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RISK FACTORS FOR CARBAPENEM-RESISTANT *Pseudomonas aeruginosa* IN A UNIVERSITY HOSPITAL

Fatores de risco para *Pseudomonas aeruginosa* resistente aos carbapenem em um hospital universitário

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Abstract:
The increase in hospital environment's Carbapenem-resistant *Pseudomonas aeruginosa* (CRPA) prevalence in Latin America is related to risk factors. Thus, identification of them can contribute to microbial resistance control. This study aimed to identify association between risk factors and *Pseudomonas aeruginosa* resistance to carbapenems in a university hospital. A quantitative approach case-control study was performed, with data collected from medical records and forms from Infection Control Service Related to Health Care. Patients admitted between January 2016 and December 2017 and hospitalized for at least 24 hours, with positive culture for *P. aeruginosa*, were included. Odds Ratio and Fisher's Exact Test were used for statistical analysis. 91 cultures were evaluated for resistance and 47 for risk factors. Factors that reflected greatest chance of developing resistance to carbapenems were: prior tracheostomy use (OR: 6.050, CI: 1.542 – 23.735); pulmonology sector hospitalization (OR: 5.882, CI: 0.604 - 57.296); prior aminoglycosides and colistin use (OR: 4.167, IC: 0.400 - 43.379); Intensive Care Unit (ICU) admission (OR: 3.818, CI: 1.043 - 13.981); prior mechanical ventilation use (OR: 3.521, CI: 0.952 - 13.026); male gender (OR: 2.727, CI: 0.825 - 9.011); and prior carbapenems use (OR: 2.600, CI: 0.796 – 8.488). Furthermore, this pathogen showed greater resistance for 4th generation cephalosporin and sensitivity for colistin. In conclusion, previous tracheostomy use is the main risk factor for CRPA and possible risk factors reflect in greater chances for resistance to carbapenems in teaching hospital.
Keywords: Pseudomonas aeruginosa; Risk factors; Anti-infective agentes; Drug resistance microbial.

Resumo:
O aumento da prevalência de *Pseudomonas aeruginosa* resistente a Carbapenem (CRPA) em ambiente hospitalar na América Latina está relacionado a fatores de risco. Dessa forma, a identificação dos mesmos pode contribuir para o controle da resistência microbiana. Este estudo objetivou identificar a associação entre os fatores de risco e a resistência de *Pseudomonas aeruginosa* aos carbapenêmicos em um hospital universitário. Foi realizado um estudo caso-controle de abordagem quantitativa, com coleta de dados em prontuários e fichas do Serviço de Controle de Infecção Relacionada à Assistência à Saúde. Foram incluídos pacientes internados entre janeiro de 2016 e dezembro de 2017 e internados por pelo menos 24 horas, com cultura positiva para *P. aeruginosa*. Odds Ratio e Teste Exato de Fisher foram usados para análise estatística. 91 culturas foram avaliadas para resistência e 47 para fatores de risco. Os fatores que refletiram a maior chance de desenvolver resistência aos carbapenêmicos foram: uso prévio de traqueostomia (OR: 6,050, IC: 1,542 -

23,735); internação no setor de Pneumologia (OR: 5,882, IC: 0,604 - 57,296); uso anterior de aminoglicosídeos e colistina (OR: 4,167, IC: 0,400 - 43,379); admissão em Unidade de Terapia Intensiva (UTI) (OR: 3,818, IC: 1,043 - 13,981); uso prévio de ventilação mecânica (OR: 3,521, IC: 0,952 - 13,026); sexo masculino (OR: 2,727, CI: 0,825 - 9,011); e uso prévio de carbapenêmicos (OR: 2.600, CI: 0,796 - 8,488). Além disso, esse patógeno apresentou maior resistência à cefalosporina de 4ª geração e sensibilidade à colistina. Em conclusão, o uso prévio de traqueostomia é o principal fator de risco para CRPA e possíveis fatores de risco refletem em maiores chances de resistência aos carbapenêmicos em hospital universitário.
Palavras-chave: Pseudomonas aeruginosa; Fatores de risco; Anti-infecciosos; Resistência microbiana a medicamentos.

1. Introduction

Microbial resistance has become a serious worldwide problem, associated with increased hospital stay length, treatment costs and high morbidity and mortality rates in affected patients. Indiscriminate and incorrect antimicrobial use in community and in hospitals is highlighted as a risk factor for appearance and spread of microbial resistance[1].

In health services, the main resistant microorganisms are: *Acinetobacter baumannii*; carbapenem-resistant *Pseudomonas aeruginosa* (CRPA); *Enterobacteria* producing broad-spectrum beta-lactamases (ESBL) and carbapenemases (ERC); *Enterococcus spp.* vancomycin resistant (VRE); *Staphylococcus aureus* resistant to oxacillin (MRSA) and vancomycin (VISA)[2].

The European Center for Disease Prevention (ECDP) and the Epidemiological Report 2016 released data presented by 15 European Union countries, Iceland, Liechtenstein and Norway, reporting on Health Care Associated Infections (HAIs) acquired in intensive care unit (ICU). Data revealed *Pseudomonas aeruginosa* was considered the pathogen most frequently isolated in bloodstream infections, urinary tract infections and pneumonia[3].

Furthermore, according to the International Hospital Infection Control Consortium report, data from a surveillance study from January 2010 to December 2015 in 703 ICUs worldwide demonstrated HAIs caused by *P. aeruginosa* showed a high resistance level to several antibiotics[4].

The World Health Organization presents CRPA as a pathogen of critical priority for new antibiotics development. This microorganism is one of gram-negative bacteria that cause infections

associated with medical care in hospitalized patients. Due to increasing resistant *P. aeruginosa* rates, there is an increase in HAIs in institutions[5].

CRPA prevalence increase in hospital environment in Latin America portrays an emerging challenge for public health, due to active therapeutic agents' limitation for this pathogen's adequate treatment. Labarca *et al*.[6] obtained about 66% resistance to carbapenems for *P. aeruginosa*, over a period of 11 years (2002 - 2013).

This increase in resistance prevalence is related to risk factors, among which we can mention: previous antimicrobials use, medical devices use, ICU admission, underlying diseases, patient's clinical characteristics and hospital stay[7,8].

Given this context, this study aimed to identify whether risk factors, such as stay length, invasive devices use, underlying pathology and previous antimicrobials use are associated with *P. aeruginosa* resistance to carbapenems at the institution in study.

It is hoped, based on risk factors analysis for *P. aeruginosa* acquisition, results of this study can support development and/or revision of empirical treatment protocols for infections, avoiding resistant bacteria selection, as well as help guide actions of infection control services and other professionals involved in patient care.

2. Materials and methods

2.1. *Study Design*

This is a case-control study with quantitative analysis.

2.2. *Study Location*

The study was carried out at the University Hospital of the Federal University of Sergipe (HU/UFS), located in Aracaju, Sergipe (SE), Brazil. This medium-sized teaching hospital is affiliated to the Unified Health System (SUS) and serves Aracaju's population, municipalities in Sergipe's

countryside and neighboring states. It had 78 active hospital beds, five of which were ICU, 22 surgical, 36 clinical and 15 pediatric.

2.3. *Study Sample*

Results of positive cultures for *P. aeruginosa* obtained from patients admitted to the institution between January 2016 and December 2017 for this study were evaluated.

2.4. *Inclusion Criteria*

Patients admitted to the University Hospital of Sergipe from January 2016 to December 2017 who remained hospitalized for at least 24 hours and who presented positive microbiological culture results for *P. aeruginosa* were included. Samples for microbiological analysis were collected from different sites, totaling 99 positive cultures. For this study, first positive culture for *P. aeruginosa* was considered for patients who obtained more than one diagnostic culture for this pathogen, totaling 47 cultures analyzed.

2.5. *Exclusion Criteria*

From positive cultures for *P. aeruginosa*, eight samples classified as contamination were excluded. In addition, cultures classified as Surgical Site Infection were excluded for resistance to carbapenems' risk factors analysis, because this infection was diagnosed in patient's readmission in the institution under study.

2.6. *Data Collection*

Positive diagnostic culture data for *P. aeruginosa* were obtained from medical records and forms of search for surveillance of the Infection Control Service Related to Health Care, followed by demographic, clinical and microbiological data and research interest variables collection, which were consolidated in a specific form directed to this study.

2.7. *Microbiological Cultures and Antibiogram*

Cultures and respective antibiograms are regularly processed in the hospital's Microbiology laboratory under study in automated equipment (Siemens Microscan), according to established criteria by the Clinical and Laboratory Standard Institute's (CLSI) standards[9,10]. Cultures with

antibiogram showing antibiotic with intermediate resistance were classified as resistant group for analysis, since they need adjustments in antimicrobial treatment. Antimicrobial agents tested for this microorganism were: amikacin, cefepime, ciprofloxacin, colistin, gentamicin, imipenem, meropenem and piperacillin/tazobactam (pip/tazo), and they were grouped into classes for risk factors analysis.

Cultures clinical interpretation follows diagnostic criteria defined by the National Health Surveillance Agency (ANVISA/Brazil) and as determined by the CLSI, which define as: Colonization, Contamination, Community Infection (HF), HAI of institution and HAI Admission. These culture results were analyzed and classified, weekly, by the infectologist at the Infection Control Service Related to Health Care and by the researcher.

2.8. *Ethical Considerations*

This research was approved by the Ethics and Research Committee of the Federal University of Sergipe (CAAE n ° 74181317.8.0000.5546).

2.9. *Statistical Analysis*

Tabulation and organization of database occurred using the Excel 365 program and then analyzed statistically by software R version 3.5.0, where results were obtained in absolute and relative frequency. Confidence interval used was standardized at 95% to present statistical significance ($p < 0.05$).

To assess variables probability as possible risk factors in relation to resistance to carbapenems, Odds Ratio was used, as well as Fisher's Exact Test was used to assess distributions between variables in relation to sensitivity to carbapenems. To analyze exposure time as a numerical variable based on sensitivity to carbapenems, it was necessary to verify scores' normal distribution using the Kolgomorov-Smirnov test with Lilliefors correlation. After determining nonparametry

(heterogeneous distribution), the U Mann-Whitney test was used to assess exposure time distribution in relation to sensitivity.

3. Results

During evaluated period, 47 patients who had HAI or colonization by *P. aeruginosa* analyzed in the study, with 44.7% (21) of patients obtaining cultures with CRPA. Individuals with CRPA had an average age of 52.6 years (standard deviation of 19.809), while individuals with carbapenem-susceptible *P. aeruginosa* (CSPA) had an average age of 54 years (standard deviation of 22.173).

Regarding patient's gender, it was observed 56% (14) of male patients were affected by CRPA. It was also found males were almost three times more likely to develop resistance to carbapenems than females (OR = 2.727) (Table 1).

As for hospitalization sectors, only pulmonology and ICU sectors showed greater chances of developing resistance to carbapenems, with almost six and four times more chances of developing resistance to carbapenems, respectively (OR = 5.882; OR = 3.818). It was emphasized 80% (4) and 66.7% (10) of patients admitted to these sectors, respectively, presented CRPA. (Table 2).

When evaluating hospital departures (discharge or death), it was identified patients affected by CRPA were almost four times more likely to die (OR = 3.667). However, in statistical analysis, no significant difference was identified in distribution between sensitivity to carbapenems and patient outcomes ($p > 0.05$) (Table 3).

When observing patient's underlying diseases, the most common was infectious-parasitic disease, affecting 40.4% (19), but none of diseases showed a statistically significant difference between sensitivity and resistance to carbapenems ($p> 0.05$). However, skin and respiratory disease reflected a greater chance of developing resistance to carbapenems, when compared to other diseases (OR = 4.167; OR = 2.824) (Table 4).

Regarding patient's history, it was observed 61.7% (29) of patients did not undergo surgery during hospitalization and 51.1% (24) had no previous hospitalization. None of variables showed a difference in distribution between history and resistance to carbapenems (Table 5).

Regarding previous medications use, the most used antimicrobials class was 4th generation cephalosporin with 51.1% (24), followed by carbapenems with 48.9% (23). Regarding corticosteroids use, 59.6% (28) of patients used them. Only previous quinolones and corticoids use was not considered a risk factor for CRPA (OR = 0.210; OR = 1.192). Other drugs showed greater chances of developing resistance to carbapenems, with emphasis on aminoglycosides and colistin (OR = 4.167), followed by carbapenems (OR = 2.600) and fourth generation cephalosporin, with 1.5 times more chances to develop resistance (OR = 1.556) (Table 6).

The most used invasive device in patients was central venous catheter, present in 80.8% (38) patients, followed by foley catheter with 70.2% (33), mechanical ventilation with 52.5% (21) and tracheostomy with 31.9% (15). Regarding tracheostomy use, 73.3% (11) of individuals who used it obtained results with CRPA, showing a statistically significant difference in relation to this device use when compared to resistance to carbapenems ($p < 0.05$) (Table 7).

Thus, it was identified tracheostomy use increased chance of developing resistance to carbapenems by six times (OR = 6.050), being considered the main risk factor. In addition to tracheostomy, mechanical ventilation and central venous catheter devices stand out (OR = 3.521; OR = 3.500, respectively), considered important factors influenced resistance to carbapenems (Table 7).

Regarding hospital stay length until collection time, it was note patients with resistant culture had a median of 25 days, ranging from 0 to 71 days, while patients with sensitive culture had a median of 27.5, ranging from 0 to 339 days, with no statistical difference between them when analyzing resistance to carpabenems ($p > 0.05$) (Table 8).

4. Discussion

Findings of this present study reveal patients affected by CRPA were almost four times more likely to die, compared to patients affected by sensitive microorganisms. Similarly, other researchers

showed a strong relationship between microbial resistance and increase in mortality rates, directly reflecting on costs related to health services[6,11,12].

In analyzing association between patient's sex and CRPA strains identification, this study identified males were almost 3 more times likely to develop resistance to carbapenems than females. In a study by Lin *et al*.[13], male gender was presented as the one most likely to develop bacteria resistant to carbapenems, demonstrating similarity with results obtained.

This finding may be associated with less male concern in relation to treatments or basic prophylaxis, causing greater losses in more serious situations or greater chance of developing complications in diseases would be easier to treat. Thus, although there is no predilection for P. aeruginosa for one of sexes by *P. aeruginosa*, both in infections and in colonization, this can be considered a factor reflects a greater chance to develop resistance.

As for hospitalization sector, results demonstrate patients hospitalized in pulmonology and ICU, whether colonized or infected with *P. aeruginosa*, were almost 6 and 4 more times likely, respectively, to develop resistance to carbapenems. A similar result was found by Nóbrega *et al*.[14], who states ICU admission is a risk factor for resistance, especially in infection or colonization cases, with colonization being a relevant part of bacterial load in this sector, as well as the main source of bacterial transmission.

In ICU and pulmonology sectors, respectively, critical patients and individuals with respiratory problems are admitted, who most need invasive devices use and they are commonly submitted to empirical antimicrobial therapy, which may justify higher resistance levels. According to Nóbrega *et al*.[14], devices can enable pathogen introduction and, consequently, increase mortality rates associated with inadequate empirical therapy. Furthermore, according to Santos & Pereira[15], ICU may be associated with resistance to carbapenems as it is a sector with a high frequency of prescription for this antimicrobials class, due to its broad spectrum of action.

Analyzing underlying diseases, this study proved skin and respiratory diseases presented themselves as factors that reflected greater chances in the resistance to carbapenems. Data compatible

with the Centers for Disease Control and Prevention (CDC)[16], which describes there is a strong link between *P. aeruginosa* and respiratory and epithelial diseases, since these areas are main focuses of gram-negative microorganism.

Regarding previous medications use, current study revealed previous aminoglycosides, colistin, carbapenems and 4th generation cephalosporins use reflected greater chances in resistance to carbapenems. These results are in line with studies by Lin *et al.*[13] and Garcia *et al.*[17], in which aminoglycosides, cephalosporins, carbapenems and colistin use were risk factors, which may double or even quadruple resistance chances, depending on infection classification.

According to Kosai *et al.*[18], this is justified by the fact carbapenems and aminoglycosides are commonly prescribed as an empirical treatment for infection caused by non-fermenting Gram-Negative Bacillus, exposing bacteria to these antimicrobials and facilitating resistance by them. Harris *et al.*[19] adds inappropriate antibiotics use or their prior use to antibiogram result produces several adverse effects on human body, as well as allowing bacterial genetic triggering, which induce new mechanisms of bacterial resistance to antibiotics.

Results obtained in this study did not demonstrate previous quinolones use can be considered a risk factor, which does not corroborate with study by Tsao *et al.*[20], who states antimicrobials based on nalidixic acid (quinolones) use was a risk factor of almost 3 times more likely to develop CRPA.

In contrast, there is no association between vancomycin, ampicillin + sulbactam and first and second-generation cephalosporins use with CRPA. This may be related to unusual or low frequency use in hospital settings, being limited to specific agents. However, it is important to note, despite not being a CRPA risk factor, other antibiotics misuse can cause resistance to other microorganisms, such as indiscriminate vancomycin use that can induce resistance in enterococcus[7].

In association analysis between devices use and resistance, results of present study demonstrated previous tracheostomy use was considered the main risk factor for *P. aeruginosa* resistance to carbapenems, followed by mechanical ventilation and central venous catheter. In agreement with this, Boyle & Zembower[21], Dantas *et al.*[22] and Venier *et al.*[23] also identified use of

devices connected to respiratory system was related to development of resistance for microorganism, as well as prolongation time of its use. In addition, according to Lima *et al*.[24], mechanical ventilation use can be considered a risk factor for development of pneumonia associated with mechanical ventilation, due to bacterial ease of producing biofilm on device wall.

Despite invasive devices and previous antimicrobials use are considered as important CRPA risk factors, their use is considered a rule in hospital environments, requiring new strategies for prevention of infections development, and, consequently, minimize resistance[17].

5. Conclusion

This study shows previous tracheostomy use was the main risk factor for resistance to carbapenems in *Pseudomonas aeruginosa* and reports possible factors that reflected greater chances for CRPA. It becomes important to identify pathogens early, analyze antibiogram and manage antibiotics (rational antibiotics use) to assist clinicians in infections treatment, as well as contain spread of multi-resistant microorganisms through knowledge of this agent's resistance mechanisms, according to each institution, reducing morbidity and mortality of patients admitted to hospitals.

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Table 1. Gender evaluation as a risk factor for infection/colonization by *Pseudomonas aeruginosa* resistant to carbapenems at a university hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Gender n (%)		Total n (%)	p [a]	OR (IC 95%)[b]
	Male	*Female*			
Resistant	14 (56)	7 (31.8)	21 (44.7)	0.143	2.727 (0.825 – 9.011)
Sensitive	11 (44)	15 (68.2)	26 (55.3)		
Total	25 (53.2)	22 (46.8)	47 (100)		

(a) Fisher's Exact Test and (b) Odds Ratio

Table 2. Hospitalization sector evaluation as a risk factor for infection/colonization by *Pseudomonas aeruginosa* resistant to carbapenems at a university hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Hospitalization Sector n (%)		Total n (%)	p[a]	OR (IC 95%)[b]
	Pneumology	*Other sector*			
Resistant	4 (80)	17 (40.5)	21 (44.7)	0.158	5.882 (0.604 – 57.296)
Sensitive	1 (20)	25 (59.5)	26 (55.3)		
Total	5 (10.6)	42 (89.3)	47 (100)		
	Intensive Care Unit	*Other sector*			
Resistant	10 (66.7)	11 (34.4)	21 (44.7)	0.059	3.818 (1.043 – 13.981)
Sensitive	5 (33.3)	21 (65.6)	26 (55.3)		
Total	15 (31.9)	32 (68.1)	47 (100)		
	Medical Clinic	*Other sector*			
Resistant	3 (30)	18 (48.6)	21 (44.7)	0.475	0.452 (0.101 – 2.024)
Sensitive	7 (70)	19 (51.4)	26 (55.3)		
Total	10 (21.3)	37 (78.7)	47 (100)		
	Infectology	*Other sector*			
Resistant	3 (27.3)	18 (50)	21 (44.7)	0.300	0.375 (0.085 – 1.646)
Sensitive	8 (72.7)	18 (50)	26 (55.3)		
Total	11 (23.4)	36 (76.6)	47 (100)		
	Surgical Clinic	*Other sector*			
Resistant	1 (16.7)	20 (48.8)	21 (44.7)	0.204	0.210 (0.023 – 1.958)
Sensitive	5 (83.3)	21 (51.2)	26 (55.3)		
Total	6 (12.7)	41 (87.2)	47 (100)		

(a) Fisher's Exact Test and (b) Odds Ratio.

Table 3. Analysis of *Pseudomonas aeruginosa* resistance profile in infection/colonization in patients outcomes at a university hospital from Sergipe, 2016-2017.

Outcome	**Carbapenem Sensitivity/Resistance n (%)**		**Total n (%)**	**p[a]**	**OR (IC 95%)[b]**
	Resistant	Sensitive			
Death					
Yes	11 (52.4)	6 (23.1)	17 (36.2)	0.066	3.667 (1.049 – 12.814)
No	10 (47.6)	20 (76.9)	30 (63.8)		
Total	21 (44.7)	26 (55.3)	47 (100)		
Discharge					
Yes	11 (52.4)	6 (23.1)	17 (36.2)	0.250	0.481 (0.148 – 1.562)
No	10 (47.6)	20 (76.9)	30 (63.8)		
Total	21 (44.7)	26 (55.3)	47 (100)		
Transfer					
Yes	0 (0)	4 (15.4)	4 (8.5)	0.117	-
No	21 (100)	22 (84.6)	43 (91.5)		
Total	21 (44.7)	26 (55.3)	47 (100)		

(a) Fisher's Exact Test and (b) Odds Ratio

Table 4. Underlying diseases as a risk factor for infection/colonization by carbapenem-resistant *Pseudomonas aeruginosa* at a university hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Disease n (%)		Total n (%)	p[a]	OR (IC 95%)[b]
	Respiratory Disease	*Another disease*			
Resistant	3 (75.0)	18 (41.9)	21 (44.7)	0.311	4.167 (0.400 – 43.379)
Sensitive	1 (25.0)	25 (58.1)	26 (55.3)		
Total	4 (8.5)	43 (91.5)	47 (100)		
	Skin Disease	*Another disease*			
Resistant	4 (66.7)	17 (41.5)	21 (44.7)	0.386	2.824 (0.463 – 17.210)
Sensitive	2 (33.3)	24 (58.5)	26 (55.3)		
Total	6 (12.7)	41 (87.3)	47 (100)		
	Circulatory Disease	*Another disease*			
Resistant	1 (50.0)	20 (44.4)	21 (44.7)	1.000	1.250 (0.074 – 21.256)
Sensitive	1 (50.0)	25 (55.6)	26 (55.3)		
Total	2 (4.2)	45 (95.8)	47 (100)		
	Digestive Disease	*Another disease*			
Resistant	1 (50.0)	20 (44.4)	21 (44.7)	1.000	1.250 (0.074 – 21.256)
Sensitive	1 (50.0)	25 (55.6)	26 (55.3)		
Total	2 (4.2)	45 (95.8)	47 (100)		
	Infectious-parasitic Disease	*Another disease*			
Resistant	8 (42.1)	13 (46.4)	21 (44.7)	1.000	0.839 (0.259 – 2.718)
Sensitive	11 (57.9)	15 (53.6)	26 (55.3)		
Total	19 (40.4)	28 (59.6)	47 (100)		
	Genital Disease	*Another disease*			
Resistant	1 (33.3)	20 (45.5)	21 (44.7)	1.000	0.600 (0.051 – 7.113)
Sensitive	2 (66.7)	24 (54.5)	26 (55.3)		
Total	3 (6.4)	44 (93.6)	47 (100)		
	Nervous System Disease	*Another disease*			
Resistant	1 (25.0)	20 (46.5)	21 (44.7)	0.617	0.383 (0.037 – 3.984)
Sensitive	3 (75.0)	23 (53.5)	26 (55.3)		
Total	4 (8.5)	43 (91.5)	47 (100)		
	Neoplasm	*Another disease*			
Resistant	1 (16.7)	20 (48.8)	21 (44.7)	0.204	0.210 (0.023 – 1.958)
Sensitive	5 (83.3)	21 (51.2)	26 (55.3)		
Total	6 (12.7)	41 (87.3)	47 (100)		

(a) Fisher's Exact Test and (b) Odds Ratio

Table 5. Surgical procedure history and previous hospitalization as risk factors for infection/colonization by *Pseudomonas aeruginosa* resistant to carbapenems at a university hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Patient history n (%)		Total n (%)	p[a]	OR (IC 95%)[b]
	Surgical history	*Did not*			
Resistant	8 (44.4)	13 (44.8)	21 (44.7)	1.000	0.985 (0.302 – 3.215)
Sensitive	10 (55.6)	16 (55.2)	26 (55.3)		
Total	18 (38.3)	29 (61.7)	47 (100)		
	Previous hospitalization	*Did not*			
Resistant	10 (43.5)	11 (45.8)	21 (44.7)	1.000	0.909 (0.288 – 2.873)
Sensitive	13 (56.5)	13 (54.2)	26 (55.3)		
Total	23 (48.9)	24 (51.1)	47 (100)		

(a) Fisher's Exact Test and (b) Odds Ratio

Table 6. Previous drugs use as a risk factor for infection/colonization by *Pseudomonas aeruginosa* at a university hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Previous medications use n (%)		Total n (%)	p[a]	OR (IC 95%)[b]
	Aminoglycosides	*Unused*			
Resistant	3 (75.0)	18 (41.9)	21 (44.7)	0.311	4.167 (0.400 – 43.379)
Sensitive	1 (25.0)	25 (58.1)	26 (55.3)		
Total	4 (8.5)	43 (91.5)	47 (100)		
	Colistin	*Unused*			
Resistant	3 (75.0)	18 (41.9)	21 (44.7)	0.311	4.167 (0.400 – 43.379)
Sensitive	1 (25.0)	25 (58.1)	26 (55.3)		
Total	4 (8.5)	43 (91.5)	47 (100)		
	Carbapenems	*Unused*			
Resistant	13 (56.5)	8 (33.3)	21 (44.7)	0.147	2.600 (0.796 – 8.488)
Sensitive	10 (43.5)	16 (66.7)	26 (55.3)		
Total	23 (48.9)	24 (51.1)	47 (100)		
	4th generation cephalosporin	*Unused*			
Resistant	12 (50.0)	9 (39.1)	21 (44.7)	0.561	1.556 (0.489 – 4.953)
Sensitive	12 (50.0)	14 (60.9)	26 (55.3)		
Total	24 (51.1)	23 (48.9)	47 (100)		
	Corticoid	*Unused*			
Resistant	13 (46.4)	8 (42.1)	21 (44.7)	1.000	1.192 (0.368 – 3.859)
Sensitive	15 (53.6)	11 (57.9)	26 (55.3)		
Total	28 (59.6)	19 (40.4)	47 (100)		
	Quinolones	*Unused*			
Resistant	1 (16.7)	20 (48.8)	21 (44.7)	0.204	0.210 (0.023 – 1.958)
Sensitive	5 (83.3)	21 (51.2)	26 (55.3)		
Total	6 (12.7)	41 (87.3)	47 (100)		

a) Fisher's Exact Test and (b) Odds Ratio

Table 7. Previous invasive devices use as a risk factor for resistance to carbapenems in infection/colonization by *Pseudomonas aeruginosa* at a University Hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Previous invasive device use n (%)		Total n (%)	p[a]	OR (IC 95%)[b]
	Tracheostomy use	*Unused*			
Resistant	11 (73.3)	10 (31.3)	21 (44.7)	0.011	6.050 (1.542 -23.735)
Sensitive	4 (26.7)	22 (68.7)	26 (55.3)		
Total	15 (31.9)	32 (68.1)	47 (100)		
	Mechanical Ventilation use	*Unused*			
Resistant	13 (61.9)	6 (31.6)	19 (47.5)	0.067	3.521 (0.952 – 13.026)
Sensitive	8 (38.1)	13 (68.4)	21 (52.5)		
Total	21 (52.5)	19 (47.5)	40 (100)		
	Central Venous Catheter use	*Unused*			
Resistant	19 (50)	2 (22.2)	21 (44.7)	0.160	3.500 (0.642 – 19.068)
Sensitive	19 (50)	7 (77.8)	26 (55.3)		
Total	38 (80.8)	9 (19.1)	47 (100)		
	Gastrostomy use	*Unused*			
Resistant	4 (50)	17 (43.6)	21 (44.7)	1.000	1.294 (0.282 – 5.938)
Sensitive	4 (50)	22 (56.4)	26 (55.3)		
Total	8 (17)	39 (83)	47 (100)		
	Foley catheter use	*Unused*			
Resistant	15 (45.5)	6 (42.9)	21 (44.7)	1.000	1.111 (0.315 – 3.921)
Sensitive	18 (54.5)	8 (57.1)	26 (55.3)		
Total	33 (70.2)	14 (29.8)	47 (100)		

(a) Fisher's Exact Test and (b) Odds Ratio

Table 8. Relationship between sensitivity/resistance to carbapenems and time at risk of patients with a positive culture for *Pseudomonas aeruginosa* at a University Hospital from Sergipe, 2016-2017.

Sensitivity/ Resistance to Carbapenems	Median	Minimum	Maximum	Interquartile range	p*
		Time at risk			
Resistant	25.0	0	71	33.0	0.692
Sensitive	27.5	0	339	51.3	

U Mann-Whitney*