RBFHSS
Revista Brasileira de Farmácia Hospitalar e Serviços de Saúde

Original Paper

Open Access

Microbiological profile of isolated specimens in patients admitted to a university hospital from Fortaleza, Brazil

Thalita Melo FREIRE[1], Elana Figueiredo CHAVES[1], José Martins ALCÂNTARA-NETO[1], Paulo Pereira SOUSA[1], Jorge Nobre RODRIGUES[1], Henry Campos REIS[1]

[1]Walter Cantídio teaching hospital

Corresponding author: Freire TM, thalitamelo.f@gmail.com

Submitted: 08-09-2019 Resubmitted: 11-04-2020 Accepted: 20-04-2020

Peer review: blind reviewers

Abstract

Objective: To assess the microbiological profile of culture results of patients admitted in a public university hospital from Fortaleza, Brazil. **Methods:** This is a descriptive and prospective study with patients being followed up in an antimicrobial stewardship program and in use of reserve or strategic antimicrobial agents, which had cultures requested between May and November 2017. Data was obtained from the patient's records, registered and analyzed using Excel spreadsheets and Graph Pad Prism statistical software. **Results:** Male patients (60.2%), non-elderly (63.6%), with hospital discharge clinical outcome (84.7%) and kidney transplant specialty (35.6%) prevailed. We analyzed the result of 490 cultures, with a higher frequency of urine cultures (35.3%) and blood cultures (34.7%) than others cultures. The specialty with most requests was kidney and liver transplant. 19.8% of the cultures were positive, predominantly gram-negative bacilli (72.2%), especially in the urine cultures of transplant patients. Microbiological analysis showed that *Klebsiella pneumoniae* (49.1%) and *Escherichia coli* (39.6%) were the bacteria most frequently found. Regarding the microbial resistance profile, we identified carbapenemase producing bacteria (16.7%), Extended spectrum beta-lactamases (ESBL; 33.3%) within the group of gram-negative bacilli and Vancomycin-resistence *enterococcus* (VRE; 13.5%) within the group of gram-positive cocci. **Conclusions:** The study enabled the knowledge of the profile of microorganisms isolated in the wards under study, which is of fundamental importance for local epidemiological studies and for the control of microbial resistance.

Keywords: antimicrobial stewardship, microbiology, microbial drug resistance, cross infection.

Perfil microbiológico de espécimes isolados em pacientes internados em um hospital universitário de Fortaleza, Brasil

Resumo

Objetivo: Avaliar o perfil microbiológico de resultados de cultura de pacientes internados em um hospital universitário de Fortaleza, Brasil. **Métodos**: Trata-se de um estudo descritivo e prospectivo realizado com pacientes acompanhados em um Programa *Stewardship Antimicrobial,* em uso de antimicrobianos de reserva ou estratégicos e que tiveram culturas solicitadas entre maio e novembro de 2017. Os dados foram coletados em formulário próprio a partir de prontuários dos pacientes e, em seguida, compilados em planilhas de Excel e analisados em programa estatístico Graph Pad Prism. **Resultados**: Prevaleceram pacientes do sexo masculino (60,2%), não idosos (63,6%), com desfecho clínico alta (84,7%) e da especialidade transplante renal (35,6%). Foram analisados resultados de 490 culturas, com maior frequência de uroculturas (35,3%) e hemoculturas (34,7%). A especialidade transplante foi a que apresentou maior número de resultados de culturas. Foram positivas 19,8% das culturas, com predomínio de bacilos Gram negativos (72,2%), especialmente entre uroculturas de transplantados. A análise microbiológica mostrou que *Klebsiella pneumoniae (*49,1%) e *Escherichia coli* (39,6%) foram as bactérias mais frequentemente isoladas. Quanto ao perfil de resistência microbiana, identificou-se a presença de bactérias produtoras de carbapenemase (16,7%), *Extended spectrum beta-lactamases* (ESBL; 33,3%), além de Vancomycin-resistence *enterococcus* (VRE; 13,5%). **Conclusões:** O estudo possibilitou o conhecimento do perfil de microrganismos isolados nas enfermarias em estudo o que é de fundamental importância para estudos epidemiológicos locais e para o controle da resistência microbiana.

Palavras-chave: gestão de antimicrobianos, microbiologia, resistência microbiana a medicamento, infecção hospitalar.

RBFHSS
Revista Brasileira de Farmácia Hospitalar e Serviços de Saúde

Introduction

In terms of public health, one of the biggest concerns worldwide is the growing resistance to antimicrobials[1]. The emergence of microorganisms resistant to different classes of antimicrobials represents one of the great challenges of Brazilian hospitals and has a great economic and clinical impact[2]. The increase in bacterial resistance is multi-factorial, mainly due to the irrational use of antimicrobials, and can be associated with both colonization and infection itself[3].

A mean is estimated of 50,000 deaths per year caused by resistant micro-organisms in the United States and Europe. Projections of the global impact show that, in 2050, this will be the main cause of death[2]. Brazil and Latin America have shown higher levels of bacterial resistance compared to the United States and to European countries, with emphasis on bacteria producing Extended Spectrum Beta-Lactamase (ESBL) and carbapenemases[4]. Thus, the World Health Organization (WHO) warns that it is essential that antimicrobials are used rationally to avoid therapeutic exhaustion[5].

In this context, knowledge of the susceptibility profile to antimicrobials is essential in hospital settings, since it can guide prevention and control of infections, in addition to enabling the rational use of the antimicrobial therapy[6]. The presence of active surveillance programs, in order to facilitate the identification of colonized patients, and the evaluation of cultures of patients with signs of infection is essential since, in addition to enabling the identification of emerging pathogens, it provides for the monitoring of the epidemiological tendencies[7].

One way to promote the rational use of antimicrobials in order to reduce the development of resistance mechanisms is through the implementation of an "Antimicrobial Stewardship Program" (ASP). The program aims to achieve better clinical results and to minimize negative consequences, such as infection by *Clostridium difficile* and the occurrence of adverse events. In addition, it aims to reduce the costs of treating infections[8,9]. In an ASP, faster and more accurate microbiological diagnoses are essential to determine the adequate therapy and to provide an epidemiological profile of the institution, which makes collaboration with the microbiology laboratory a key strategy of the Program[10]. Adherence to the guidelines recommending cutoff points for the antibiogram, such as those by The Clinical & Laboratory Standards Institute (CLSI), allows for greater precision and assessment of susceptibility patterns[11].

Given this scenario, the present study aims to analyze the microbiological profile and sensitivity pattern of isolated specimens in patients admitted to a university hospital in Fortaleza, Brazil.

Methods

This is a prospective and cross-sectional study, conducted between May and November 2017 at a university hospital in Fortaleza, Brazil. The hospital under study has a quaternary level of health care and is integrated into the Public Health System (*Sistema Único de Saúde*, SUS). The study was carried out according to the guidelines and regulatory standards for research involving human beings (Resolution 466/12, National Health Council) and was approved by the hospital's Research Ethics Committee (Number: 2945868).

The study included adult patients (aged ≥ 18 years old), who were admitted to the cardiology wards (12 beds), medical clinic (12 beds), liver and kidney transplant (20 beds), followed up by ASP pharmacists, and in use of antimicrobials standardized at the institution as a therapeutic and/or strategic reserve for at least 48 hours. Patients with no request for culture of biological material were excluded, with results unavailable due to problems with the biological sample collected and/or with the absence of fundamental data for the research. Results of culture of samples understood as contamination were also excluded.

Data collection was carried out from Monday to Friday by clinical pharmacists from the Hospital's Pharmacy Service, when a reserve or strategic antimicrobial was prescribed. Patients who started using these antimicrobials during the weekends or on public holidays were included in the analysis on the first following working day. The verification of the prescription of such antimicrobials was carried out through the validation of the second via daily medical prescription in the pharmacy. The variables collected included gender, age, medical specialty, clinical outcome, culture tests requested, isolated microorganisms and resistance profile to antimicrobials. The patients were classified according to age in the following categories: elderly (age ≥ 60 years old) and non-elderly (age < 60 years old).

The therapeutic reserve antimicrobials are those that are especially effective in relation to other alternatives available for the treatment of severe or refractory infections and include liposomal amphotericin B, lipid complex amphotericin B, anidulafungin, daptomycin, ertapenem, imipenem + cilastatin, linezolid, meropenem, micafungin, piperacillin-tazobactan, polymyxin B, teicoplanin, tigecycline, vancomycin, voriconazole. The antimicrobials considered strategic are those that can be used for optimization actions such as sequential oral therapy, due to their good bioavailability profile above 80%, and include the following: voriconazole, fluconazole, ciprofloxacin, metronidazole, clindamycin and levofloxacin[14].

The biological materials of the patients were analyzed at the institution's Microbiology Laboratory, where their identification (ID) and the Antibiotic Sensitivity Test (AST) were performed using the *VITEK® 2* automated system (*BioMérieux®, Marcy-l'Etoile, France*), which uses the OBSERVA system for data archiving. The interpretation of the susceptibility data was defined following the cutoff points of CLSI 2017. For colistin, the microorganisms were classified using the Epidemiological Cutoff Value (ECV). This value is defined by the clinical practice and by MIC, separating bacterial populations into groups that have acquired and have not acquired resistance mechanisms to colistin[15].

The patient data monitored by the ASP were collected in a specific form through the patient's physical and electronic medical record. After a clinical outcome occurred (discharge, death or hospital transfer), the forms were reviewed and included in the Program's database by a clinical pharmacist from the service responsible for the ASP.

The categorical variables of the study were expressed in absolute and relative frequencies and the numerical variables in the form of arithmetic mean and standard deviation using Microsoft Office Excel® 2013. The population characterization data were analyzed using Student's t test and Fisher's exact test in the Graph Pad Prism statistical program, version 7.0d (USA), considering a p value <0.05 as significant.

Results

129 patients were included in this study. However, ten were excluded because they did not have a request/result for culture of biological material and one because the only existing culture result for him was suggestive of contamination. Thus, this study evaluated the culture results of 118 patients (Figure 1). The demographic and clinical data of the patients are described in Table 1.

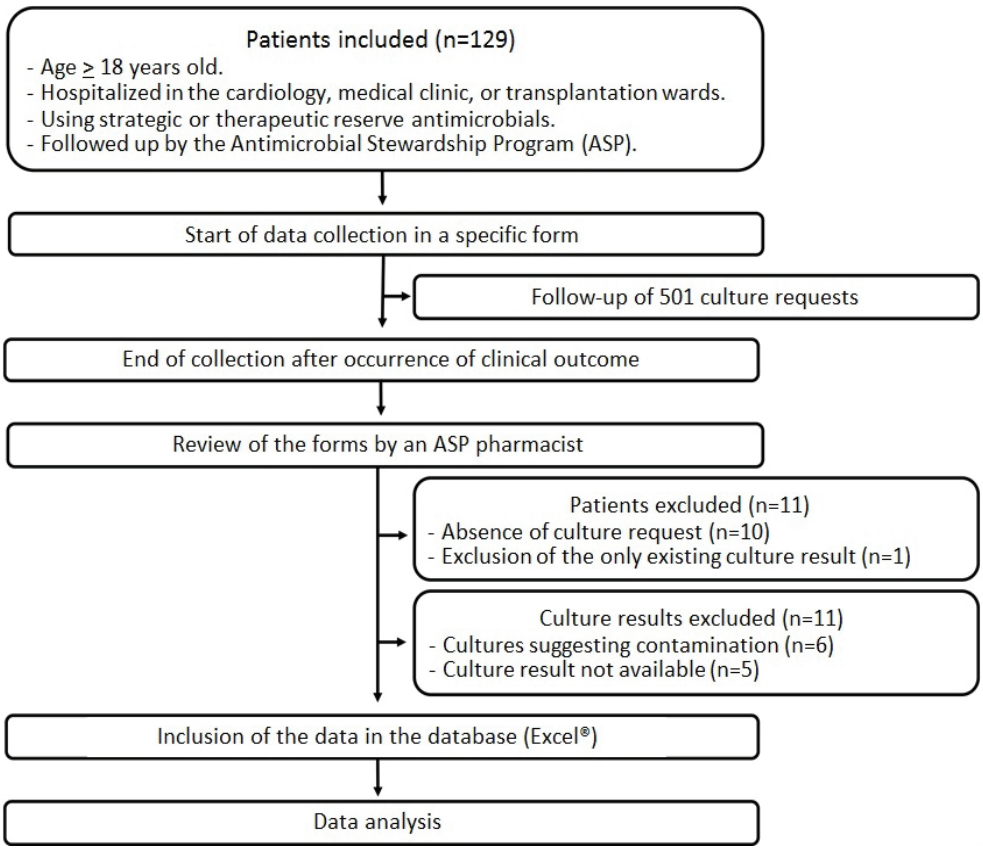
501 culture results were requested from the study patients. However, six results were excluded for being suggestive of contamination, and five for not being available. Thus, a total of 490 culture results were evaluated in this study (Figure 1). The mean number of cultures per patient was 4.2.

Table 1. Clinical and demographic characteristics of the study patients associated with the presence or absence of relevant microbial resistance profiles assessed from May to November 2017 in a university hospital in Fortaleza, Ceará, Brazil.

Data	N (%) N=118	Patients with resistant culture[a] n (%) (N=35)	Patients without resistant culture[b] n (%) (N=83)	p value
Male gender	71 (60.2)	25 (71.4)	46 (55.4)	0.149
Age group (Mean: 51.8±16.8)				
Non-elderly	75 (63.6)	19 (54.3)	56 (67.5)	0.211
Elderly	43 (36.4)	16 (45.7)	27 (32.5)	
Clinical outcome				
Discharge	100 (84.7)	24 (68.6)	76 (91.6)	
Death	13 (11.0)	8 (22.9)	5 (6.0)	0.008[c]
Hospital transfer	5 (4.2)	3 (8.6)	2 (2.4)	
Specialty				
Renal transplant	42 (35.6)	17 (48.6)	25 (30.1)	0.062
Hepatic transplant	38 (32.2)	13 (37.1)	25 (30.1)	0.520
Cardiology	28 (23.7)	2 (5.7)	26 (31.3)	0.002[d]
Medical Clinic	10 (8.5)	3 (8.6)	7 (8.4)	1.000

[a] Patients with at least one culture result with the presence of resistance profiles analyzed in this study. [b] Patients who did not show any culture results with the resistance profiles studied in this study. [c] Hospital transfer data were not included in the analysis; Relative Risk: 2.564; 95% CI: 1.474-4.460. [d] Relative Risk: 1.466; 95% CI: 1.215-1.769.

Figure 1. Methodological flowchart of the study carried out from May to November 2017 at a university hospital.



RBFHSS
Revista Brasileira de Farmácia Hospitalar e Serviços de Saúde

Of the evaluated cultures, 19.6% (n=96) were positive for the growth of some microorganism. Positive results were more frequently found in patients in the transplant specialties (90.6%; n=87) and in urine cultures (35.3%) (Table 2). Positive urine cultures (n=37) for the growth of microorganisms were more frequent among renal transplant patients (73.0%; n=27), followed by liver transplantation (21.6%; n=8), in the medical clinic (5.3%; n=2), and in cardiology (2.7%; n=1). Regarding positive blood cultures (n=19), there was a higher frequency among liver transplant patients (42.1%; n=8) and renal transplant patients (36.8%; n=7), followed by the medical clinic (15.78%; n=3) and by cardiology (5.26%; n=1).

The microbiological profile of the cultures is shown in Table 4. There was a prevalence of gram-negative bacteria isolation (74%), especially *Klebsiella pneumoniae* and *Pseudomonas aeruginosa*. Regarding the isolated fungus species, *Candida albicans* was the most prevalent (50%; n=3), followed by *Candida tropicalis* (33.3%; n=2) and by *Candida glabrata* (16.7%; n=1). The isolated fungi in the cultures (6.3%; n=6/96) were sensitive to fluconazole.

Gram-negative bacilli producing Extended Spectrum Beta-Lactamases (ESBLs) and carbapenemase-producing bacteria were found in 33.3% (n=32) and 16.7% (n=16) of the positive culture results, respectively. Vancomycin-resistant *Enterococcus* (VRE) were found in 13.5% (n=13) of the positive results. Among the *Staphylococcus spp* strains, one (1.0%; n=1) was of the *Methicillin-Resistant Staphylococcus Aureus* (MRSA) type and was isolated in bone culture. It is noteworthy that, among the bacteria producing carbapenemase and VRE isolated, 50.0% (n=8/16) and 69.2% (n=9/13), respectively, came from rectal swab cultures and were requested for transplant patients. This data demonstrates that microorganisms with a resistance profile of clinical importance VRE and KPC were very present in surveillance cultures as colonizing agents, and not as infecting agents.

The correlation tests showed a statistically significant association between the outcome of death and the resistance profiles of clinical relevance evaluated (ESBL, KPC, MRSA and VRE). In addition, patients in the cardiology specialty showed a statistically significant association with the absence of such resistance profiles. No associations were found between the gender and age variables and the culture profiles evaluated (Table 1). Blood cultures showed a statistically significant association with cultures without any of the resistance profiles evaluated (Table 3). On the other hand, the *Klebsiella pneumoniae* strains were associated with cultures with a clinical resistance profile (Table 4).

Table 2. Types of culture and medical specialties by culture results of patients using antimicrobials from May to November 2017 at a university hospital in Fortaleza, Ceará, Brazil.

Variable	Total n (%) (N=490)	Positive culture n (%) (N=96)	Negative culture n (%) (N=394)
Medical specialty			
Hepatic Transplant	195 (39.8)	48 (50.0)	147 (37.3)
Renal Transplant	152 (31.0)	39 (40.6)	113 (28.7)
Cardiology	102 (20.8)	4 (4.2)	98 (24.9)
Medical Clinic	41 (8.4)	5 (5.2)	36 (9.1)
Type of culture			
Uroculture	173 (35.3)	37 (7.6)	136 (34.5)
Blood culture	170 (34.7)	19 (19.8)	151 (38.3)
Rectal swab	72 (14.7)	18 (3.7)	54 (13.7)
Body fluids	26 (5.3)	5 (5.2)	21 (5.3)
Catheter tip	16 (3.3)	6 (6.3)	10 (2.5)
Tracheal aspirate	13 (2.7)	5 (5.2)	8 (2.0)
Secretion of wounds	13 (2.7)	4 (4.2)	9 (2.3)
Others[a]	7 (1.4)	2 (2.1)	5 (1.3)

[a]Others: renal graft, bronchoalveolar lavage, bone, heart valve.

Table 3. Profile of cultures performed in study patients from May to November 2017 at a university hospital in Fortaleza, Ceará, Brazil.

Type of culture	All N=490 n (%)	Culture with resistance[a] N=62 n (%)	Culture with no resistance[b] N=428 n (%)	p value
Uroculture	173 (35.3)	20 (32.3)	153 (35.7)	0.671
Blood culture	170 (34.7)	8 (12.9)	162 (37.9)	<0.0001[d]
Rectal swab	72 (14.7)	17 (27.4)	55 (12.9)	0.006[e]
Body fluids	26 (5.3)	3 (4.8)	23 (5.4)	1.000
Catheter tip	16 (3.3)	5 (8.1)	11 (2.6)	0.040[f]
Tracheal aspirate	13 (2.7)	5 (8.1)	8 (1.9)	0.016[g]
Secretion of wounds	13 (2.7)	2 (3.2)	11 (2.6)	0.674
Others[c]	7 (1.4)	2 (3.2)	5 (1.2)	0.218

[a] Patients with at least one culture result with the presence of resistance profiles analyzed in this study. [b] Patients who did not show any culture results with the resistance profiles studied in this study. [c] Others: Renal graft, bone fragment, cardiac valve, and bronchoalveolar lavage. [d] Relative Risk: 3.586; 95% CI:1.747-7.360. [e] Relative Risk: 2.193; 95% CI: 1.332-3.612. [f] Relative Risk: 2.599; 95% CI: 1.207-5.594. [g] RR: 3.219; 95% CI: 1.552-6.677.

Table 4. Isolated microbiological profile in positive cultures associated with the presence or absence of resistance profile of assessed relevance of the patients using antimicrobials from May to November 2017 in a university hospital in Fortaleza, Ceará, Brazil.

Microbiological profile isolated in cultures	Total N=96 n (%)	With resistance[a] N=62 n (%)	Without resistance[b] N=34 n (%)	p value
Gram-negatives	71 (74.0)	48 (77.4)	23 (67.6)	0.782[a]
Gram-negative fermenting bacilli – Enterobacteria				
Klebsiella pneumoniae	26 (49.1)	22 (35.5)	4 (11.8)	0.047[b]
Escherichia coli	21 (39.6)	11 (17.7)	10 (29.4)	0.104
Enterobacter spp	6 (11.3)	3 (4.8)	3 (8.8)	0.370
Non-fermenting gram-negative bacilli				
Pseudomonas aeruginosa	12 (66.7)	11 (17.7)	1 (2.94)	0.095
Sphingomonas paucimobilis	3 (16.7)	1 (1.6)	2 (5.9)	0.227
Burkholderia cepacia	2 (11.1)	-	2 (5.9)	0.094
Acinetobacter baumanii	1 (5.6)	-	1 (2.9)	0.311
Gram-positive	19 (19.8)	14 (22.6)	5 (14.7)	
Gram-positive cocci				
Enterococcus spp.	15 (78.9)	13 (21.0)	2 (5.9)	0.133
Staphylococcus spp.	3 (15.8)	1 (1.6)	2 (5.9)	0.227
Streptococcos agalactiae	1 (5.3)	-	1 (2.9)	0.311
Fungi[a]	6 (6.3)	-	6 (17.6)	-

[a]Patients with at least one culture result in the presence of the resistance profiles analyzed in this study. [b]Patients who did not show culture results with the resistance profiles studied in this study.

Discussion

In the present study it was possible to identify the profile of microorganisms isolated in cultures of patients using strategic and reserve antimicrobials within an ASP. The study shows a higher prevalence of isolation of gram-negative bacteria when compared to gram-positive bacteria, in addition to associations between the presence of a resistance profile of clinical relevance with the characteristics of the patients and of the cultures.

Most of the patients in the study were from the transplant specialty, either liver or kidney, so that a comparison of the epidemiological profile of the patients can be made, with studies of transplant patients. A number of studies carried out in different periods in the last years, in the same institution of this study, with transplanted inpatients and outpatients also point out a prevalence of male patients with age between 40 and 50 years old[12--14].

An association was found between the death outcome and culture results with the presence of profiles of clinical relevance. In fact, a number of studies report that the growing emergence of microorganisms resistant to antimicrobials has been a major concern worldwide, since it is related to the increase in hospital stay and treatment costs, to the reduction of the therapeutic arsenal, and/or even due to the risk related to patient death. In the hospital setting, mortality related to infections is closely associated with factors such as the adequacy of the therapy and the sensitivity of the microorganisms to the antimicrobials[6].

A higher frequency of requests for cultures was observed by the liver and kidney transplant service. This data can be justified by the need for greater monitoring of these patients due to immunosuppression, which increases the susceptibility to infections. In addition, infections acquired by transplanted patients can be difficult to diagnose, as this population can often show typical signs of infections, such as fever, in rejection processes. Thus, the request for cultures to guide microbiological diagnosis is of great importance in this group of patients in the hospital setting, where resistant microorganisms, such as MRSA, VRE, ESBL, and carbapenemase-producing bacteria, are frequent[15].

A meta-analysis carried out by Ziakas and collaborators (2014) found that patients undergoing solid organ transplantation are more frequently colonized with MRSA or VRE, being associated with increased risk factors for infections in this population. It was also seen that this incidence is similar to that observed in patients in the intensive care unit (ICU) and this can be justified by the intense exposure to the hospital setting, before and after the transplant (including ICU stay)[16]. These data corroborate those found in this study, which, despite not having an expressive number of MRSA bacteria, resulted in 100% (n=13) of the isolated VREs in rectal swab cultures in cultures of transplanted patients.

Among the cultures with positive results, greater positivity was observed with the biological material: urine. A similar result was found in a retrospective cohort study conducted in 2009 in a public hospital in southeastern Brazil with kidney transplant patients, which observed a frequency of 49.0% of the patients affected by infections, with a predominance of urinary tract infections (UTIs) caused by gram-negative bacilli[17].

A review study on UTI places gram-negative bacilli among the main causative agents and warns of the risk of secondary bloodstream infections when patients are using a bladder catheter[18]. In transplant patients, UTI is the most common cause of infection in the hospital setting, with *E. coli* and *K. pneumoniae* being commonly isolated in the urocultures of these patients[19,20].

Most of the positive blood cultures in this study were in transplant patients with a microbiological profile similar to that presented by Kritiko and Manuel (2016) in a review article[21]. These authors report that gram-negative bacilli (predominantly *E. coli, P. aeruginosa* and *Klebsiella ssp.*) are generally identified as the main pathogens responsible for bloodstream infections in kidney transplant recipients, due to the frequent urinary origin of the microorganisms. They also report that pathogens producing

carbapenemase and ESBL have been frequently reported in studies. Therefore, measures such as implantation of an ASP are necessary to reduce the use of antimicrobials that favor the development of resistance mechanisms[21].

Regarding the microbiological profile, the result found is not surprising. The highest prevalence of *K. pneumoniae, E. coli* and *P. aeruginosa*, mainly in urine and blood culture, is in agreement with reports in the literature[22,23]. Perencevich and collaborators (2008) described that the endemicity of gram-negative infections may be related to climatic conditions and reported higher rates of these bacteria during spring and summer than during autumn and winter[22]. These data may justify the prevalence of gram-negatives in this study, considering that the state of Ceará has a predominantly hot climate throughout the year. In addition, our study showed a statistically significant association between *Klebsiella pneumoniae* and cultures with a clinical resistance profile, which represents a concern for the hospital under study and a greater need for epidemiological monitoring of such species in the units studied.

A retrospective, multi-center study which analyzed blood culture results in 2004 in the United States found that *S. aureus*, *E. coli*, *Enterococcus spp.*, *K. pneumoniae*, SCN, and *P. aeruginosa* were the microorganisms most present in clinically proven infectious episodes, a result similar to the present study[24].

In this study, fungi were the least isolated microorganisms. The most frequent were *C. albicans* and *C. tropicalis,* in accordance with the Brazilian scenario which has a prevalence of *C. albicans* (34.3%), *Candida parapsilosis* (24.1%), *C. tropicalis* (15.3%) and *C. glabrata* (10.2%), a result from a multi-center study carried out in 16 hospitals in the five regions of Brazil from June 2007 to March 2010[25].

Although carbapenemase-producing bacteria are not found with a relatively high frequency in the present study, the increase in carbapenema-producing gram-negative bacilli has been a threat to the usefulness of carbapenemic antimicrobials. The abundance of these pathogens is reported as a widespread problem, not being restricted to ICU patients who are often the most affected, but with the capacity to ease transmission to other patients[26].

In a published review article, Sampaio and Gales (2016) reported that multi-drug-resistant microorganisms are present in several Brazilian states, including Ceará, and that their presence has increased in the studied populations[27]. To meet the demands of this crisis, the Innovative Medicines Initiative (IMI) European group invested in strategies to assist in the development of new antimicrobials, in partnerships between the public and private networks. This group developed the New drugs for bad bugs project, which includes clinical trials and epidemiological studies in order to boost the development of new drugs[28].

Our study provides valuable information about the microbiological profile of patients admitted to a university hospital in Ceará within an ASP. However, it does have some limitations. First, this was a single-center study carried out over a short period of time intended only to analyze the microbiological profile of cultures of hospitalized patients, not associating the microbiological data with the clinical data of the patients. In addition, the data collected may have shown observer bias, as they were collected by different clinical pharmacists in the service and the collection form underwent changes during the study period, considering that the ASP was in the initial phase of its implementation. More studies are needed in order to assess the impact of the implementation of ASP on the modification of the institution's antimicrobial resistance profile.

Conclusion

In conclusion, this study enabled knowing the microbial profile of culture results of patients admitted to a university hospital, which is of fundamental importance for local epidemiological studies and for the control of microbial resistance. The studied population consisted mostly of patients from the kidney and liver transplant specialties and found a statistically significant association between the death outcome and resistance profiles of clinical relevance. A higher frequency was observed of gram-negative bacteria, as well as an association between *Klebisiella pneumoniae* and resistance profiles of clinical relevance. The death outcome was statistically significant with resistance profiles of clinical relevance. New studies should be carried out periodically in order to monitor changes in the microbiological profile and to control the increase in the resistance to antimicrobials.

Funding sources

The research did not receive financing for its realization.

Collaborators

Freire TM, Reis HC, Alcântara-Neto JM: participation in the design of the project. Freire TM, Alcântara-Neto JM, Chaves EF: participation in data analysis and interpretation. Freire TM, Alcântara-Neto JM, Chaves EF: participation in the writing of the article and responsibility for all information on the work, ensuring the accuracy and integrity of any part of the paper. Freire TM, Reis HC, Alcântara-Neto JM, Chaves EF, Sousa PP, Rodrigues JN: relevant critical review of the intellectual content and final approval of the version to be published.

Conflict of interest statement

The authors declare that there are no conflicts of interest regarding this article.

References

1. Sabtu N, Enoch DA, Brown NM. Antibiotic resistance: what, why, where, when and how? Br Med Bull. 2015;1(116):105-13.
2. O'Neill J. Antimicrobial resistance: tackling a crisis for the health and wealth of nations. Review on Antimicrobial Resistance, 2014. Available from: https://amr-review.org/sites/default/files/AMR%20Review%20Paper%20-%20Tackling%20a%20crisis%20for%20the%20health%20and%20wealth%20of%20nations_1.pdf. Accessed on 25 Jan 2018.
3. Hwang AY, Gums JG. The emergence and evolution of antimicrobial resistance: impact on a global scale. Bioorgan Med Chem. 2016;24(24):6440-5.
4. Rossi F. The challenges of antimicrobial resistance in Brazil. Clin Infect Dis. 2011, 4;52(9):1138-43.
5. World Health Organization. WHO patient safety research:

better knowledge for safer care [Internet]. 2009. Available from http://whqlibdoc.who.int/hq/2009/WHO_IER_PSP_2009.10_eng.pdf. Accessed on 10 Jan 2017.

6. Souza ES, Belei RA, Carrilho CMD de M, *et al*. Mortalidade e riscos associados a infecção relacionada à assistência à saúde. Texto e Context Enferm. 2015;24(1):220–8.
7. Magalhães MC, Cruz RF, Silva GMM. Perfil microbiológico dos pacientes submetidos à cultura de vigilância ativa em um hospital universitário da Região Sudeste de Minas Gerais. HU Rev. 2019;44(3):361–7.
8. Spellberg B, Blaser M, Guidos RJ, *et al*. Combating antimicrobial resistance: policy recommendations to save lives. Clin Infect Dis. 2011;52(5):S397-428.
9. Barlam TF, Casgrove SE, Abbo LM, *et al*. Implementing an antibiotic stewardship program: guidelines by the infectious diseases society of America and the society for healthcare epidemiology of America. Clin Infect Dis. 2016;62(10):e51-77.
10. Morency-Potvin P, Schwartz DN, Weinstein RA. Antimicrobial stewardship: how the microbiology laboratory can right the ship. Clin Microbiol Rev. 2016;30(1):381-407.
11. Avdic E, Carroll KC. The role of the microbiology laboratory in antimicrobial stewardship programs. Infect Dis Clin North Am. 2014;28(2):215-35.
12. Adriano LS, Martins BC, Lima LF, *et al*. Pharmaceutical interventions and their clinical outcomes in an inpatient post-transplant unit. Rev. Bras. Farm. General Serv. 2017;8(1):15-21.
13. Portela MP, Neri EDR, Fonteles MMF, *et al*. O custo do transplante hepático em um hospital universitário do Brasil. Rev Assoc Med Bras. 2010; 56(3):322-6.
14. Silva JM, Fialho AVM, Borges MCLA, *et al*. Perfil epidemiológico dos pacientes transplantados renais em hospital universitário e o conhecimento sobre uso de drogas imunossupressoras. JBT J Bras Transpl. 2011;14:1449-94.
15. Fishman JA. Infection in solid-organ transplant recipients. N Engl J Med. 2007;357(25):2601-14.
16. Ziakas PD, Pliakos EE, Zervou FN, *et al*. MRSA and VRE colonization in solid organ transplantation: a meta-analysis of published studies. Am J Transplant. 2014;14(8):1887-94.
17. Sousa SR, Galante NZ, Barbosa DA, *et al*. Incidência e fatores de risco para complicações infeciosas no primeiro ano após o transplante renal. J Bras Nefrol. 2010;32(1):77-84.
18. Flores-Mireles AL, Walker JN, Caparon M, *et al*. Urinary tract infections: epidemiology, mechanisms of infection and treatment options. Nat Rev Microbiol. 2015;13(5):269-84.
19. Parasuraman R, Julian K. AST infectious diseases community of practice. Urinary tract infections in solid organ transplantation. Am J Transplant. 2013;13(Suppl 4):327-36.
20. Ariza-Heredia EJ, Beam EN, Lesnick TG, *et al*. Impact of urinary tract infection on allograft function after kidney transplantation. Clin Transplant. 2014;28(6):683-90.
21. Kritikos A, Manuel O. Bloodstream infections after solid-organ transplantation. Virulence. 2016;7(3):329-40.
22. Perencevich EN. Summer peaks in the incidences of gram-negative bacterial infection among hospitalized patients. Infect. Control. Hosp. Epidemiol. 2008;29:1124-1131.
23. Kaye KS, Pogue JM. Infections caused by resistant gram-negative bacteria: epidemiology and management. Pharmacotherapy. 2015;35(10):949-62.
24. Pien BC, Sundaram P, Raoof N, *et al*. The clinical and prognostic importance of positive blood cultures in adults. Am J Med. 2010;123(9):819-28.
25. Doi AM, Pignatari AC, Edmond MB. Epidemiology and microbiologic characterization of nosocomial candidemia from a Brazilian National Surveillance Program. PLoS One. 2016;11(1):1-9.
26. Decker B, Masur H. Bad bugs, no drugs: are we part of the problem, or leaders in developing solutions? Crit Care Med. 2015;43(6):1153-5.
27. Sampaio JLM, Gales AC. Antimicrobial resistance in Enterobacteriaceae in Brazil: focus on β-lactams and polymyxins. Braz J Microbiol. 2016;31-37.
28. Kostyanev T, Bonten MJ, O'Brien S, *et al*. The innovative medicines initiative's new drugs for bad bugs programme: european public-private partnerships for the development of new strategies to tackle antibiotic resistance. J Antimicrob Chemother. 2016;71(2):290-5.