

<http://dx.doi.org/10.35630/2199-885X/2022/12/2.9>

ANALYSIS OF THE SENSITIVITY OF STAPHYLOCOCCUS AUREUS TO ANTIBIOTICS IN PATIENTS WITH PURULENT-SEPTIC DISEASES

Received 29 January 2022;
Received in revised form 3 March 2022;
Accepted 7 March 2022

Valeh Jafarov, Konstantin Horak ,
Artem Morozov , Elizaveta Sobol,
Anastasia Domracheva , Anastasia Romanova ,
Sofia Zinkovskaia 

Tver State Medical University, Tver

✉ ammorozovv@gmail.com

RELEVANCE

The purulent-septic infection caused by *Staphylococcus aureus* is one of the biggest problems of modern medicine.

There are some strategies to control the increasing antibiotic resistance of bacteria. They are the development and introduction of new antibacterial drugs into surgical practice, the improvement of antimicrobial therapy methods and the rotation of antibacterial drugs [1, 2, 3].

Staphylococcus aureus is one of the most common causative agents of infections of various localizations. The development of mechanisms of antibiotic resistance of bacteria is more often determined by genes located on the bacterial chromosome or R-plasmids. Particular attention is paid to methicillin-resistant staphylococci (MRS strains). They are registered in nosocomial or out-of-hospital infections. The resistance of staphylococci to β -lactam antibiotics is due to the presence of the *mec A* gene. It encodes the penicillin-binding protein (PBP). The *mec A* gene is located on a mobile genetic element. This element is called the staphylococcal chromosome cassette (SCC*mec*). Methicillin-resistant *Staphylococcus aureus* is resistant to all β -lactam antibiotics. Currently, it is necessary to use combinations of antibacterial drugs for the treatment of infections caused by methicillin-resistant staphylococci [4, 5, 6, 7].

Purpose:

to analyze the sensitivity of *Staphylococcus aureus* detected in patients with various purulent-inflammatory diseases to antibacterial drugs of different classes.

MATERIALS

The present study provided a statistical analysis of 300 registration forms of the microbiological study re-

ABSTRACT — **RELEVANCE:** The study of microflora speciation is one of the important aspects of surgical practice. The gram-positive microorganisms are the most common causative agents of surgical infection. *Staphylococcus aureus* is the most pathogenic species of staphylococci. It is the causative agent of purulent-inflammatory human diseases. Of particular importance is the increase in the frequency with which hospital strains adapted to hospital conditions are released.

PURPOSE: to analyze the sensitivity of *Staphylococcus aureus* detected in patients with various purulent-inflammatory diseases to antibacterial drugs of different classes.

MATERIALS: The present study provided a statistical analysis of 300 registration forms of the microbiological study results of the microbiological landscape of purulent-septic diseases. The study was conducted on the basis of the surgical department of the City Clinical Hospital No. 7 (Tver, Russia) for the period 2020-2021. Statistical data processing was carried out using Microsoft Excel 2020 licensed software.

RESULTS: The study identified *Staphylococcus aureus* as the most common causative agent of purulent-septic diseases. It was found that this pathogen was detected in 99 out of 300 patients. The study included patients with phlegmon of the lower extremities (23.8%), phlegmon of the upper extremities (16.09%), festering atheromas (50%), gangrene of the lower extremities (28.6%), osteomyelitis (14.4%), soft tissue abscesses (33.3%). It was found that ciprofloxacin was one of the most common antibiotics, to which *Staphylococcus aureus* showed the greatest sensitivity in case of phlegmon of the upper and lower extremities, festering atheromas, gangrene of the lower extremities and osteomyelitis. *Staphylococcus* showed the greatest sensitivity to gentamicin (21.6%) and amikacin (8.1%) in case of soft tissue abscesses. This pathogen also showed sensitivity to tetracycline (8.1%) and doxycycline (5.4%) in patients with abscesses. *Staphylococcus aureus* showed identical sensitivity to fosfomicin, ofloxacin, vancomycin, meronem, imipenem and clindamycin in various nosologies. **CONCLUSION:** *Staphylococcus aureus* showed the greatest sensitivity to antibiotics of the cephalosporin class. The second most common were representatives of the class of aminoglycosides — gentamicin and amikacin. The sensitivity of *Staphylococcus aureus* to vancomycin and clindamycin was manifested only in patients with suppurated atheromas. The sensitivity to erythromycin was observed in *Staphylococcus aureus* only in patients with soft tissue abscesses. The results of this study showed that *Staphylococcus aureus* exhibits different sensitivity to antibacterial drugs depending on the specific purulent-inflammatory disease. It must be taken into account when starting etiotropic therapy until the sensitivity is determined in each specific situation.

KEYWORDS — *Staphylococcus aureus*, antibiotic resistance, antibacterial drugs.

sults of the microbiological landscape of purulent-septic diseases. The study was conducted on the basis of the surgical department of the City Clinical Hospital No. 7 of Tver (Russia) for the period 2020–2021. The clinical material was taken with a sterile tampon probe, which was placed in a tube containing Ames' transport environment with coal. The obtained samples were stored at a temperature not lower than + 5° C and not higher than +30. They were delivered to the laboratory within half an hour after taking them. The bacteriological study of clinical material was carried out on Endo selective and differential diagnostic media, yolk-salt agar, blood agar. It used the classical bacteriological method in aerobiosis at 37° C. The morphological and biochemical identification was carried out after the isolation of the pure culture. It used the clinical recommendations "Determination of the sensitivity of microorganisms to antimicrobials" (2018) to establish the category of sensitivity of microorganisms, according to the international European system EUCAST. The sensitivity of the isolated strains was determined by the disk diffusion method using OXOID disks. Then it was determined by degree of sensitivity according to the diameter of the lysis area. Statistical data processing was carried out using Microsoft Excel 2020 licensed software.

RESULTS AND DISCUSSION

In the present study we evaluated the clinical samples of wound discharge from patients with phlegmon of the upper and lower extremities, soft tissue abscesses, wet gangrene of the lower extremities, osteomyelitis and suppurated atheromas. It was found that a Gram-positive pathogen (*Staphylococcus aureus*) was detected in 99 out of 300 patients (33%).

The investigated pathogenic microorganism shows different sensitivity to antibacterial drugs depending on the nosology.

In the study of Tokaeva B.T. (2014) it was found that *Staphylococcus aureus* is sensitive to the following antibacterial drugs: glycopeptides, carboxypenicillins, macrolides, aminoglycosides and cephalosporins. In the course of this clinical study, it was found that *Staphylococcus aureus* is sensitive to antibiotics of the penicillin, tetracycline, aminoglycoside, cephalosporin, oxazolidinone, and sulfonamide classes.

84 cases of the clinical specimens received from patients with phlegmon of the lower extremities were studied. *Staphylococcus aureus* was isolated in 20 cases (23.8%). This pathogen in vitro showed the highest sensitivity to the group of cephalosporins (30%), in particular to ceftriaxone (20%). The sensitivity to cefepime (5%) was manifested only in the pathogen obtained from patients with this nosology. The sen-

sitivity to aminoglycosides was manifested in 25% of cases (Table 1).

Staphylococcus aureus was isolated in 14 cases out of 87 patients with phlegmon of the upper extremities (16.09%). This pathogen was found to be sensitive to cephalosporins in 35.7%. The sensitivity to antibiotics of the aminoglycoside class was 21.4%. The representatives of this drugs group were amikacin (7.1%) and gentamicin (14.3%). *Staphylococcus aureus* also showed sensitivity to tetracycline (14.3%) (Table 1).

Based on the research of Naumkina E.V. (2018) it can be noted that strains of *Staphylococcus aureus* are sensitive to fluoroquinolone antibiotics at 39%. They were isolated from patients in the department of purulent surgery. In the present study, the pathogen showed sensitivity to a representative of the fluoroquinolone class (ofloxacin) only in 14.7% of cases.

Staphylococcus aureus was isolated in 24 cases out of 48 patients with suppurated atheromas (50%). The greatest sensitivity of this pathogen was manifested to antibiotics of the cephalosporin class (33.3%). Only *Staphylococcus aureus*, isolated from patients with suppurated atheromas, showed a sensitivity of 4.3% to vancomycin and meropenem (Table 1).

According to the study of Lipatov K.V. (2019), the isolated strains of *Staphylococcus aureus* in patients with purulent-septic diseases are characterised by high sensitivity to vancomycin and linezolid. However, the present study showed the least sensitivity to these antibiotics. The sensitivity to linezolid was manifested only by *Staphylococcus aureus*, isolated from patients with phlegmon of the upper extremities, soft tissue abscesses. The sensitivity to vancomycin was observed only in patients with suppurated atheromas.

Staphylococcus aureus was isolated in 8 cases out of 28 patients with gangrene of the lower extremities (28.6%). This pathogen showed the highest sensitivity to antibiotics of the cephalosporin class (44.5%). The lowest sensitivity (11.1%) was found to imipenem, tetracycline and norfloxacin (Table 1).

Staphylococcus aureus was detected in 27 cases out of 37 patients with soft tissue abscesses (72.9%). This pathogen showed little sensitivity to antibiotics of the aminoglycoside class: to gentamicin (21.6%) and to amikacin (8.1%). *Staphylococcus aureus* showed sensitivity to amoxicillin in 19% of cases. The sensitivity of *Staphylococcus aureus* to the tetracycline class was manifested in 13.5% of cases. *Staphylococcus aureus* was sensitive to doxycycline in 5.4% (Table 1).

Staphylococcus aureus was isolated in 6 cases out of 16 patients with osteomyelitis (37.5%). This pathogen showed the greatest sensitivity to antibiotics of the cephalosporin class (41%). *Staphylococcus aureus*

Table 1. Sensitivity of *Staphylococcus aureus* in various purulent-septic diseases

Antibiotic	Phlegmon of the upper extremities	Phlegmon of the lower extremities	Soft tissue abscesses	Festering atheromas	Gangrene of the lower extremities	Osteomyelitis
Ceftriaxone	30%	28,6%	20%	20,8%	22,2%	20,5%
Gentamicin	20%	14,3%	21,6%	11,7%	11,1%	20,5%
Amoxicillin	15%	0%	19%	8,3%	0%	9%
Tetracycline	10%	14,3%	8,1%	0%	11,1%	0%
Cefepime	5%	0%	0%	0%	0%	0%
Cefazolin	5%	0%	0%	8,3%	11,1%	20,5%
Amikacin	5%	7,1%	8,1%	20,8%	11,1%	20,5%
Imipenem	5%	0%	2,48%	4,3%	11,1%	0%
Ofloxacin	5%	0%	5,4%	4,3%	0%	0%
Clindamycin	5%	7,15%	0%	4,3%	0%	0%
Co-Trimoxazole	5%	0%	2,48%	0%	0%	0%
Norfloxacin	0%	7,15%	0%	0%	11,1%	0%
Linezolid	0%	7,15%	2,48%	0%	0%	0%
Ciprofloxacin	0%	7,1%	0%	4,2%	11,1%	0%
Doxycycline	0%	0%	5,4%	0%	0%	9%
Fosfomycin	0%	0%	2,48%	4,3%	0%	0%
Erythromycin	0%	0%	2,48%	0%	0%	0%
Vancomycin	0%	0%	0%	4,3%	0%	0%
Meropenem	0%	0%	0%	4,3%	0%	0%

showed sensitivity to ceftriaxone in 20.5% of cases. The sensitivity to amikacin and gentamicin is 41%. *Staphylococcus aureus* is sensitive to amoxicillin and doxycycline in 9% of cases using the method of determining the sensitivity to antibacterial drugs using OXOID discs. The sensitivity to doxycycline was observed only in patients with soft tissue abscesses and osteomyelitis.

CONCLUSION

Staphylococcus aureus showed the greatest sensitivity to antibiotics of the cephalosporin class. The second most common were representatives of the class of aminoglycosides — gentamicin and amikacin. The sensitivity of *Staphylococcus aureus* to vancomycin and clindamycin was manifested only in patients with supplicated atheromas. Sensitivity to erythromycin was observed in *Staphylococcus aureus* only in patients with soft tissue abscesses. The results of this study showed that *Staphylococcus aureus* exhibits different sensitivity to antibacterial drugs depending on the specific purulent-inflammatory disease. Therefore, etiotropic therapy may only be started after the sensitivity for each specific situation is determined.

REFERENCES

1. MISHYNA M. M. Microbiological characterization of pathogenicity factors of candida albicans and staphylococcus aureus association affecting neutrophil phagocytic activity / M.M. Mishyna, O.V. Kochneva, O.V. Kotsar // West Kazakhstan Medical Journal. – 2021. – № 2(63). – P. 70–76. – DOI 10.24412/2707-6180-2021-63-70-76
2. Fluorescence detection of *Staphylococcus aureus* using vancomycin functionalized magnetic beads combined with rolling circle amplification in fruit juice / Y. Wang, Z. Wang, Z. Zhan [et al.] // Analytica Chimica Acta. – 2022. – Vol. 1189. – P. 339213. – DOI 10.1016/j.aca.2021.339213
3. Bioactive glass particles as multi-functional therapeutic carriers against antibiotic-resistant bacteria / N. Pajares-Chamorro, X. Chatzistavrou, Y. Wagley [et al.] // Journal of the American Ceramic Society. – 2021. – DOI <https://doi.org/10.1111/jace.17923>
4. Antibiotic sensitivity of clinical isolates at outpatient unit in Tver, Russia: a comparative / K. Horak, K. Gorodnischev, A. Morozov [et al.] // Archiv EuroMedica. – 2020. – Vol. 10. – No 4. – P. 77–79. – DOI 10.35630/2199-885X/2020/10/4.17
5. Development of antibiotic resistance in the aspect of outpatient services / A. M. Morozov, A. N. Sergeev, V. A. Kadykov [et al.] // Vestnik sovremennoy klinicheskoy meditsiny. – 2021. – T. 14. – No 5. – P. 43–50. – DOI 10.20969/VSKM.2021.14(5).43–50
6. Interaction of the antimicrobial peptide $\Delta M3$ with the *Staphylococcus aureus* membrane and molecular models / M. Manrique-Moreno, E. Patiño-González, E. Fandiño-Devia [et al.] // Biochimica et Biophysica Acta (BBA) – Biomembranes. – 2021. – Vol. 1863. – No 2. – P. 183498. – DOI <https://doi.org/10.1016/j.bbame.2020.183498>
7. DIAS, T. A computer-driven approach to discover natural product leads for methicillin-resistant staphylococcus aureus infection therapy † / T. Dias, S. P. Gaudêncio, F. Pereira // Marine Drugs. – 2019. – Vol. 17. – No 1. – P. 16. – DOI 10.3390/md17010016