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Antimicrobial resistance patterns of Staphylococcus aureus in the Intensive Care Unit at a tertiary hospital

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Abstract

***Purpose*: The objective of the present study is to determine the pattern of antimicrobial resistance of Staphylococcus aureus (S. aureus) in the Intensive Care Unit at a tertiary hospital in Mexico.**

***Methods*: 1,511 cultures in general surgery, internal medicine, neurosurgery and the ICU were analyzed, the sample pool was limited to ICU patients and out of those, only samples positive for S. aureus were included, meticillin resistance was confirmed.**

***Results*: Of a total of 1,511 samples, 206 (13.63%) were culture positive for S. aureus. In the ICU, antimicrobial resistance to beta-lactams (penicillin, ampicillin, cephalothin, cefotaxime, cefazolin, amoxicillin/Ac. Clavulanate and imipenem) averaged 73.52%; for clindamycin was 65.12%; ciprofloxacin 59.09%, erythromycin 65.31% and for vancomycin was 6.52%.**

***Conclusions*: The present study showed a high incidence of MRSA in an Intensive Care Unit at a tertiary hospital.**

Key words: Staphylococcus aureus, Intensive Care Unit, meticillin resistant Staphylococcus aureus.

Introduction

During the discovery of Penicillin in 1928, Fleming found it to be an effective treatment against infections caused by Staphylococcus aureus (S. aureus). However, by 1946 the resistance rate was found to be at 60%, which led to its decline in use against this organism. By 1959, methicillin, the first semisynthetic penicillin was obtained by altering the chemical structure of natural penicillin, which was rapidly reaching 90% resistance levels. (1) Methicillin became the agent of choice for the treatment of infection by this beta-lactamase producing bacteria due to its ability to evade the actions of beta-lactamases.

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Methicillin-resistant Staphylococcus aureus (MRSA) strains are prevalent bacterial pathogens that cause both health care and community-associated infections. Increasing resistance to commonly prescribed antibiotics has made MRSA a serious threat to public health worldwide. (2)

Antimicrobial stewardship is of great relevance in the Intensive Care Unit (ICU) because it involves a multifaceted approach aimed at combating the emergence of antibiotic resistance, improving patient outcomes, and controlling healthcare costs by optimizing antimicrobial use. The rapid pace of escalating antibiotic resistance and the widespread use of antibiotics in critical care require that stewardship programs be routinely employed in the ICU setting. (3)

Nowadays, MRSA is believed to be the causative agent in about 50% of the nosocomial infections, especially in hospitals that provide complex care or contain a large number of beds, rendering it an endemic in many hospital settings. (4) It has become in many places the primary causal organism involved in nosocomial pneumonia, surgical infections, and nosocomial bacteremia. (5)

It is well known that the prevalence rate of nosocomial infections varies according to geographic region and hospital size. However, in a general comparison, the management of infections caused by MRSA not only triples the health care costs compared to nosocomial infections by methicillin

sensitive Staphylococcus aureus, but also increases mortality rates up to more than 40%. This is especially true in patients under multiple antibiotic regimens. (6)

The objective of the present study is to determine the pattern of antimicrobial resistance of S. aureus in the Intensive Care Unit at a tertiary hospital (General Hospital of Culiacan, Sinaloa) in Mexico.

Materials and methods

A descriptive and retrospective study was performed on 1,511 cultures in general surgery, internal medicine, neurosurgery and the ICU, between the periods of June 30, 2004 and July 1, 2007. These cultures consisted of bronchial, urine, central venous catheter, blood, and surgical wound cultures for in-hospital patients. For purposes of this study, the sample pool was limited to ICU patients and out of those, only samples which were positive for S. aureus were included in the study.

The samples were incubated for 24 hours at 37 °C on blood agar and MacConkey's agar. The macroscopic characteristics of the colonies were observed (shape, size, production of pigments, and odor) and, subsequently, identified as S. aureus. The antimicrobial susceptibility testing of isolates was performed by a quantitative serial dilution method by the Kirby-Bauer method on Mueller-Hinton medium. This was done according to the criteria of the Clinical and Laboratory Standards Institute (CLSI) (7) to determine sensitivity to the following listed antibiotics: penicillin, ampicillin, cephalothin, cefotaxime, cefazolin, amoxicillin/clavulanic acid, clindamicin, ciprofloxacin, erythromycin, clarithromycin, tetracycline, rifampin, imipenem and vancomycin.

The samples were analyzed by the Sensititre ARIS® 2X system and observed for 18 hours to determine their antimicrobial susceptibility pattern. The samples were plated on sheep's blood agar, from which the replicated colonies of Staphylococcus sp, were identified by Gram stain, catalase test and coagulase test tube. After identification, a confirmatory test was undertaken by fermentation with mannitol for identification as S. aureus.

Once the resistance to oxacillin was confirmed by the antibiogram, a screening test on Mueller-Hinton supplemented with oxacillin (6 mg/ml) and NaCl (4%) was performed as confirmation. Confirmed MRSA isolates underwent screening disk diffusion-with-cefoxitin for predicting methicillin resistance mediated by the mecA gene. Tabulated data in Excel were analyzed in Statistics/Data Analysis STATA V 6.0.

Results

Of a total of 1,511 samples from different sites of patients hospitalized in general surgery, internal medicine, neurosurgery and the intensive care unit, in the period of July 30, 2004 to July 4, 2007, 206 (13.63%) were culture positive for S. aureus: 27 (13.10%) of central venous catheter, 36 (17.47%) of wound and ulcers, 70 (33.98%) of sputum, 32 (15.53%) of blood cultures, 13 (6.31%) of third space fluid (cerebrospinal fluid, ascitis, pleural fluid, pericardial or peritoneal fluid), foley catheter 24 (11.65%) and other sites 4 (1.94%).

The proportion of positive cultures for S. aureus according to the service was 52 of 374 (13.9%) samples from the intensive care unit (ICU), 58 of 415 (13.79%) from general surgery, 75 of 550 (13.63%) from internal medicine and 21 of 172 (12.20%) of neurosurgery. Of the sites of infection with positive cultures for S. aureus in the ICU, 4 (7.69%) were central venous catheter, 2 (3.85%) for sores and wounds, 33 (63.46%) sputum, 10 (19.23%) for blood cultures, 2 for the third space fluid and 1 for foley tip.

In the ICU, antimicrobial resistance to beta-lactams (penicillin, ampicillin, cephalothin, cefotaxime, cefazolin, amoxicillin/ac. clavulanate and imipenem) averaged 73.52%; for clindamycin was 65.12%; for ciprofloxacin 59.09%, erythromycin 65.31% and for vancomycin was 6.52% (**Table 1**).

The expectoration antimicrobial resistance to beta-lactams average against non-beta-lactams was a 69.29% vs. 37.74% followed by blood cultures with 76.92% vs. 64.29% respectively, and foley catheter tip and central venous catheter 100% in both groups (**Table 2**).

Discussion

We found that the presence of S. aureus in sputum samples was isolated in 63.43% of cases, and of these, 73.52% were methicillin resistant. This showed to be slightly higher than as reported by Casanova-Cardiel et al. In their study they tried to find antimicrobial resistance patterns in tracheal aspirates of patients with ventilator-associated pneumonia in an intensive care unit of a hospital in Mexico. They found a frequency of S. aureus of 24% and in turn reported a frequency of 70% methicillin resistant. (8)

We know that bacterial resistance is enhanced by the widespread use of antibiotics. Significant changes in the use can affect the antimicrobial susceptibility and promoting and accelerate the increase of antibiotic resistance. These results

should be made alert about the use of antibiotics in the ICU and other areas, as it should be rational and prudent. (9-11)

An inspection conducted on antimicrobial resistance in Europe in 2005, in 35 different intensive care units, showed a proportion of MRSA with a median of 11.6% (range 0-92%). None of the participating institutions established screening for MRSA at admission as a requirement, nor were individual rooms for isolation. Interestingly vancomycin resistant strains were not obtained in any of the samples. (12)

Another study of microbial infection surveillance and MRSA was performed in Germany between the periods of 2008 and 2010, in which blood cultures from laboratories and hospitals belonging to the European Network for Antimicrobial Resistance Surveillance found a rate of 19.2% in MRSA in hospitalized patients and 10.6% in outpatients. The units with higher proportions of MRSA were nephrology, geriatrics, neurology and surgical intensive care, with 49.4%, 45.82%, 34.2% and 27%, respectively. In outpatients, urology patients had the highest rates (29.2%). (13)

Our study shows a high incidence of MRSA in an Intensive Care Unit at a tertiary hospital, emphasizing some points that are worthy to be taken into account. First, there is a growing incidence of antimicrobial resistance of S. aureus. Second, there is a high frequency of MRSA in intensive care units in tertiary hospitals. Finally, there is a high prevalence of MRSA in hospitals in Latin America. This and other previously published studies (8,11,14) should serve as a guideline to take serious measures to antimicrobial resistance in Latin American countries.

In the present study we analyzed the distribution by gender, age, length of hospital stay, costs, and mortality. This study is part of a hospital surveillance program that aims to develop strategies for type prevention in order to know the most common microorganisms according to the type of biological and drug resistance patterns most commonly used.

In our study we found positive cultures for S. aureus at a frequency of 13.9%, down from the 24.2% reported in a hospital of Saudi Arabia. However, we found that the frequency of resistance to vancomycin was at 6.52% compared to the Baddor et al study conducted in several hospitals of Saudi Arabia, where all strains of S. aureus were susceptible to vancomycin. (15)

It is clear that the results of this study indicate that this is a strain of S. aureus resistant to multiple antibiotics. Therefore, antimicrobial therapy does not consider the local antimicrobial resistance patterns to continue on using those antibiotics which are considered a risk factor for infection by S. aureus. Thus, it is quite difficult to overcome this perennial problem.

The present study did not analyze the following factors: sex ratio, age, attributable cost, length of hospital stay, and mortality of S. aureus infection. The reason being this study is part of a medical surveillance program to establish which function of preventive strategies to order to know the most common microorganisms to accord the type of biological samples and drug resistance patterns for S. aureus isolates. In those patients whose strains of S. aureus were resistant to vancomycin, it mandated close monitoring and follow-up in order to assess the association amongst hospital stay, morbidity and mortality.

Finally, in Mexico in 2010, there was a major advance in the control and management of the institute antibiotic prescribing the use of the prescription for dispensing the same. (16) However, no national registry includes infections caused by S. aureus in intensive care units. Thus, it is useful for determining bacterial migration patterns and management of patients.

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Table 1. Frequency of antimicrobial resistance of Staphylococcus aureus by type of antibiotic

Antibiotic (n)	Frecuency
Penicillin (23)	91.30
Ampicillin (27)	88.89
Cephalotin (47)	68.09
Cefotaxime (50)	68.00
Cefazolin (48)	66.67
Amoxicillin/clavulanic acid (44)	63.64
Imipenem (47)	68.09
Clindamycin (43)	65.12
Ciprofloxacin (44)	59.09
Erythromycin (49)	65.31
Clarithromyicin (44)	61.36
Tetracycline(48)	39.58
Rifampicin (43)	20.93
Vancomycin (46)	6.52

Table 2. Antimicrobial resistance pattern of Staphylococcus aureus by sample type

Antibiotic	Sputum (%)	Wounds (%)	Foley tip (%)	Third space fluid (%)	Central catheter (%)	Blood culture (%)
Penicillin	93.75	-	-	100	100	75
Ampicillin	100	-	-	100	100	60
Cephalotin	60.71	-	100	93.33	100	80
Cefotaxime	59.38	-	100	100	100	88.89
Cefazolin	56.67	50	100	100	100	80.77
Amoxicillin/Ac. clavulanic	55.56	-	100	100	100	75
Imipenem	60	-	100	100	100	78.78
Clindamycin	53.85	-	100	100	100	87.50
Ciprofloxacin	50	-	100	100	100	77.78
Erythromycin	58.06	-	100	50	100	88.89
Clarithromycin	55.17	67.86	100	100	100	71.43
Tetracycline	27.59	-	100	50	75	60
Rifampicin	16	-	-	50	-	44.44
Vancomycin	3.57	-	-	-	-	20

Legend: Third space fluid=cerebrospinal fluid, ascites fluid, pleural fluid, pericardial fluid or peritoneal fluid.

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