Comparison of Antibiotic Susceptibility Pattern of *Pseudomonas aeruginosa* from Critical and Non-Critical Areas at a Tertiary Care Hospital

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ABSTRACT

BACKGROUND

Pseudomonas aeruginosa is the most common gram-negative bacterium associated with nosocomial infections. Active observation of changes in antibiotic resistance of *Pseudomonas aeruginosa* is necessary for the selection of appropriate antimicrobial agent for empirical therapy. This study was conducted to determine the antibiotic susceptibility pattern of *Pseudomonas aeruginosa* isolated from various clinical samples collected from patients admitted in critical and non-critical areas.

METHODS

Pseudomonas aeruginosa isolates obtained from various samples in critical and non-critical areas during one-year period were included in the study. The isolates were identified using standard laboratory procedures, and the susceptibility was checked using the Kirby-Bauer disk-diffusion assay according to Clinical and Laboratory Standard Institute (CLSI) guidelines-2019.

RESULTS

During one-year period, 224 *Pseudomonas aeruginosa* isolates were isolated from patients admitted to various units, out of which 143 (63.8 %) were from non-critical areas and 81 (36.1 %) were from critical areas. Highest isolation from non-critical area was observed from pus sample 49 (34.26 %) followed by sputum and urine samples 46 (32.16 %) and 27 (16.78 %) respectively. *Pseudomonas aeruginosa* isolated from critical areas were mainly from endotracheal aspirates 36 (44.4 %) and all were multidrug resistant (MDR) (36.3 %).

CONCLUSIONS

The present study helps in understanding the emergence of MDR strains in intensive care units (ICUs). Thus, regular surveillance of antibiotic susceptibility pattern is important for reducing the healthcare associated infection (HAI) rates and antimicrobial resistance.

KEYWORDS

Antibiotic Susceptibility Pattern, *Pseudomonas aeruginosa*, Critical and Non-Critical Areas

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BACKGROUND

Pseudomonas aeruginosa is an aerobic, gram negative, motile, catalase and oxidase positive bacterium whose pathogenicity includes production of toxins such as exotoxin A, exoenzyme S and T, and production of several proteolytic enzymes (e.g., elastase) and haemolysins (e.g., phospholipase C).[1] They are the commonest non-fermenting gram negative pathogens isolated from the clinical specimens associated with various infections such as urinary tract infections (UTIs), skin and soft tissue infections and among burns and in immunocompromised patients.[2,3] Hospital-acquired infections (HAIs), also called nosocomial infections have led to an increase in morbidity, mortality and healthcare costs due to such opportunistic pathogens.[4] Although the intensive care units (ICUs) account for fewer number of beds in most hospitals, more than 20 % of all nosocomial infections are acquired in ICUs.[5]

Due to infections with pseudomonas, patients admitted in intensive care unit (ICU) are more prone to HAIs 5 to 7 - fold as compared to non-critical areas.[4] The choice of empiric treatment in ICUs is difficult since there is a need to balance between broad spectrum and too narrow spectrum of antibiotics.[6] Rise in multidrug-resistant pseudomonas is limiting the available therapeutic options for infections in the critical areas.[7]

The severe outcome and high morbidity and mortality due to *Pseudomonas aeruginosa* infection emphasize the prompt need for obtaining data along with the resistance pattern that are beneficial in guiding physicians for appropriate antibiotic therapy providing valuable understanding from proper supervision of antibiotic.

METHODS

This is a cross-sectional study conducted in the bacteriology laboratory of Department of Microbiology. The non-duplicate clinical isolate from various clinical specimens were included in our study. During the one-year study period, Jan 2019 to Dec 2019 samples of blood, sputum, pus, urine and body fluids such as tracheobronchial aspirates, bronchoalveolar lavage (BAL) fluid, cerebrospinal fluid (CSF), ascitic, pleural and peritoneal fluid received from the inpatient department (IPD) patients were processed in the bacteriology laboratory as per the standard protocol.[8]

Antibiotic susceptibility testing was performed using the Kirby–Bauer disk-diffusion method according to the clinical and laboratory standards institute (CLSI) guideline 2019.[9] Antibiotic disks used for performing antibiotic susceptibility testing were from HiMedia. Following antibiotics were used: aztreonam (30 mcg), ceftazidime (30 mcg), ciprofloxacin (5 mcg), gentamicin (10 mcg), imipenem (10 mcg), meropenem (10 mcg), piperacillin / tazobactam (100 / 10 mcg), tobramycin (10 mcg), piperacillin (100 mcg), ticarcillin (75 mcg), polymyxin B (300 units), levofloxacin (5 mcg), nitrofurantoin (300 mcg) and norfloxacin (10 mcg).[9] Result generated from the data was analysed using chi-square test.

RESULTS

During the study period, 2024 non-repeat samples were tested culture positive. Out of which, 433 (21.39 %) were non-fermenters, 944 (46.64 %) were fermenters and 647 (31.96 %) were gram positive cocci. Among non-fermenters, most common pathogen was *Pseudomonas aeruginosa* 224 (51.73 %) followed by acinetobacter species (40 %), proteus species (6.6 %) and other non-fermenters (3.05 %). When the distribution of *Pseudomonas aeruginosa* strains was evaluated according to the site and areas from which samples were taken; among non-critical areas maximum 49 (10.6 %) were isolated from pus sample and from critical areas maximum 40 (19.8 %) were isolated from endotracheal aspirate. [Table 1]

Distribution among Critical and Non-Critical Areas

Pseudomonas aeruginosa was found in 224 (11.067 %) samples, out of which 143 (63.8 %) were from non-critical areas and 81 (36.1 %) from critical areas. Out of 143 isolates from non-critical areas highest isolation was observed from surgery ward (30.76 %), followed by medicine ward (25.17 %), respiratory ward (23.77 %), obstetrics and gynaecology ward (12.58 %), orthopaedics (4.89 %) and paediatrics (2.79 %). Among 81 isolates from critical areas highest isolation was from medicine intensive care unit (MICU) (56.79 %), followed by surgery intensive care unit (SICU) (29.62 %), respiratory intensive care unit (RICU) (12.34 %) and paediatric intensive care unit (PICU) (1.23 %). For both critical and non-critical areas the p-value was highly significant ($P < 0.00001$) [Table 2, 3].

Prevalence rate of *P. aeruginosa* was 11.0 %. Most common specimen isolated from non-critical area was pus (61.2 %) from surgery ward and from critical area it was endotracheal aspirate (38.8 %) from MICU.

Specimens	Critical		Non-Critical		P-Value
	Total No. of Culture Positive N	*P. aeruginosa* Isolates n (%)	Total No. of Culture Positive N	*P. aeruginosa* Isolates n (%)	
Sputum	0	0	169	46 (27.2)	
Pus	85	13 (15.3)	461	49 (10.6)	P = 0.01
Body fluids	26	5 (19.2)	27	3 (11.1)	(significant)
Urine	139	11 (7.9)	458	27 (5.9)	
Blood	212	12 (5.6)	203	18 (8.8)	
Endotracheal aspirate	202	36 (17.8)	0	0	
Stool	7	0	35	0	
Total	**671**	**81 (12.0)**	**1353**	**143 (10.5)**	

Table 1. Distribution of Pseudomonas Aeruginosa

Antibiotic Susceptibility Pattern

Antibiotic susceptibility profile of *Pseudomonas aeruginosa* isolates was determined using Kirby-Bauer disk-diffusion method. On analysis of antibiotic susceptibility profile, following findings were observed:

1. In non-critical areas the isolates showed highest resistance to meropenem (41.95 %) followed by levofloxacin (37.76 %), ciprofloxacin (33.56 %), imipenem (20.27 %) and 100 % sensitivity was observed against polymyxin B and colistin [Table 4.1].
2. In critical area, all *Pseudomonas aeruginosa* isolates were found to be multi drug resistant (MDR) (36.3 %) [Table 4.2].

MDR is defined as isolates resistant to at least one antibiotic in 3 or > 3 different classes of antibiotics.[10]

Specimens	Non-Critical Areas N = 143						
	Medicine (36)	Surgery (44)	Obs / Gynae (18)	Paediatrics (4)	Respiratory Medicine (34)	Orthopaedics (7)	Total
Pus	7 (14.3)	30 (61.20	7 (14.3)	-	-	5 (10.2)	49 (34.26)
Urine (catheterised)	2 (40)	2 (40)	1 (20)	-	-	-	5 (3.4)
Urine (non-catheterised)	9 (40.9)	4 (18.1)	3 (13.6)	2 (9)	3 (13.6)	1 (4.5)	22 (15.3)
Body fluids	1 (33.3)	-	-	-	2 (66.6)	-	3 (2)
Blood	7 (38.9)	3 (16.6)	5 (27.8)	2 (11.1)	1 (5.5)	-	18 (12.5)
Sputum	10 (21.7)	5 (10.8)	2 (4.3)	-	28 (60.8)	1 (2.1)	46 (32.1)
P-value	P < 0.00001 (Highly Significant)						

Table 2. Pseudomonas aeruginosa from Non-Critical Areas

Specimens	Critical Areas N = 81				
	MICU = 46	SICU = 24	PICU = 01	RICU = 10	Total
Pus	5 (38.4)	7 (53.8)	-	1 (7.7)	13 (16)
Urine (catheterised)	10 (91)	1 (9)	-	-	11 (13.5)
Body fluids	8 (80)	1 (20)	-	-	9 (11.1)
Blood	9 (75)	2 (16.6)	1 (8.3)	-	12 (14.9)
Endotracheal aspirate	14 (38.8)	13 (36.1)	-	9 (25)	36 (44.4)
P-value	P < 0.00001 (highly significant)				

Table 3. Pseudomonas aeruginosa from Critical Areas

Antibiotics	Resistant N (%)	Sensitive N (%)
Piperacillin	39 (27.27)	104 (72.72)
Ticarcillin	38 (26.50)	105 (73.42)
Piperacillin-tazobactam	28 (19.58)	117 (81.8)
Ceftazidime	43 (30.0)	102 (71.3)
Ciprofloxacin	48 (33.56)	97 (67.83)
Levofloxacin	54 (37.76)	91 (63.63)
Gentamicin	42 (29.37)	103 (72.02)
Tobramycin	26 (18.18)	119 (83.21)
Imipenem	29 (20.27)	116 (81.11)
Meropenem	60 (41.95)	85 (59.44)
Aztreonam	36 (25.17)	109 (76.22)
Polymyxin B	0 (0)	143 (100)
Colistin	0 (0)	143 (100)
Nitrofurantoin	03 (60)	02 (40)
Norfloxacin	02 (40)	03 (60)

Table 4.1. Antibiotic Susceptibility Pattern of Pseudomonas aeruginosa from Non-Critical Areas - Total Number = 143

Antibiotics	Resistant N (%)	Sensitive N (%)
Piperacillin	81 (100)	0 (0)
Ticarcillin	65 (80.24)	16 (19.75)
Piperacillin-tazobactam	81 (100)	0 (0)
Ceftazidime	81 (100)	0 (0)
Ciprofloxacin	66 (81.48)	15 (18.51)
Levofloxacin	60 (74.07)	21 (25.92)
Gentamicin	81 (100)	0 (0)
Tobramycin	81 (100)	0 (0)
Imipenem	67 (82.72)	14 (17.28)
Meropenem	66 (81.48)	15 (18.51)
Aztreonam	67 (82.72)	14 (17.28)
Polymyxin B	0 (0)	81 (100)
Colistin	0 (0)	81 (100)

Table 4.2. Antibiotic Susceptibility Pattern of Pseudomonas aeruginosa from Critical Area - Total Number = 81

DISCUSSION

Despite the improvements in the clinical setting during the last decade, healthcare-associated infections are a potentially higher source of morbidity and mortality particularly in ICU admitted patients.[11] Several risk factors, such as severity of illness, underlying conditions, immunosuppression, exposure to multiple invasive devices and procedures and increased patient contact with healthcare personnel in a small specialised area may contribute to the increased risk of infection in ICU patients.[11] The proportion of healthcare-associated infections caused by MDR gram-negative bacteria is on the rise, due to the indiscriminate use of the antimicrobial agents.

"In our study, 11.06 % prevalence rate of *Pseudomonas aeruginosa* were observed which was similar to the study done by Chaitali Pattanayak et al. (2013) (13.2 %).[12] On the contrary, higher prevalence rate of 32.1 % and lower prevalence rate of 2.1 % was observed by Rajat et al. (2012) and O KO et al. (2010) respectively.[13,14] The varied prevalence of *Pseudomonas aeruginosa* rates in different places may be attributed to the clinical samples received for examination, studied population, type of hospitals and geographical locations. The present study showed higher isolation of *Pseudomonas aeruginosa* from pus sample (34.26 %) in non-critical area which is in accordance with the findings (47.11 %) reported by Senthamarai S et al. (2014).[15] On the contrary, Shreshta S et al. (2016) reported higher isolation from sputum and urine samples (36.3 %) followed by pus and devices (9.8 %).[16] Whereas, in critical area, higher isolation was observed from endotracheal aspirate (19.8 %) similar to the study done by Kumari M et al. (2019) who reported 23.3 % isolates.[17] On the other hand higher isolation rate (28 %) of endotracheal aspirate sample was observed by Harris A. D et al. (2016).[18] The distribution of *Pseudomonas aeruginosa* among non-critical area was highest among the surgery ward (30.76 %) in the present study which coincided with the study done by Ranjan K et al. (2010) where 29.6 % pseudomonas was isolated from post-operative patients.[19] However, lower isolation (22 %) was recorded by Kumari M et al. (2019).[17] Among the critical area, our study showed maximum isolations from MICU (56.79 %), whereas lower isolation of 42.9 % was observed by the study done by Saeed M et al. (2018)."[20]

"Antibiotic susceptibility pattern of *Pseudomonas aeruginosa* isolated from non-critical areas showed resistance to meropenem (41.95 %), levofloxacin (37.76 %) and ciprofloxacin (33.56 %). The above findings correlate with the studies where similar resistance pattern of 33.3 % against ciprofloxacin and 44.8 % resistance against meropenem was observed by Bayani M et al. (2013) and Rytekar Namita A et al. (2017).[4,16] Resistance rate against imipenem was found to be 20.27 % which is in accordance (20.8 %) with the study published by Raakhee et al. in 2014.[21] However, isolates from critical area were resistant to multiple classes of antibiotics [piperacillin, piperacillin-tazobactam, 3rd generation cephalosporins, aminoglycosides and carbapenems] which was similarly reported by Senthamarai S et al. (2014).[22] 100 % sensitivity against polymyxin B and colistin was observed in both the critical

and non-critical areas. From the above findings, we have observed that sensitivity against carbapenems and fluroquinolones is still higher in non-critical areas than the sensitivity in the critical areas. This emphasises the urgent need for rational use of antimicrobial agents and strict adherence to the concept of reserve drugs" so as to minimize the misuse of currently available antibiotics.[23] Therefore, regular antimicrobial susceptibility surveillance is essential for area-wise monitoring of the resistance patterns against pathogenic microorganisms.[19]

CONCLUSIONS

Present study focused on antibiotic susceptibility pattern of *Pseudomonas aeruginosa* from various clinical samples in the critical and non-critical wards. It contributes in understanding the emergence of MDR strains in ICUs which is increasing at an alarming rate. Thus, regular surveillance of antibiotic susceptibility pattern is important for reducing the HAI rate and antimicrobial resistance.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
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