavulanic acid 30/10µg	A ≥ 5mm increase in zone diameter of both the antimicrobial agents tested in combination with clavulanate v/s the zone diameter when tested alone = ESBL

Table III: Carbapenemase screening test as per CLSI [6]

Antimicrobial concentration	Test interpretation
Ertapenem (10µg) or Meropenem(10 µg)	≤ 19 mm ; potential carbapenemase producers

Confirmatory tests for Carbapenemases:

1. Modified Hodge test (MHT): [6]

A 0.5 McFarland standard suspension of *E.coli* ATCC 25922 in broth or saline was prepared and diluted in 1:10 saline or broth. A MHA plate was inoculated as for routine disc diffusion procedure. After allowing the plate to dry for 3-10 minutes, as appropriate, Meropenem 10µg or Ertapenem10µg was placed on the plate. Using a 10µl loop, 3-5 colonies of test organisms grown overnight were picked and inoculated in a straight line outwards from the edge of the disk. The plates were then incubated at 37ºC for 16-18 hours. The MHA plate was then examined for enhanced growth at the intersection of the test organism streak and the zone of inhibition.

Enhanced growth- positive for carbapenemase production

No enhanced growth- negative for carbapenemase production

2. Imipenem – Imipenem/EDTA combined disc diffusion test: [7]

Screening for metallo-β-lactamase production was done on Imipenem resistant isolates of *Pseudomonas aeruginosa, Acinetobacter baumannii, Klebsiella pneumoniae, E.coli* by Imipenem–EDTA (Ethylenediamine tetra acetic acid) combined disc test as described by Yong et.al [7]

Test organism was inoculated onto Mueller-Hinton agar as recommended by Clinical and Laboratory Standard Institute (CLSI) guidelines. Two 10 µg Imipenem discs were placed on the plate and about 10 µl of 0.5 M EDTA solution was added to one of them. The zone of inhibition around Imipenem and Imipenem- EDTA disc were compared after overnight incubation at 37ºC. An increase in zone size of at least 7 mm around the Imipenem - EDTA disc as compared to Imipenem disc alone was recorded as positive result.

Even though CLSI recommended phenotypic methods for confirmation of carbapenemases is applicable only to Enterobacteriaceae, in our study an attempt was made to detect carbapenemase production in all Gram negative isolates.

Results:

A total of 123 isolates were obtained from 110 cases of burns. Maximum number of patients (27) were in the age group 20-29 years (24.54%) followed by children in the age group 0-9 years (20) (18.18%). Female patients were more (61) as compared to males (49). Maximum number of burns cases were accidental (82.72%), 14.54% were suicidal and 2.72% were homicidal. Maximum number of patients (40.90%) had 21-30% burns. It was observed that single isolates- 97(88.18%) were seen more commonly than multiple isolates 13(11.81%). Overall Gram negative bacteria (78.86%) were more common than Gram positive bacteria (21.13%). The most predominant bacterial isolate was *Pseudomonas aeruginosa* (40.65%) followed by *Acinetobacter baumannii* (29.26%) and Methicillin sensitive *Staphylococcus aureus* (12.19%) (**Table IV**).

The antibiotic sensitivity profile of the gram negative isolates and gram positive isolates is as shown in **Table V** and **Table VI**.

Table IV: Profile of bacteria isolated

Bacteria isolated	Number	Percentage
Gram negative bacteria(97)		
Pseudomonas aeruginosa	50	40.65
Acinetobacter baumannii	36	29.26
Klebsiella pneumoniae	7	5.69
Escherichia coli	2	1.62
Enterobacter cloacae	2	1.62
Gram positive bacteria(26)		
MSSA	15	12.19
MRSA	11	8.94
Total isolates	123	100

Table V: Antibiotic sensitivity profile of Gram negative isolates

Antibiotic tested	***Pseudomonas aeruginosa*(50)**		***Acinetobacter baumannii*(36)**		***Klebsiella pneumoniae*(7)**		***E.coli* (2)**		**E. cloacae (2)**	
	S*	**%**	**S**	**%**	**S**	**%**	**S**	**%**	**S**	**%**
Ampicillin(10µg)	NT	NT	0	0	0	0	0	0	0	0
Gentamicin (10µg)	30	60	7	19.4	5	71.4	2	100	2	100
Ciprofloxacin (5µg)	32	64	7	19.4	4	57.1	2	100	2	100
Ceftriaxone/ Ceftazidime (30µg)#	36	72	2	5.5	4	57.1	1	50	2	100
Amikacin (30µg)	35	70	4	11.1	5	71.4	2	100	2	100
Cefoperazone- Sulbactam (75-30µg)	34	68	8	22.2	4	57.1	2	100	2	100
Piperacillin- Tazobactam (100-10µg)	31	62	7	19.4	4	57.1	1	50	2	100
Imipenem(10µg)	36	72	6	16.6	4	57.1	2	100	2	100
Meropenem(10µg)	36	72	7	19.4	4	57.1	2	100	2	100
Tigecycline	NT	NT	36	100	7	100	2	100	2	100
Colistin	50	100	36	100	7	100	2	100	2	100

Among the 3rd generation Cephalosporins, Ceftazidime was used for testing *P.aeruginosa* and Ceftriaxone was used for testing *E.coli, K.pneumoniae, A.baumannii and E. cloacae*
S*- sensitive

Table VI: Antibiotic sensitivity profile of Gram positive isolates

Antimicrobial tested	MSSA (15)		MRSA (11)	
	Number (Sensitive)	Percentage	Number (Sensitive)	Percentage
Penicillin(10 IU)	1	6.66	0	0
Ampicillin(10µg)	1	6.66	0	0
Cefoxitin (30µg)	15	100	0	0
Cotrimoxazole(1.25+23.75µg)	15	100	4	36.36
Gentamicin(10µg)	15	100	6	54.54
Ciprofloxacin(5µg)	12	80	0	0
Erythromycin(15µg)	12	80	0	0
Clindamycin(2µg)	15	100	0	0
Linezolid(30µg)	15	100	11	100
Vancomycin*	15	100	11	100

Table VII: Phenotypic screening tests for ESBL and Carbapenemases

Organism	ESBL		Carbapenemase	
	Number	%	Number	%
Pseudomonas aeruginosa (50)	14	28	13	26
Acinetobacter baumannii (36)	33	91.66	28	77.77
Klebsiella pneumoniae (7)	3	42.85	3	42.85
Escherichia coli (2)	1	50	0	0
Enterobacter cloacae (2)	0	0	0	0

Table VIII: Phenotypic confirmatory test for ESBL

Organism	Number (Positive)	Percentage
Pseudomonas aeruginosa (50)	6	12
Acinetobacter baumannii (36)	21	58.33
Klebsiella pneumoniae (7)	3	42.85
Escherichia coli (2)	1	50
Enterobacter cloacae (2)	0	0

Table IX: Phenotypic confirmatory tests for Carbapenemases

Organism	MHT	I-I/EDTA	Positive by at least 1 method
Pseudomonas aeruginosa (50)	4	8	9
Acinetobacter baumannii (36)	13	25	28
Klebsiella pneumoniae (7)	0	1	1
Escherichia coli (2)	0	0	0
Enterobacter cloacae (2)	0	0	0

Phenotypic screening for ESBL and Carbapenemases among the Gram negative bacilli showed high prevalence of ESBL and Carbapenemases, especially in Acinetobacter and Klebsiella species as shown in **Table VII**. Confirmatory tests were done on the screen positive isolates. Out of 14 ESBL screen positive

Pseudomonas, 6 were found to be positive by confirmatory tests. Out of 32 Acinetobacter, 21 were positive by confirmatory tests. All 3 of the screen positive Klebsiella were positive for ESBL by confirmatory test as shown in **Table VIII**. Two tests were used for the confirmation of carbapenemases- Modified Hodge Test (**Figure I**) and Imipenem-Imipenem/EDTA double disc diffusion test (**Figure II**). An isolate which gave a positive result with at least one phenotypic confirmatory methods was taken to be carbapenemase producer as in **Table IX**.

Figure I: Modified Hodge Test

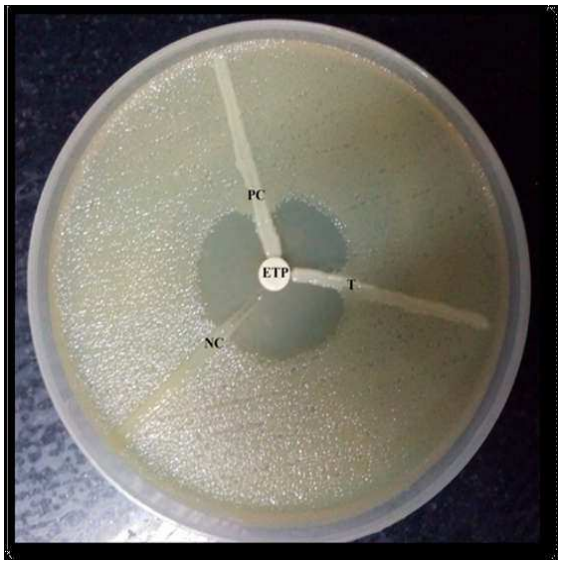
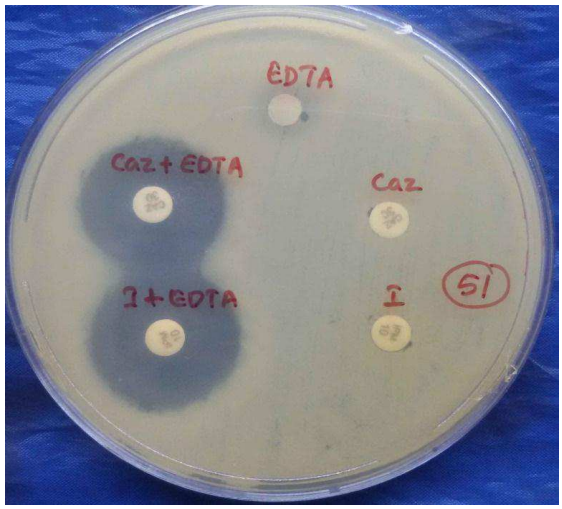


Figure II: I/I-EDTA Double Disc Diffusion Test- Positive



Multi-drug resistance was defined as resistance to 3 or more antimicrobial classes[8]. *Acinetobacter baumannii* showed the maximum multi-drug resistance (86.11%) followed by *Staphylococcus aureus* (46.15%) and Klebsiella spp. (42.85%). Most of the multi-drug resistant organisms were isolated from patients on prior antibiotics when the culture was sent as shown in **Table X**.

Table X: Multi-drug resistance among the isolates

Organism	Total number of isolates	On Antibiotic	Number of MDR organisms (%)	On Antibiotic
Pseudomonas aeruginosa	50	19	12(24)	11
Acinetobacter baumannii	36	24	31(86.11)	21
Klebsiella pneumoniae	7	3	3(42.85)	3
E coli	2	1	1(50)	1
Enterobacter cloacae	2	0	0	0
S. aureus	26	6	11(46.15)	4

Discussion:

Infection has always been the predominant determinant of wound healing, incidence of complications and outcome of burn patients. The effective fluid resuscitation regimens and protection of organ function in burn patients has led to marked decrease in shock as a cause of death and served to accentuate the relative importance of infection. Evaluation and treatment of bacterial flora in the burn wounds to prevent serious septic complications are challenging clinical problems.

In our study, the maximum number of patients (24.54%) were in the 20-29 year age group. This correlates well with studies conducted by Datta et al[9] and Smita Sharma et al [10] in which 33.3% patients belonged to 21-30 years. This may be attributed to the fact that burn injuries are common in the productive period of life when people are more exposed to the hazards of fire, both at home and outside.

But the significant proportion (18.18%) of children in the age group of 0-9 years in our study is in contrast to studies by Kulkarni et al[11] in which only less than 8% of cases belonged to 0-9 years age. This finding in our study is possibly because children in this age group are more prone to accidental injuries, especially scalds caused by spillage of hot fluids.

Majority (55.45%) of the patients were females. Similar female sex predominance was noted in the studies conducted by Bhama S et al [12] and Mundhada SG et al[13] .This female preponderance can be attributed to females being more exposed to household fire while cooking and also suicidal and dowry deaths.

In this study, the numbers of monomicrobial isolates were 97 (88.18 %). Of the monomicrobial isolates, *Pseudomonas aeruginosa* was the most common organism isolated (40.65%), followed by *Acinetobacter baumannii* (29.26%), MSSA (12.19%), MRSA (8.94%), *E coli* and *Enterobacter cloacae*. The use of broad spectrum antibiotics effective against Staphylococcus might have led to the emergence of *P.aeruginosa*, a predominant organism causing burn wound infections. The present finding correlated with studies of Saxena N et al[2] and Bhama S et al [12]

The second most common isolate in our study was *Acinetobacter baumannii* (29.26%) in accordance with studies by Mehta et al [14] and Ramakrishnan et al [15]. Fournier et al [16] have supported the hypothesis that Acinetobacter spp. might be more prevalent in warm climates with corresponding increase in colonization and nosocomial infection which could be the explanation for the increased isolation rate of Acinetobacter spp. in our study also.

In our study, 8.94 % MRSA were isolated and it constituted 42.30% of all the *S. aureus* isolates. According to the study by Rode H et al [17], Methicillin-resistant *Staphylococcus aureus* strains (MRSA) have become increasingly prevalent as nosocomial pathogens, especially in burn wounds. MRSA constituted 38 % of all *S.aureus* isolates which is in correlation with our study

Other gram negative isolates in our study were *K.pneumoniae* (5.69%), *E.coli* (1.62%) and *Enterobacter cloacae* (1.62%). These findings are in accordance with studies by Shareen George et al [18]and C Glen Mayhall [3] et al.

Increasing antimicrobial resistance among burn wound isolates is a matter of concern, with limited treatment options available for multi-drug resistant strains. Phenotypic screening for ESBL and Carbapenemase production were done in all the Gram negative isolates showing resistance to third generation cephalosporins and Carbapenems respectively. Confirmatory tests for ESBL and Carbapenemases (MBL) were done on the screen positive isolates. The 97 isolates of Gram negative bacilli when tested for ESBL and MBL production, gave interesting results. Out of

97 isolates, 31(31.95%) were ESBL producers and 39(39.17 %) were MBL producers. Among these Gram negative isolates, 6 (12%) cases of *Pseudomonas aeruginosa*, 21(58.33%) cases of *Acinetobacter baumannii*, 3 (42.85%) cases of *Klebsiella pneumoniae*, one isolate (50%) of *E. coli*, were found to be ESBL producers. In accordance with our present study, a study conducted by Bandekar et al [19]showed that the ESBL producers were 39.8 %. Studies conducted by Clark N M et al [20] and Sarma S et al[10] reported that increased prevalence of extended-spectrum betalactamases has contributed to the emergence of multi-drug resistance among bacteria such as Klebsiella and *Escherichia coli*. In contrast to a study by Altoparlak et al [21], the prevalence of ESBL among Pseudomonas spp. was low (12%) in our study. But the increased detection of ESBL in Acinetobacter spp (58.88%) is in contrast to most of the previous studies which is an indicator of emergence of Acinetobacter spp. as an important multi-drug resistant nosocomial pathogen in our burns unit.

Nine (18%) isolates of *Pseudomonas aeruginosa*, 28(77.77%) isolates of *Acinetobacter baumannii*, one (14.28%) isolate of *Klebsiella pneumoniae* were carbapenemase (MBL) producers. A study conducted by Avneet Kaur et al [22] showed 61% of *Acinetobacter baumannii* were Carbapenemase producers which is consistent with our study. Study conducted by Nahia et al has reported 66.6% of MBL producing isolates were Acinetobacter species, 89.6% Pseudomonas species and 70% Klebsiella species. The lower prevalence of MBL among Pseudomonas and Klebsiella species in our study is in contrast to many of the previous studies.

A high percentage of multi-drug resistant isolates is probably due to empirical use of broad spectrum antibiotics and non-adherence to hospital antibiotic policy. Once MDR strains become established in the hospital environment, they can persist for months. Therefore careful microbiological surveillance and in vitro testing before the start of antibiotic therapy and restrictive antibiotic policy may be of great help in prevention and treatment of MDR isolates in burn units and thus reduction of overall infection related morbidity and mortality. The overcrowding in burns ward is an important cause of cross infection and must be avoided in order to control hospital acquired infection.

Conclusion:

Multi-drug resistance in Gram negative bacteria causing burn wound infections due to the production of various beta lactamases is growing at an alarming rate. In our study also, the incidence of ESBLs and Carbapenemases were found to be high. The prevalence of multi-drug resistant organisms is to be considered as a warning sign for the emerging spread of antibiotic resistance and the need for urgent implementation of strict antibiotic policy and infection control measures. For the development of antibiotic policy, a good communication must exist between the surgeon and the microbiologist. Timely change of antibiotics is essential for good healing. For infection control, the revival of activities of Infection Control Committee in the Hospital is necessary.

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