

Microbial drug resistance in a Nursing Home

Resistência microbiana a medicamentos em uma Instituição de Longa Permanência para Idosos
Resistencia microbiana a medicamentos en una institución de larga estadía para adultos mayores

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Resumo

Objetivo: Caracterizar os microrganismos e sua suscetibilidade antimicrobiana em uroculturas de idosos residentes de uma instituição de longa permanência.

Métodos: Estudo observacional transversal com 116 indivíduos de uma Instituição de Longa Permanência para Idosos de um município do sul da Bahia. O estudo foi aprovado por Comitê de Ética em Pesquisa e utilizou-se Termo de Consentimento Livre e Esclarecido. Foram realizadas coleta e análise laboratorial de urina tipo I e urocultura. Realizaram-se testes de sensibilidade a antimicrobianos conforme os critérios do *European Committee on Antimicrobial Susceptibility Testing*. Para o diagnóstico de infecção do trato urinário, foram utilizados os critérios de McGeer. A análise de dados se deu por estatística descritiva, com frequências absolutas e relativas.

Resultados: A prevalência de infecção do trato urinário foi de 33,62%, com predominância no sexo feminino e idade acima de 80 anos. Os uropatógenos foram: 69,2% *Escherichia coli*, 20,6% *Klebsiella pneumoniae* e 5,1% *Providencia stuartii* e *Acinetobacter baumannii*. As cepas de *E. coli* apresentaram suscetibilidade para a maior parte dos antimicrobianos; já nas de *K. pneumoniae*, a suscetibilidade foi variável. *P. stuartii* e *A. baumannii* não apresentaram resistência a carbapenêmicos e aos betalactâmicos aztreonam e piperacilina associados a tazobactam.

Conclusão: As cepas mais prevalentes e o perfil de suscetibilidade seguiram padrão próximo ao hospitalar, o que implica a necessidade de a instituição promover melhores estratégias de controle de infecção e envolver a equipe de enfermagem no gerenciamento dos casos e na qualificação da prescrição antimicrobiana, para reduzir a resistência bacteriana e efeitos adversos nos idosos.

Abstract

Objective: Characterize the microorganisms and their antimicrobial susceptibility in urine cultures of elderly residents of a nursing home.

Methods: A cross-sectional observational study with 116 subjects from a nursing home in a city in southern Bahia. The Ethics Committee approved the study, and the Informed Consent Form was used. Collection and laboratory analysis of type I urine and urine culture were performed. Antimicrobial susceptibility tests were performed according to the criteria of the European Committee on Antimicrobial Susceptibility Testing. For the diagnosis of urinary tract infection, McGeer's criteria were used. Data analysis was performed using descriptive statistics with absolute and relative frequencies.

Results: The prevalence of urinary tract infection was 33.62%, predominantly female and aged over 80 years. The uropathogens were: 69.2% *Escherichia coli*, 20.6% *Klebsiella pneumoniae*, and 5.1% *Providencia stuartii*

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and *Acinetobacter baumannii*. *E. coli* strains showed susceptibility to most antimicrobials; in *K. pneumoniae*, the susceptibility was variable. *P. stuartii* and *A. baumannii* showed no resistance to carbapenems and beta-lactams aztreonam and piperacillin associated with tazobactam.

Conclusion: The most prevalent strains and the susceptibility profile followed a pattern close to the hospital one. It implies the need for the nursing home to promote better infection control strategies and involve the healthcare nursing staff in case management and qualification of antimicrobial prescription to reduce bacterial resistance and adverse effects in the elderly.

Resumen

Objetivo: Caracterizar los microorganismos y su susceptibilidad antimicrobiana en urocultivos de adultos mayores residentes en una institución de larga estadía.

Métodos: Estudio observacional transversal con 116 individuos de una institución de larga estadía para adultos mayores de un municipio del sur del estado de Bahía. El estudio fue aprobado por el Comité de Ética de Investigación y se utilizó Consentimiento Informado. Se obtuvieron muestras de orina, con las cuales se realizó análisis de laboratorio tipo I y urocultivo. Se realizaron pruebas de sensibilidad a antimicrobianos según los criterios del *European Committee on Antimicrobial Susceptibility Testing*. Para el diagnóstico de infección del tracto urinario, se utilizaron los criterios de McGeer. El análisis de datos se obtuvo mediante estadística descriptiva, con frecuencias absolutas y relativas.

Resultados: La prevalencia de infección del tracto urinario fue del 33,62 %, con predominancia del sexo femenino y edad superior a 80 años. Los uropatógenos fueron: 69,2 % *Escherichia coli*, 20,6 % *Klebsiella pneumoniae* y 5,1 % *Providencia stuartii* y *Acinetobacter baumannii*. Las cepas de *E. coli* presentaron susceptibilidad en la mayor parte de los antimicrobianos, en las de *K. pneumoniae*, la susceptibilidad fue variable. *P. stuartii* y *A. baumannii* no presentaron resistencia a carbapenémicos ni a los betalactámicos aztreonam y piperacilina asociados a tazobactam.

Conclusión: Las cepas más prevalentes y el perfil de susceptibilidad presentaron un patrón parecido al hospitalario, lo que implica la necesidad de que la institución promueva mejores estrategias de control de infecciones e involucre al equipo de enfermería en la gestión de los casos y en la cualificación de la prescripción antimicrobiana para reducir la resistencia bacteriana y los efectos adversos en los adultos mayores.

Introduction

Institutionalization, by itself, brings greater vulnerability and exposure of the elderly to conditions such as infections, intense interaction in the same space, by sharing utensils, or by structural issues. In addition, nursing homes do not commonly have infection control protocols and continuous training of staff for epidemiological surveillance, which can lead to infectious outbreaks or local bacterial resistance.⁽¹⁻⁴⁾

Studies on infections, the use of antimicrobials, and the development of bacterial resistance in nursing homes are still scarce.^(5,6) Among the infections that most affect institutionalized elderly is urinary tract infection, with a prevalence between 15% and 30%.^(2,7)

In addition to the less effective immune response resulting from the natural aging process, the literature points to a greater propensity of the elderly to develop urinary infections due to the higher prevalence of chronic-degenerative diseases, urinary and fecal incontinence, polypharmacy, among others.^(2,5,7)

The prescription of antimicrobials is based on imprecise diagnoses and disregards drug interactions and clinical conditions of the elderly.⁽⁷⁾ The diagnosis and prescription are not the responsibility

of nursing, but the team must be committed to identifying adverse effects and clinical responses of the elderly, discussing the cases with the prescriber for possible adjustments.

International studies show that one in ten seniors in nursing homes receives some antibiotic a day. These are the most prescribed drugs and represent 20% of adverse events in this population.^(3,7) The unnecessary and excessive consumption of antimicrobials causes interactions with other drugs and promotes bacterial resistance.^(8,9)

Bacterial resistance occurs due to selective pressure exerted by the use of antibiotics, a natural biological phenomenon, but the inadequate use of these drugs has created a correlation between higher consumption of antibiotics and high levels of resistance, both in the community and in hospitals and nursing homes.^(6,8,9)

The gold standard for effective antimicrobial prescription is identifying microorganisms and susceptibility through urine culture results but associated with careful clinical evaluation. This condition avoids unnecessary prescriptions, as occurs with asymptomatic bacteriuria, which is not treatable. Also, the most appropriate choice, according to the clinical conditions of the elderly, ensures a better response to treatment and reduces drug interactions, adverse effects, and antimicrobial resistance.^(3,5-7)

From this context, the question is: Which strains of uropathogens are associated with urinary tract infection in the elderly, and what is their susceptibility to antimicrobials? Knowing this scenario and the behavior of strains against antimicrobials is understood to reduce bacterial resistance, qualify drug prescriptions, promote health surveillance, and involve the nursing staff in discussing prescriptions and case management of urinary tract infection in nursing homes.

This study aimed to characterize the microorganisms and their antimicrobial susceptibility in urine cultures of elderly residents of a nursing home.

Methods

A cross-sectional study was carried out from July to December 2018 in a nursing home in a municipality in the countryside of Bahia – Brazil. The study population consisted of 116 institutionalized elderly by convenience. The inclusion criterion was age equal to or greater than 60 years. Exclusion criteria were: using antibiotic therapy for urinary tract infection, using a urinary catheter or having had its removal in less than 72 hours, having been hospitalized for less than two weeks, and having asymptomatic bacteriuria.

The first author of the study performed urine collection for type I laboratory analysis and urine culture of the elderly in the first hour of the morning. Elderly with mobility and preserved cognitive conditions were guided and accompanied to the toilets to perform antisepsis of the urogenital region with water and neutral soap. The first jet of urine was discarded, collecting the sample in a medium jet until half the capacity of the collection bottle (disposable, sterile, of inert material, dry, and leak-proof); the rest was discarded.

For the elderly without mobility, severe cognitive difficulties, and diapers, urine was collected by vesical catheterization in bed by the same investigator. A disposable vesical catheterization kit was used with aseptic technique: positioning of the elderly in bed (men in supine position, women in gynecological position), urogenital hygiene with procedure

gloves, the opening of the catheterization kit, use of sterile gloves, urogenital antisepsis with aqueous iodophor, field fenestration, and introduction of a 12-gauge FR catheter (for both sexes) with anesthetic gel (2% lidocaine gel). The initial 10 mL of urine in an emesis basin was discarded, and half of the collection bottle was collected; the rest was discarded.

The samples were identified with the elderly's name and date of birth, placing them in a thermal box with reusable rigid ice and sending them to the institution's reference laboratory with a maximum interval of 30 minutes after collection.

According to the European Committee on Antimicrobial Susceptibility Testing (EUCAST), the laboratory used the interpretation standards for antimicrobial susceptibility tests.⁽¹⁰⁾ Thus, a calibrated platinum loop (0.01 mL) was used, inoculated in CLED Agar/MacConkey Agar culture media, and the samples were kept at 37°C/24 hours in an oven. Bacteria were then classified as Gram-positive or Gram-negative with Gram stain. The antibiogram consisted of sowing a dilution of the culture to be tested in Mueller-Hinton Agar; placing antibiotic-containing discs on the agar; incubation; plaque verification and definition of antibiotics that inhibited bacterial growth; classifying it sensitive or resistant to the tested antibiotics.

There was a clinical evaluation of the elderly, carried out by a volunteer medical professional, accompanied by the first author of the study, concomitantly with the urine collection. Clinical information was recorded in the elderly's medical records, and the diagnosis was established after the results of urine cultures. The diagnostic definition for urinary tract infection followed McGeer's international criteria, which are urinalysis with pyuria (>10 leukocytes per field); urine culture with a bacteriological presence greater than 10⁵ CFU/mL, and presence of at least two of the signs/symptoms: fever >38°, acute dysuria, suprapubic pain/tenderness, pain/tenderness in the costovertebral angle, worsening or urinary urgency, current urinary incontinence.⁽¹¹⁻¹⁴⁾

Data analysis was performed using descriptive statistics with absolute and relative frequencies, using the R software. The isolated microorganisms

were analyzed based on the distribution by age group and gender of the elderly. The susceptibility variable consisted of the sensitivity (a combination of sensitive and intermediate) and resistance categories, analyzed by class and type of antimicrobial.⁽¹⁰⁾

The project was submitted to the Ethics Committee, CAAE number 91836318.8.0000.5505, and approved by opinion 2.776.379/18. An Informed Consent Term signed by the elderly or legal guardian (in cases of cognitive impossibility) was used.

Results

Of the 116 urine samples, 39 were from symptomatic elderly, composing a prevalence of 33.6% of urinary tract infections.

All uropathogens were Gram-negative and of four species. The most prevalent bacterium was *Escherichia coli*, with 27 cultures (69.2%), followed by *Klebsiella pneumoniae*, with eight (20.6%), and *Providencia stuartii* and *Acinetobacter baumannii*, with two cultures each (5.1%).

There were five cases of urinary tract infection (12.8%) in the age group 60 to 65 years, four cases (10.3%) among the elderly aged 66 to 70 years,

eight (20.5%) in the age group from 71 to 75 years and six (15.4%) between 76 to 80 years, and the most affected was the age group above 80 years, with 16 cases (41.0%). In this group, *E. coli* was the most prevalent, responsible for 11 cases of urinary tract infection (28.2%). It is noteworthy that *P. stuartii* and *A. baumannii* were present in urine cultures only in this age group and were bacteria characteristically found in hospital settings.

The study showed a higher prevalence of urinary tract infection among women, with 27 cases (69.2%), and *E. coli* was present in 23 of these urine cultures (58.9% of the total).

Table 1 shows the resistance profile of microorganisms by type of antimicrobial.

E. coli were sensitive to almost all antimicrobials, with 27 cases (100%) of resistance to amoxicillin associated with clavulanic acid. The antimicrobials cephalothin and sulfamethoxazole associated with trimethoprim had eight cases of resistant strains (29.6%), and nalidixic acid had nine cases (33.3%).

K. pneumoniae strains showed more variable sensitivity and resistance. The highest sensitivity concerned nitrofurantoin (75% - six cases). The highest resistance occurred against beta-lactam amoxicillin associated with clavulanic acid with five cases (62.5%). Piperacillin associated with tazobactam

Table 1. Resistance profile of urine culture microorganisms from symptomatic elderly to urinary tract infection, by antimicrobial type

Antimicrobials		Microorganisms			
		<i>Escherichia coli</i> (n=27) n(%)	<i>Klebsiella pneumoniae</i> (n=8) n(%)	<i>Acinetobacter baumannii</i> (n=2) n(%)	<i>Providencia stuartii</i> (n=2) n(%)
Class	Type	R	R	R	R
Beta-lactams	Aztreonam	4(14.8)	0	0	0
	Piperacillin + tazobactam	3(11.1)	3(37.5)	1(50.0)	0
	Amoxicillin + clavulanic acid	27(100)	5(62.5)	2(100)	2(100)
	First-generation cephalosporin: cephalothin	9(33.3)	4(50.0)	2(100)	2(100)
	Second-generation cephalosporin: cefuroxime	4(14.8)	4(50.0)	2(100)	2(100)
	Third-generation cephalosporin: ceftriaxone	1(3.7)	4(50.0)	2(100)	2(100)
	Fourth-generation cephalosporin: cefepime	0	1(12.5)	2(100)	2(100)
Quinolones	Norfloxacin	0	4(50.0)	2(100)	2(100)
	Ciprofloxacin	0	4(50.0)	2(100)	2(100)
	Levofloxacin	0	4(50.0)	2(100)	2(100)
	Nalidixic acid	8(29.6)	4(50.0)	2(100)	2(100)
	Nitrofurantoin	5(18.5)	2(25.0)	2(100)	2(100)
Aminoglycoside	Amikacin	0	1(12.5)	0	0
	Gentamicin	1(3.7)	2(25.0)	0	2(100)
Carbapenem	Meropenem	0	1(12.5)	0	0
	Imipenem	0	0	0	0
Sulfonamide	Sulfamethoxazole + trimethoprim	9(33.3)	4(50.0)	2(100)	2(100)

R - resistance

showed three resistant cases (37.5%), and two strains (25%) showed resistance to carbapenems. Resistance to other antimicrobials was 50% (four cases).

The uropathogens *A. baumannii* and *P. stuartii*, with two cases each strain, were sensitive to beta-lactams aztreonam and piperacillin associated with tazobactam, to aminoglycosides (both against amikacin, gentamicin only for *A. baumannii*) and carbapenems (meropenem and imipenem), but with 100% resistance to other beta-lactams, quinolones, and sulfonamide.

Discussion

The results showed a prevalence of urinary tract infection of 33.6% (39 elderly affected). It is noteworthy that 12 elderly (10.34%) who had asymptomatic bacteriuria were excluded. Similar information can be found in national and international studies on bacteriuria in approximately 50% of the urine cultures of institutionalized elderly.^(2,6,14)

Prescribing antimicrobials for asymptomatic bacteriuria is common in nursing homes but not recommended. Lack of knowledge and difficulty in evaluating other clinical criteria that make up the diagnosis of urinary tract infection are the factors that promote this fallacy in the prescription and increase in resistant strains and deleterious effects on the liver and kidneys.^(11,14)

The false situation of urinary tract infections and unnecessary prescriptions could be reduced if the observation of more accurate clinical signs was the object of surveillance by the nursing staff, especially the nurses, since these professionals monitor the elderly continuously, differently from the prescriber. The Brazilian Health Regulatory Agency, in line with the protocols of the Centers for Disease Control (CDC) of the United States, reinforces the need for discussion of cases and prescriptions in a multidisciplinary team, which makes nursing work in this context essential.⁽¹⁵⁾

In the present study results, the uropathogens were Gram-negative. Except for *A. baumannii* from the *Moraxellaceae* family, the others belong to the *Enterobacteriaceae* family, which corresponds to

most urinary tract infections, as they are prevalent in the intestinal microbiota. In general, studies show that this family represents 70% of urinary tract infections in institutionalized elderly.^(8,9)

Elderly over 80 years were the most affected by urinary infections, similar to other studies. The highest rates of these infections in this age group are based on dysfunctional characteristics that, over the years, are intensified by senescence and a lower immune response. Allied to this, the continuous use of many medications for chronic comorbidities enhances drug interactions with antimicrobials, causing less response to treatment or microbial resistance.^(2,6,16,17,18)

Older women are more affected by urinary infections because they present genitourinary prolapse as a common condition, which results in incomplete emptying of the bladder, and may explain, together with menopause and shorter urethra, the high prevalence.^(8,19) The findings of this study fit this perspective.

Most samples showed bacterial growth of *E. coli* (almost 70%). Other researches show rates between 50% and 80%, showing a tendency of this microorganism to compose the pictures of urinary infections in the elderly.^(2,8,9) As it is a bacterium of the intestinal tract, the lack of care by the healthcare professionals for the elderly, such as the delay in time between a diaper change and feces remaining in them, hand hygiene, or inadequate self-hygiene of the elderly, can be elements that favor infection.

In European research, *E. coli* strains in nursing homes showed higher resistance to carbapenems than to beta-lactams.^(9,10) In American studies, on the other hand, the most resistant strains are the extended-spectrum beta-lactamase producers, which are 100% resistant to beta-lactams, such as first- to fourth-generation cephalosporins and quinolones.⁽¹⁸⁾ In the studied urine cultures, the behavior was similar to the American and Brazilian profiles.⁽¹⁸⁻²¹⁾

The uropathogen *K. pneumoniae*, in the last two decades, has become relevant for infections related to health care, being the causative agent of approximately 14% to 20% of infections related to the urinary tract.^(22,23) A Brazilian study pointed to an 8.5% prevalence in urine samples of community

origin and variation from 16% to 18% in hospitals.^(20,21) In the nursing home studied, eight cases of urinary tract infection (20.5%) were associated with this microorganism, approaching the national and international literature and following the trend of hospital prevalence.

The concern with *K. pneumoniae* is the ability to form biofilms that protect the pathogen from host immune responses and the action of antibiotics. The effects are the constitution of multi-resistance and easy dissemination, with greater persistence in the epithelium, tissues, and surfaces of instruments used in healthcare.^(8,18,22)

K. pneumoniae strains exhibit resistance to a broad spectrum of beta-lactams, such as penicillins, third- and fourth-generation cephalosporins, and carbapenems, due to the production of extended-spectrum beta-lactamase and resistance to carbapenems. They also resist other classes, such as sulfonamides, fluoroquinolones, and aminoglycosides.^(8,18-20,22)

The findings at the nursing home followed the same trend, with 40% to 60% resistance to beta-lactams, quinolones, and sulfonamides, but less resistance to aminoglycosides (12% to 25%). In this sense, the nursing home presents itself as an encouraging space for the development of resistance or multi-resistance to antimicrobials by this microorganism, requiring continuous surveillance of cases of infection.

Resistance in *K. pneumoniae* strains has repercussions on few antimicrobial options for prescription and more significant observance of interactions and adverse effects. Furthermore, choices should consider more restricted spectrum antimicrobials to avoid resistance. The nursing staff, especially the nurse, must stick with the physician to study the less harmful antimicrobial to the elderly, time of use, dosage form, and side effects of prescription. Follow-up of these cases requires continuous monitoring of the evolution, as this can lead to a future hospitalization due to aggravation of the infection.

In this study, only two cases of *A. baumannii* and *P. stuartii* emerged. The hands of healthcare professionals are the most common means of transmission, increasing the likelihood of patients being colonized and equipment contaminated. One of

the biggest challenges for treatment is the ability to develop resistance through biofilms and persist in the environment.^(9,18,23,24)

These microorganisms have intrinsic natural resistance to the antimicrobials ampicillin, amoxicillin, first- and second-generation cephalosporins, and nitrofurantoin, requiring observing this aspect in antibiograms and prescriptions. In the present study, sensitivity occurred to beta-lactams, aminoglycosides, and carbapenems, causing no major concerns but requiring vigilance. There are studies in which strains of these microorganisms resistant to carbapenems demonstrated multi-resistance, being practically untreatable.^(6,8,23,24)

Studies indicate the need for delineating the local microbiota with antimicrobial susceptibility profiles to carry out case management as a team in different health services.⁽²³⁻²⁵⁾ Even with little research and proposals for infection control and epidemiological surveillance programs, it is understood that nursing homes should follow the same prerogative.

From recognizing this conjuncture of the most prevalent microorganisms and their susceptibility profile in the nursing home studied, the need for antimicrobial management as part of patient safety becomes evident. Due to this aspect, the nurse's role must stick to the daily assessment of the clinical conditions of the elderly and observe the safety and response to antibiotic therapy, given that, in most institutions of this type, the physician is not a constant and permanent figure on site. By monitoring the elderly, it is possible to discuss de-escalation, which is the narrowing of the antimicrobial spectrum guided by the pathogen's susceptibility.⁽²⁵⁾

The de-escalation process is interdisciplinary and promotes the discussion of cases between the physician prescriber and the nurse. The aim is to reduce the possibilities of generating bacterial resistance, reduce treatment costs, and minimize teratogenic situations in the elderly.⁽²⁵⁻²⁷⁾ In this way, the results of this study are considered to contribute to improving rationality in prescriptions, monitoring of cases, and constitution of a culture of surveillance in local healthcare.

This study was carried out in only one nursing home. The small sample limits the performance of

association tests by sex, age group, polypharmacy, and clinical conditions, which can influence the pharmacodynamics and pharmacokinetics of antimicrobials.

Conclusion

The results showed that the most prevalent strains and the susceptibility profile followed a pattern close to the hospital one. It implies the need for the nursing home to promote better infection control strategies, involves the nursing staff in case management, and qualify the antimicrobial prescription to reduce bacterial resistance and adverse effects on the elderly.

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Collaborations

Silva JLA, Silva MR, Ferreira SMIL, Rocha RM, Barbosa DA collaborated with the project design, data analysis and interpretation, article writing, relevant critical review of the intellectual content, and approval of the final version to be published.

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