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Incidence of Surgical Site Infections (SSIs) and Antimicrobial Resistance their Pathogens in Ukraine

Abstract

OBJECTIVE — to analyses the results of patients' surgery, to determine the incidence rate of surgical site infections (SSIs) and to identify prevailing pathogens and their resistance to antibiotics in Ukrainian hospitals.

MATERIALS AND METHODS. The investigation included 9,408 patients who underwent surgeries during 2015 in 12 surgical hospitals in different Ukrainian regions. In order to determine the incidence rates of SSIs were used the standard definition that were developed by the CDC (USA). The investigation included the analysis of 1,248 strains from patients with clinical symptoms SSIs. The identification and antimicrobial susceptibility of cultures were determined, using automated microbiology analyzer Vitek 2 Compact (BioMerieux, France). Susceptibility to antibiotics was determined using AST cards (BioMerieux, France). Some antimicrobial susceptibility test used Kirby — Bauer antibiotic testing. Interpretative criteria were those suggested by the CLSI (USA).

RESULTS AND DISCUSSION. Data analysis demonstrated that 13.3 % (CI 95 %: 12.3—14.2 %) patients developed postoperative SSIs. Infection rates after various surgical procedures at surgical sites were observed. Shows the high infection rate in appendectomy (17.47 %), gastric, small and large bowel surgeries (18.23 %). The infection rate in orthopedic procedures (13.27 %), cholelithiasis (hepatobiliary) (14.93 %), uterus and adnexal structures (11.10 %), urinary tract and genitalia (9.37 %) and hernia (14.1 %) are comparatively lower. The infection rate in lower segment caesarean structure is 4.24 % and excision of dermoid cysts, lipomas 3.22 %. *Staphylococcus aureus* was identified as the most common causative agent of SSIs (27.6 %), followed by *Escherichia coli* (14.1 %), *Enterococcus faecalis* (13.5 %), and *Pseudomonas aeruginosa* (10.1 %). Frequency of *Klebsiella pneumoniae*, *Acinetobacter baumannii, Enterobacter aerogenes*, *Enterococcus faecium*, *Streptococcus spp*., *Staphylococcus epidermidis* and *Proteus vulgaris* was 7.1 %, 6.9 %, 6.1 %, 4.7 %, 4.6 %, 3.6 %, and 1.6 %, respectively. Antibiotic susceptibility testing showed that all strains of *S. aureus* resistant to penicillin. The most active antibiotics found were linezolid, tigecycline, and mupirocin, showing growth inhibition of 100 % strains tested, followed by nitrofurantoin, trimethoprim/sulphamethoxazole, to fusidic acid, teicoplanin, fosfomycin, gentamycin, vancomycin. Susceptibility to tetracycline, rifampicin, erythromycin, and clindamycin was observed to be some lower. Methicillin-resistant *S. aureus* comprised 29.1 %, while Vancomycin-resistant *S. aureus* comprised 9.3 %. Resistance *E. faecalis* to ceftibuten, chloramphenicol, moxifloxacin, and teicoplanin was 100 % and to cefepime 96 %. The proportion of vancomycin-resistant enterococci was 6.9 %. 26.5 % of *E. coli* strains showed resistance to all tested antibiotics. The most potent antimicrobials were imipenem, tobramycin, meropenem, levofloxacin and amikacinum. The high rates of resistance were found to penicillum, lincomycin, clindamycin, ampicillin, clarithromycin, amoxicillin, and to cefuroxime. *K. pneumoniae* showed the lowest resistance to amikacin and imipenem, and was moderately sensitive to cefepime, gentamicin, ceftriaxone, tobramycin, piperacillin/tazobactam, ciprofloxacin, tetracycline, ceftazidime, and aztreonam. 39.6 % of *P. aeruginosa* were resistant to all tested antibiotics. The most potent antimicrobials were meropenem, tobramycin, imipenem and levofloxacin. The high rates of resistance were found to penicillin, erythromycin, rifampicin, tetracycline, azithromycin, amoxicillin, cefalexin, ampicillin/sulbactam, clarithromycin, and to pefloxacin. *P. aeruginosa* were 100 % resistant to oxacillin, ceftibuten, tetracycline, and erythromycin.

CONCLUSIONS. SSIs remain an important cause of postoperative morbidity. Antimicrobial resistance among these and other clinically important pathogens is an increasing problem. The clinical should choose antimicrobial drug in accordance with the local bacterial resistance characteristics for reduce the production of drug resistance and improve the effect of anti-infection treatment possibly.

KEY WORDS: surgical site infection, surgical procedure, antibiotic susceptibility, nosocomial infection, Ukraine.

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INTRODUCTION

Despite major advances in infection control interventions, health care-associated infections (HAI) remain a major public health problem and patient safety threat worldwide [1, 2]. The global estimated prevalence of HAI, at any given time, approximates 1.4 million [3]. Surgical site infections (SSIs) are the most common type of nosocomial infection among surgical patients. [4—7]. SSIs is a wound infection that occurs following an invasive procedure. SSIs accounts for over 20 % of all healthcare-associated infections in surgical patients [4]. According to the state statistical reports, SSIs are the most frequent post-surgical complications in Ukraine with incidences from 3 % to 35 % [6, 8—10].

SSIs are defined as infections occurring up to 30 days after surgical procedures (or up to one year after surgery in patients receiving implants) and affecting either the incision or deep tissue at the operation site. Despite improvements in prevention, SSIs remain a significant clinical problem as they are associated with substantial mortality and morbidity and impose severe demands on healthcare resources. SSIs are infections of the incision or organ or space that occur after surgery [11]. Surgical patients initially seen with more complex comorbidities [12] and the emergence of antimicrobial-resistant pathogens increase the cost and challenge of treating SSIs [13].

SSIs is unequivocally morbid and costly. It has been reported that more than one-third of postoperative deaths worldwide are related to SSIs [14]. It has been estimated 300,000 SSIs annually in the United States represent the second most common infection among surgical patients, prolong hospitalization by 7—10 days, and have an estimated annual incremental cost of $1 billion [15]. Several studies have estimated that the burdens that hospitals or national health trusts face increases in costs ranging from £814 to £6,626 ($1,341—10,922) per patient in England, depending on the type of surgery involved and the severity of infection [16]. Other studies have reported an average cost of €325 ($4,544) per day in Europe and $25,546 per infection in the United States [17, 18]. The hospital-related cost of a single SSIs in the United States has been estimated at $12,000—$35,000 [19], and estimates of annual nationwide hospital costs of SSIs have ranged from $3 billion to $10 billion [20]. Costs can exceed $90,000 per infection when the SSIs involves a prosthetic joint implant [21] or an antimicrobial-resistant organism [22].

Challenges related to the prophylaxis and therapy of post-surgical pyoinflammatory infections are extremely relevant. One of the reasons for SSIs is the wide spread of conditionally pathogenic microorganisms (CPM) that are resistant to antimicrobial medicines and cause nosocomial infections [6, 13, 22]. Every year resistant nosocomial infections are becoming more and more pressing for medical specialists in Ukraine.

Current guidelines for the treatment of infections recommend the immediate prescription of antimicrobial medicines as soon as the infection is diagnosed. Broad spectrum antimicrobials should be prescribed even before the culture results are known in order to cure the most probable infection agents. Targeted antibacterial treatment should be provided following the identification of an etiological agent and resistance status. However, the results of numerous investigations prove that the prescription of an inadequate starting therapy raises the mortality rate among patients with severe infections by 1.5—3.0 times [14, 15]. In addition, inadequare therapy extends the duration of hospitalization and provokes a need for additional courses of antimicrobial therapy that makes treatment more expensive [16—22].

Surveillance, which records infection prospectively and actively, is an essential method for understanding the incidence and distribution of healthcare-associated infections. Site-oriented target surveillance, which is usually undertaken for selected high-risk infections and specialties, provides more accurate data. However, surveillance in Ukraine remains inadequate and inaccurate [6, 8—10]. In Ukraine, public reports of SSIs, obtained via ongoing national surveillance activities, have been rare over the past decades. However, many articles have reported that SSIs surveillance at hospital level varies widely.

Epidemiological control in surgical hospitals is provided through continuous microbiological monitoring to reveal, identify and register various infections, their symptoms, development tendencies and sensitivity to antimicrobial medicines. This data provides a foundation for developing a strategy for the use of antibiotics in surgery hospitals. The microbiological diagnostics of infections (identification of pathogens and sensitivity to antibiotics) is necessary for optimal antimicrobial therapy. However, data on the etiology and resistance of pathogens associated with nosocomial infections in surgical hospitals varies considerably. Thus it is necessary to continuously monitor SSIs in every surgical hospital to identify the prevailing causal agents of nosocomial infections and establish systematic epidemiological control over antibacterial resistance at the local, regional and national levels.

The goal of this investigation was to analyse the results of patients' surgery, to determine the incidence rate of surgical site infections (SSIs) and to identify the prevailing pathogens and resistance to antibiotics in Ukrainian hospitals.

MATERIALS AND METHODS

The investigation included 9,408 patients who underwent surgeries during 2015 (from January 2015 to December 2015) in 12 surgical hospitals in different Ukrainian regions that are similar in terms of medical equipment, laboratory facilities and number of surgeries performed. The patients' age ranged from 19 to 74. In order to determine the incidence rates of SSIs in the participating hospitals, passive search (through records from medical officers) and active identification (through epidemiological diagnostics) were used. The investigation was based on the standard definition of an SSIs as purulent discharge from a surgical wound and the identification of microorganisms in the liquid or tissue at the surgical site. The information was collected using tables for the standard criteria of SSIs diagnostics that were developed by the Centers for Disease Control and Prevention (Atlanta, USA) [23] and adopted for use in Ukraine. A wound was considered to be infected if any one of the following criteria was fulfilled: serous or nonpurulent discharge from the wound; pus discharge from the wound; serous or nonpurulent discharge from the wound with signs of inflammation (edema, redness, warmth, raised local temperature, tenderness, induration). Information from the microbiological laboratory reports and other types of medical documents was also considered.

The investigation included the analysis of 1.248 strains of conditionally pathogenic microorganisms from biological material obtained from patients with clinical symptoms. The clinical sample consisted of laboratory-diagnosed SSIs that emerged no less than 48 hours after a surgery. Bacterial strains obtained for a second time from the same patients were not subject to analysis.

Analysis of biological material and interpretation of results were performed in accordance with the approved rules for clinical material selection, analysis and interpretation of results. The identification and antimicrobial susceptibility of the cultures were determined, using automated microbiology analyzer Vitek 2 Compact (BioMerieux, France). Susceptibility to antibiotics was determined using AST cards (BioMerieux, France). Some antimicrobial susceptibility test used Kirby — Bauer antibiotic testing. Interpretative criteria were those suggested by the Clinical and Laboratory Standards Institute (CLSI) [24].

Data obtained were transferred for further analysis into computer software WHONET 5.1 (© 1989—2001, World Health Organization. All rights reserved. Freeware downloadable from http://www.who.int/drugresistance/whonetsoftware/en/). The analysis of statistical data was performed using Microsoft Excel. Values of $p < 0.05$ were considered statistically significant.

RESULTS

Data analysis demonstrated that 13.3 % (CI 95 %: 12.3—14.2 %) patients developed postoperative SSIs. Infection rates after various surgical procedures at surgical sites were observed. Table 1 shows the high infection rate in appendectomy

Table 1
Surgical procedures and surgical site infection rate

Surgical procedure	Number of cases	Number of cases infected	Percentage
Orthopedic procedures	844	112	13.3
Gastric and small bowel	1272	232	18.24
Appendectomy	1648	288	17.48
Cholelithiasis (hepatobiliary)	884	132	14.93
Excision of Dermoid cysts, lipomas	992	32	3.23
Hernia	2496	352	14.10
Lower segment caesarean structure	472	20	4.24
Uterus and adnexa	288	32	11.11
Urinary tract and genitalia	512	48	9.38
Total	9408	1248	13.27

Table 2
Microorganisms isolated from SSIs cases in Ukrainian surgical hospitals in 2015 (n = 1248)

Microorganisms	Number of strains	Proportion, %
Gram-positive coccus	675	54.1
Staphylococcus aureus	345	27.6
Staphylococcus epidermidis	45	3.6
Enterococcus faecalis	169	13.5
Enterococcus faecium	59	4.7
Streptococcus spp.	57	4.6
Gram-negative bacilli	573	45.9
Escherichia coli	176	14.1
Enterobacter aerogenes	77	6.1
Klebsiella pneumoniae	88	7.1
Proteus vulgaris	20	1.6
Pseudomonas aeruginosa	126	10.1
Acinetobacter baumannii	86	6.9

(17.47 %), gastric, small and large bowel surgeries (18.23 %). The infection rate in orthopedic procedures (13.27 %), cholelithiasis (hepatobiliary) (14.93 %), uterus and adnexal structures (11.1 %), urinary tract and genitalia (9.37 %) and hernia (14.1 %) are comparatively lower. The infection rate in lower segment caesarean structure (LSCS) is 4.24 % and excision of dermoid cysts, lipomas 3.22 % (Table 1).

The analyses of etiological SSIs agents showed that 54.1 % of the microorganisms obtained (675/1,248) from surgery wounds were Gram-positive and 45.9 % (573/1,248) were Gram-negative (Table 2).

Patients with SSIs *Staphylococcus* had the highest proportion of CPM (31.3 %) followed by *Enterobacteriaceae* (28.9 %). The etiological role was lower for *Streptococcaceae* (14.7 %) and *Pseudomonadaceae (P. aeruginosa)* (10.1 %). The remaining 6.9 % included *A. baumannii*. Gram-negative organisms were mostly isolated from surgeries on bowel, urinary tract and appendix. *S. aureus* is the predominant organism infecting LSCS. No other organism is particularly associated with specific surgery.

Prevailing causal agents of SSIs were resistant to many antimicrobial medicines used in the hospitals. Resistant to antibiotics SSIs agents were identified among Gram-positive and Gram-negative microorganisms.

Antibiotic susceptibility testing showed that all the strains of *S. aureus* resistant to penicillin. Based on antimicrobial susceptibility analysis,

Table 3
Antimicrobial susceptibility of *S. aureus* isolated from Ukrainian surgical hospitals (n = 345)

Antibiotic	Division by susceptibility, %		
	Resistant	Moderately resistant	Susceptible
Cefoxitin	23.7	0	76.3
Benzylpenicillin	100.0	0	0
Oxacyllin	29.1	0	70.9
Gentamycin	7.0	0	93.0
Tobramycin	8.0	0	92.0
Levofloxacin	2.0	9	89.0
Moxifloxacin	15.0	1	84.0
Erythromycin	26.0	0	74.0
Clindamycin	29.0	0	71.0
Linezolid	0	0	100.0
Teicoplanin	4.0	0	96.0
Vancomycin	9.3	0	90.7
Tetracycline	22.0	0	78.0
Tigecycline	0	0	100.0
Fosfomycin	5.0	0	95.0
Nitrofurantoin	1.0	0	99.0
Fusidic acid	1.0	1	98.0
Mupirocin	0	0	100.0
Rifampicin	18.0	5	77.0
Trimethoprim/sulphamethoxazole	1.0	0	99.0

the most active antibiotics found in the study were linezolid, tigecycline, and mupirocin, showing growth inhibition of 100 % strains tested. Susceptibility to the other antimicrobials was also on a high level: 99 % of strains were found susceptible to nitrofurantoin and trimethoprim/sulphamethoxazole, 98 % — to fusidic acid, 96 % — to teicoplanin, 95 % — to vancomycin and fosfomycin, 93 % — to gentamycin, 92 % — to tobramycin, 90,7 % — to vancomycin, and to levofloxacin (89 %). Susceptibility to tetracycline (78 %), rifampicin (77 %), erythromycin (74 %), and clindamycin (71 %) was observed to be some lower. Research of Methicillin-resistant *S. aureus* (MRSA) prevalence in Ukrainian surgical hospitals shown, that 11 % of staphylococci strains, isolated from patients having nosocomial infections (SSIs), had multiple resistance to antibiotics. MRSA comprised 29.1 %, while vancomycin-resistant *S. aureus* (VRSA) comprised 9.3 %. Further, 35.7 % of MRSA strains were resistant only to the group of beta-lactamic antibiotics, while the rest — also to the other classes of antibiotics (Table 3).

It is widely known that enterococci are by nature resistant to cephalosporins and can also acquire resistance to almost any class of antibiotics including penicillins, aminoglycosides, and glycopeptides. We focused on *E. faecalis*, the resistance of which to ceftibuten, chloramphenicol, moxifloxacin, and teicoplanin was 100 % and to cefepime and clarithromycin 96 % and 87.5 %, respectively. The proportion of vancomycin-resistant enterococci (VRE) was 6.9 %.

Studies have shown that in surgical hospitals in Ukraine, 26.5 % of *E. coli* strains showed resistance to all tested antibiotics. The most potent antimicrobials were imipenem, tobramycin, meropenem, levofloxacin and amikacinum. High rates of resistance were found to penicillum (56.9 %), lincomycin (41.4 %), clindamycin (41.1 %), ampicillin (39.6 %), clarithromycin (36.5 %), amoxicillin (36.1 %), and to cefuroxime (33.4 %).

E. aerogenes strains were resistant to piperacillin/tazobactam (74.6 %), oxacillin (73.2 %) and ciprofloxacin (71.1 %). *E. aerogenes* have

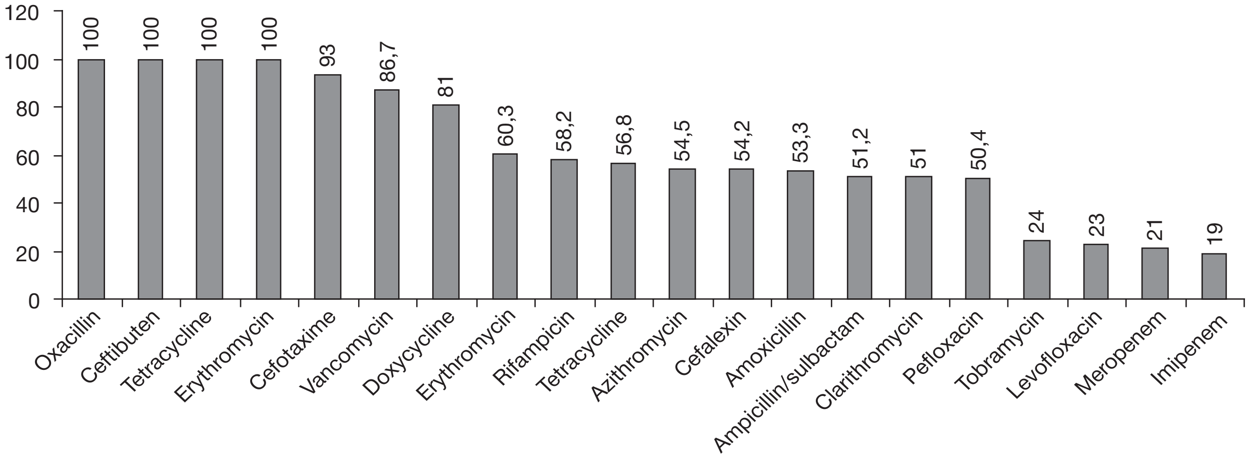

Figure 1. **The antimicrobial susceptibility test of *P. aeruginosa*,% (n = 126)**

the maximum sensitivity to imipinem (95.9 %), meropenem (88.0 %), ampicillin/sulbactam (92.3 %), netilmicin (84.6 %), clarithromycin (93.1 %), and gatifloxacin (89.1 %).

Isolates of *K. pneumoniae* showed the lowest resistance to amikacin (4.5 %) and imipenem (5.0 %). *K. pneumoniae* was moderately sensitive to cefepime (8.3 %), gentamicin (10.1 %), ceftriaxone (12.2 %), tobramycin (14.4), piperacillin/tazobactam (14.7 %), ciprofloxacin (16.8 %), tetracycline (16.4 %), ceftazidime (17.5 %), trimethoprim/sulfamethoxazole (19.5 %), and aztreonam (20.9 %). In our study, the proportion of *K. pneumoniae* isolates resistant to carbapenems was lower than those previously reported. Imipenem-resistant isolates of *K. pneumoniae* showed the lowest resistance to tetracycline (19.1 %) and amikacin (35.7 %).

In surgical hospitals of Ukraine 39.6 % of *P. aeruginosa* strains were resistant to all tested antibiotics. The most potent antimicrobials were meropenem, tobramycin, imipenem and levofloxacin. The high rates of resistance were found to erythromycin (60.3 %), rifampicin (58.2 %), tetracycline (56.8 %), azithromycin (54.5 %), amoxicillin (53.3 %), cefalexin (54.2 %), ampicillin/sulbactam (51.2 %), clarithromycin (51.0 %), and to pefloxacin (50.4 %). *P. aeruginosa* strains were 100 % resistant to oxacillin, ceftibuten, tetracycline, erythromycin, and laevomycetin. These strains also had a high resistance to cefotaxime (93 %), vancomycin (86.7 %), and doxycycline (81 %) (Figure 1).

Most of antibiotic groups were not very active to the strains of *A. baumannii*. In 2015 cephalosporin and ciprofloxacin were inactive to *A. baumannii*. Amicacine and gentamycin had very low activity (30—35 % of strains), about 50 % of strains were sensitive to piperacillin-tazobactam and cefoperazon-sulbactam. Netilmicin (80 %) was of the greatest activity. Imipenem was more active than meropenem (94 % of strains vs 64 %). Among the most common agents causing SSIs, the highest resistance was among *A. baumannii* strains; 100 % to oxacillin, ceftibuten, kanamycin, and gentamycin. Theses strains were also highly resistant to doxycycline (85.5 %), ciprofloxacin (85 %), cefepime (74.9 %), cefuroxime (72.1 %), levofloxacin (69.6 %), cefotaxime (68.7 %), chloramphenicol (68.7 %), azithromycin (68.5 %), and amikacin (67.3 %).

DISCUSSION

Results of this investigation indicate that official statistical data fail to report the actual scale of nosocomial infection transmission in Ukrainian surgery hospitals due to the lack of reliable SSIs registration. To estimate the epidemiological situation correctly, it is necessary to assess SSIs incidence rates based on diagnostic information determined by medical officers (passive method) and epidemiological data (active method) using commonly applied standard criteria of case definition.

In accordance with state statistical reports, an average of 4.3 million surgeries are conducted annually in Ukrainian hospitals. However, only 3.200 cases of SSIs are officially registered per year (0.07 % per 100 surgeries) [6, 9]. Results of our investigation revealed a much higher SSIs incidence rate that reported in the official statistical data.

The problem of postoperative wound infection is seen in both developed and developing countries, despite introduction of meticulous antiseptic regime in surgical practice. It can occur from either an endogenous or an exogenous source. In this study, 1248 patients got infected postoperatively with the postoperative SSIs rate of 13.3 %. This is comparable with the rates reported by various authors [6—10, 25, 26]. Low infection rate in developed countries may be due to vast differences in working conditions prevailing in these countries [5, 11, 13]. The higher rates reported by some authors may be due to the inclusion of contaminated and dirty wound types and also emergency surgeries in their studies.

Results showed that 1248 strains bacteria were isolated from surgical patients during the 2015, the Gram-negative bacilli was 45.9 %, Gram-positive cocci was 54.1 %. The top five were *S. aureus* (27.6 %), *E. coli* (14.1 %), *E. faecalis* (13.5 %), *P. aeruginosa* (10.1 %), and *K. pneumoniae* (7.1 %). Our results correspond to data of other investigators on prevailing species of CPM that cause SSIs in the hospitals. The distribution of various groups of microorganisms varies considerably [5—10, 25—29]. This proves the necessity of carrying out microbiological monitoring in every surgery hospital.

The problem of antimicrobial resistance is seen in both developed and developing countries. The prevailing causal agents of SSIs were resistant to many antimicrobial medicines used in the hospitals. Resistant to antibiotics SSIs agents were identified among Gram-positive and Gram-negative microorganisms. Antibiotic susceptibility testing showed that all the strains of *S. aureus* resistant to penicillin. The most active antibiotics found were linezolid, tigecycline, and mupirocin, showing growth inhibition of 100 % strains tested, followed by nitrofurantoin, trimethoprim/sulphamethoxazole, to fusidic acid, teicoplanin, fosfomycin, gentamycin, vancomycin. Susceptibility to tetracycline, rifampicin, erythromycin, and clindamycin was observed to be some lower. MRSA comprised 29.1 %, while VRSA comprised 9.3 %. Resistance *E. faecalis* to ceftibuten, chloramphenicol, moxifloxacin, and teicoplanin was 100 % and to cefepime 96 %. The proportion of vancomycin-resistant enterococci (VRE) was 6.9 %. 26.5 % of *E. coli* strains showed resistance to all tested antibiotics. The most potent antimicrobials were imipenem, tobramycin, meropenem, levofloxacin and amikacinum. The high rates of resistance were found to penicillum, lincomycin, clindamycin, ampicillin, clarithromycin, amoxicillin, and to cefuroxime. *K. pneumoniae* showed the lowest resistance to amikacin and imipenem, and was moderately sensitive to cefepime, gentamicin, ceftriaxone, tobramycin, piperacillin/tazobactam, ciprofloxacin, tetracycline, ceftazidime, and aztreonam. 39.6 % of *P. aeruginosa* were resistant to all tested antibiotics. The most potent antimicrobials were meropenem, tobramycin, imipenem and levofloxacin. The high rates of resistance were found to penicillin, erythromycin, rifampicin, tetracycline, azithromycin, amoxicillin, cefalexin, ampicillin/sulbactam, clarithromycin, and to pefloxacin. *P. aeruginosa* were 100 % resistant to oxacillin, ceftibuten, tetracycline, and erythromycin. This is comparable with the rates reported by various authors [5, 6, 10, 25—33].

Thus, the investigation demonstrated that in the Ukrainian surgery hospitals the incidence rate of SSIs causal agents resistant to antimicrobial medicines is quite high. This poses a serious problem for curing patients from nosocomial infections. Hospital strains resistant to antimicrobial medicines were found both among Gram-positive and Gram-negative bacteria. This documents the need for systematic microbiological monitoring of main causal agents of nosocomial infections in every surgery hospital as a basic measure of epidemiological control over antimicrobial resistance. Antibiotics should be prescribed in accordance to available data on SSIs resistance. Microbiological monitoring will enable to follow the recommendations for rational antibacterial therapy of patients.

Our study data have strengths and limitations. Strengths are the wide variety of antimicrobial agents included, the number of laboratories reporting data, the nationally representative geographic distribution of these institutions, and the large number of isolates. Geography is a critical consideration with surveillance of pathogens of SSIs because distribution of antimicrobial drug resistance varies within in the Ukraine [6].

CONCLUSIONS

SSIs remain an important cause of postoperative morbidity and mortality and generate considerable additional healthcare and societal costs. Most SSIs are caused by bacteria such as *S. aureus*, *E. coli*, *E. faecalis* and *P. aeruginosa*. Antimicrobial resistance among these and other clinically important pathogens is an actually problem. The clinical should choose antimicrobial drug in accordance with local bacterial resistance characteristics for reduce the production of drug resistance and improve the effect of anti-infection treatment possibly.

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Conflict of interest

No authors received financial support for doing this research, nor do they have any conflicts of interest to disclose. No organizations have a financial interest in the completion of this work.

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ЗАХВОРЮВАНІСТЬ ІНФЕКЦІЯМИ ОБЛАСТІ ХІРУРГІЧНОГО ВТРУЧАННЯ (ІОХВ) ТА РЕЗИСТЕНТНІСТЬ ЇХ ЗБУДНИКІВ ДО АНТИБІОТИКІВ В УКРАЇНІ

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Мета роботи — проаналізувати результати хірургічного лікування хворих, визначити частоту захворюваності інфекціями області хірургічного втручання (ІОХВ), провідні збудники цих інфекцій та їх стійкість до антибіотиків у лікарнях України.

Матеріали і методи. У дослідження було залучено 9408 пацієнтів, яким протягом 2015 р. проведено операції в 12 хірургічних лікарнях різних регіонів України. Для вивчення показників післяопераційної захворюваності використовували стандартне визначення ІОХВ, розроблене Центром контролю та профілактики захворювань (CDC) США. Досліджено 1248 штамів мікроорганізмів, виділених у пацієнтів з клінічними виявами ІОХВ. Ідентифікацію виділених штамів та визначення їх чутливості до антибіотиків проводили за допомогою автоматизованого мікробіологічного аналізатора Vitek 2 Compact (BioMerieux, Франція). Чутливість до антибіотиків визначали з використанням карток AST (BioMerieux, Франція). У деяких тестах для вивчення чутливості до антибіотиків застосовували диско-дифузійний метод Кірбі — Бауера. Інтерпретацію отриманих результатів проводили відповідно до критеріїв, розроблених Інститутом клінічних лабораторних стандартів (CLSI) США.

Результати та обговорення. У післяопераційний період у 13,3 % (95 % довірчий інтервал — 12,3—14,2 %) пацієнтів розвинулися ІОХВ. Інфікування рани спостерігали після різних хірургічних процедур. Виявлено високу частоту ІОХВ після апендектомії (17,47 %), шлункових, невеликих і великих кишкових операцій (18,23 %), ортопедичних процедур (13,27 %), холелітіазу (гепатобіліарного) (14,93 %), операцій на матці та придатках (11,1 %), сечових шляхах і геніталіях (9,37 %), операції з приводу грижі (14,10 %), низьку частоту — після кесаревого розтину (4,24 %), видалення дермоїдних кіст та ліпоми (3,22 %). *Staphylococcus aureus* визначено як найпоширеніший збудник ІОХВ (27,6 %), друге місце посідає *Escherichia coli* (14,1 %), третє — *Enterococcus faecalis* (13,5 %), четверте — *Pseudomonas aeruginosa* (10,1 %). Частка *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Enterobacter aerogenes*, *Enterococcus faecium*, *Streptococcus spp*., *Staphylococcus epidermidis* та *Proteus vulgaris* становила 7,1; 6,9; 6,1; 4,7; 4,6; 3,6 і 1,6 % відповідно. Тестування на чутливість до антибіотиків виявило, що всі штами *S. aureus* були стійкими до пеніциліну. Найактивнішими антибіотиками до *S. aureus* були лінезолід, тігециклін і мупіроцин, які продемонстрували інгібування росту 100 % штамів, а також нітрофурантоїн, триметоприм/сульфаметоксазол, фузидієва кислота, тейкопланін, фосфоміцин, гентаміцин, ванкоміцин. Спостерігали низьку чутливість штамів *S. aureus* до тетрацикліну, рифампіцину, еритроміцину та кліндаміцину. Частка MRSA (метицилін-резистентні штами *S. aureus*) становила 29,1 %, а VRSA (ванкоміцин-резистентні штами *S. aureus*) — 9,3 %. Резистентність *E. faecalis* до цефтибутену, хлорамфеніколу, моксифлоксацину і тейкопланіну дорівнювала 100 %, а до цефепіму — 96 %. Частка резистентних до ванкоміцину ентерококів становила 6,9 %. Серед штамів *E. coli* 26,5 % продемонстрували стійкість до всіх тестованих антибіотиків. Найефективнішими антибіотиками щодо *E. coli* були іміпенем, тобраміцин, меропенем, левофлоксацин та амікацин. Високий рівень резистентності штами *E. coli* виявили до пеніциліну, лінкоміцину, кліндаміцину, ампіциліну, кларитроміцину, амоксициліну та цефуроксиму. *K. pneumoniae* продемонстрував найменшу стійкість до амікацину та іміпенему і був помірно чутливим до цефепіму, гентаміцину, цефтріаксону, тобраміцину, піперациліну/тазобактаму, ципрофлоксацину, тетрацикліну, цефтазидиму і азтреонаму. Серед штамів *P. aeruginosa* 39,6 % були резистентними до всіх тестованих антибіотиків. Найефективнішими антибіотиками до *P. aeruginosa* були меропенем, тобраміцин, іміпенем і левофлоксацин. Високий рівень резистентності штами *P. aeruginosa* продемонстрували до пеніциліну, еритроміцину, рифампіцину, тетрацикліну, азитроміцину, амоксициліну, цефалексину, ампіциліну/сульбактаму, кларитроміцину і пефлоксацину, 100 % стійкість — до оксациліну, цефтибутену, тетрацикліну та еритроміцину.

Висновки. ІОХВ є важливою причиною післяопераційної захворюваності. Актуальною проблемою є збільшення резистентності до антибіотиків серед клінічно важливих патогенів. Лікар має обирати антимікробний препарат з урахуванням місцевих даних щодо стійкості бактерій, що дасть змогу підвищити ефективність лікування і зменшити ризик розвитку резистентності до антибіотиків.

Ключові слова: інфекція в зоні хірургічного втручання, хірургічна процедура, чутливість до антибіотиків, нозокоміальна інфекція, Україна.

ЗАБОЛЕВАЕМОСТЬ ИНФЕКЦИЯМИ В ОБЛАСТИ ХИРУРГИЧЕСКОГО ВМЕШАТЕЛЬСТВА И УСТОЙЧИВОСТЬ ИХ ВОЗБУДИТЕЛЕЙ К АНТИБИОТИКАМ В УКРАИНЕ

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Цель работы — проанализировать результаты хирургического лечения больных, определить частоту заболеваемости инфекциями в области хирургического вмешательства (ИОХВ), главных возбудителей этих инфекций и их устойчивость к антибиотикам в больницах Украины.

Материалы и методы. Исследование включало 9408 пациентов, которым в течение 2015 г. были проведены операции в 12 хирургических больницах разных регионов Украины. Для изучения показателей послеоперационной заболеваемости использовали стандартное определение ИОХВ, разработанное Центром контроля и профилактики заболеваний (CDC) США. Исследованы 1248 штаммов микроорганизмов, выделенных у пациентов с клиническими симптомами ИОХВ. Идентификацию выделенных штаммов и определение их чувствительности к антибиотикам проводили при помощи автоматизированного микробиологического анализатора Vitek 2 Compact (BioMerieux, Франция). Чувствительность к антибиотикам определяли с использованием карт AST (BioMerieux, Франция). В некоторых тестах для изучения чувствительности к антибиотикам применяли диско-диффузный метод Кирби — Бауэра. Интерпретацию полученных результатов проводили в соответствии с критериями, предложенными Институтом клинических лабораторных стандартов (CLSI) США.

Результаты и обсуждение. В послеоперационный период у 13,3 % (95 % доверительный интервал — 12,3—14,2 %) пациентов развились ИОХВ. Инфицирование раны наблюдали после разных хирургических процедур. Выявлена высокая частота ИОХВ после аппендэктомии (17,47 %), желудочных, мелких и крупных кишечных операций (18,23 %), ортопедических процедур (13,27 %), холелитиаза (гепатобилиарного) (14,93 %), операций на матке и придатках (11,1 %), мочевых путях и гениталиях (9,37 %) и операции по поводу грыжи (14,1 %), низкая частота — после кесаревого сечения (4,24 %), удаления дермоидных кист и липомы (3,22 %). *Staphylococcus aureus* определен как наиболее распространенный возбудитель ИОХВ (27,6 %), второе место занимает *Escherichia coli* (14,1 %), третье — *Enterococcus faecalis* (13,5 %), четвертое — *Pseudomonas aeruginosa* (10,1 %). Доля *Klebsiella pneumoniae*, *Acinetobacter baumannii*, *Enterobacter aerogenes*, *Enterococcus faecium*, *Streptococcus spp*., *Staphylococcus epidermidis* и *Proteus vulgaris* составила 7,1; 6,9; 6,1; 4,7; 4,6; 3,6 и 1,6 % соответственно. Тестирование на чувствительность к антибиотикам показало, что все штаммы *S. aureus* устойчивы к пенициллину. Наиболее активными антибиотиками в отношении *S. aureus* были линезолид, тигециклин и мупироцин, продемонстрировавшие ингибирование роста 100 % штаммов, а также нитрофурантоин, триметоприм/сульфаметоксазол, фузидиевая кислота, тейкопланин, фосфомицин, гентамицин и ванкомицин. Наблюдали низкую чувствительность *S. aureus* к тетрациклину, рифампину, эритромицину и клиндамицину. Доля MRSA (метициллин-резистентные штаммы *S. aureus*) составляла 29,1 %, а VRSA (ванкомицин-резистентные штаммы *S. aureus*) — 9,3 %. Резистентность *E. faecalis* к цефтибутену, хлорамфениколу, моксифлоксацину и тейкопланину составила 100 %, к цефепиму — 96 %. Доля резистентных к ванкомицину энтерококков — 6,9 %. Среди штаммов *E. coli* 26,5 % продемонстрировали устойчивость ко всем тестируемым антибиотикам. Наиболее эффективными антибиотиками к *E. coli* были имипенем, тобрамицин, меропенем, левофлоксацин и амикацин. Высокий уровень резистентности *E. coli* выявили к пенициллину, линкомицину, клиндамицину, ампициллину, кларитромицину, амоксициллину и цефуроксиму. *K. pneumoniae* показал наименьшую устойчивость к амикацину и имипенему и был умеренно чувствителен к цефепиму, гентамицину, цефтриаксону, тобрамицину, пиперациллину/тазобактаму, ципрофлоксацину, тетрациклину, цефтазидиму и азтреонаму. Среди штаммов *P. aeruginosa* 39,6 % были резистентны ко всем тестируемым антибиотикам. Наиболее эффективными антибиотиками в отношении *P. aeruginosa* были меропенем, тобрамицин, имипенем и левофлоксацин. Высокий уровень резистентности *P. aeruginosa* выявлен к пенициллину, эритромицину, рифампицину, тетрациклину, азитромицину, амоксициллину, цефалексину, ампициллину/сульбактаму, кларитромицину и цефлоксацину. Штаммы *P. aeruginosa* продемонстрировали 100 % устойчивость к оксациллину, цефтибутену, тетрациклину и эритромицину.

Выводы. ИОХВ являются важной причиной послеоперационной заболеваемости. Актуальной проблемой является увеличение резистентности к антибиотикам среди клинически важных патогенов. Врач должен выбирать антимикробный препарат с учетом местных данных об устойчивости к бактериям, что позволит повысить эффективность лечения и уменьшить риск развития резистентности к антибиотикам.

Ключевые слова: инфекция в области хирургического вмешательства, хирургическая процедура, чувствительность к антибиотикам, нозокомиальная инфекция, Украина.

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