

PRACA ORYGINALNA
ORIGINAL ARTICLE

SURGICAL SITE INFECTIONS AND ANTIMICROBIAL RESISTANCE IN KYIV CITY HOSPITALS, UKRAINE

Aidyn G. Salmanov¹, Olena A. Dyndar², Yuriy P. Vdovychenko¹, Tetiana R. Nykoniuk², Igor V. Maidannyk², Olena O. Chorna², Iryna A. Holovanova³

¹SHUPYK NATIONAL MEDICAL ACADEMY OF POSTGRADUATE EDUCATION, KYIV, UKRAINE

²BOGOMOLETS NATIONAL MEDICAL UNIVERSITY, KYIV, UKRAINE

³UKRAINIAN MEDICAL STOMATOLOGICAL ACADEMY, POLTAVA, UKRAINE

ABSTRACT

Introduction: Surgical site infections (SSIs) are associated with increased morbidity and mortality. Scant information is available on the SSI in Ukrainian hospitals.

The aim: to determine the incidence of SSIs and estimates antimicrobial resistance of the major responsible pathogens in Kyiv city hospitals.

Materials and methods: This study was conducted from January 2011 to December 2013 in 3 hospitals. Definitions of SSIs were adapted from the CDC/NHSN. The identification and antimicrobial susceptibility of cultures were determined, using automated microbiology analyzer. Some antimicrobial susceptibility test used Kirby - Bauer antibiotic testing.

Results: Among 9,162 patients, 1,912 (20.9%) SSIs were observed. The high SSI case in appendectomy (29.8%), gastric, small and large bowel surgeries (28.4%), cholelithiasis (25.7%), and orthopedic procedures (22.9%). Low infection rate in excision of dermoid cysts, lipoma (5.3%) and lower segment caesarean structure (6.5%). *Staphylococcus aureus* were most commonly reported, accounting for 27,8% of all organisms, followed by *Escherichia coli* (18.4%), *Pseudomonas aeruginosa* (11.9%) and *Enterococcus faecalis* (11.6%). The antimicrobial resistance in the isolates associated with SSIs showed, among the Gram-positive bacteria, that 43.8% and 4.7% of CoNS isolates were β -lactam (oxacillin) - and glycopeptide (teicoplanin) - resistant, respectively. Meticillin resistance was reported in 35.7% of *S. aureus* isolates

Conclusions: SSIs and antimicrobial resistance of the responsible pathogens is an actually problem. One essential step in the prevention of SSIs is to implement a national system for their surveillance.

KEY WORDS: Surgical site infection, antimicrobial resistance, surveillance

Wiad Lek 2019, 72, 5 cz. I, 760-764

INTRODUCTION

Despite major advances in infection control interventions, healthcare-associated infections (HAI) remain a major public health problem and patient safety threat worldwide [1]. Surgical site infections (SSI) are the most common type of HAI among patients [2-5]. These infections are one of the most frequently reported types of HAI, constituting up to 19.6% of all HAIs in Europe in 2011-2012 [2].

SSI associated with longer post-operative hospital stays, additional surgical procedures, treatment in intensive care units and higher mortality [6]. Furthermore, development of an SSI causes a substantial increase in the clinical and economic burden of surgery [7]. The financial burden of surgery is increased due to the direct costs incurred by prolonged hospitalization of the patient, diagnostic tests, and treatment. Certain patients may also require reoperation after the contraction of an SSI, which is associated with considerable additional costs [8].

In the literature, variable proportions of HAIs, considered to be preventable by intensive hygiene and control programs, have been reported [9, 10]. Among the infection prevention initiatives, surveillance of HAIs is the cornerstone to decrease infection rates in hospitalized

patients, and it is considered to be the best way to assure patient safety [11]. Continuous monitoring of HAI rates can be used to assess effectiveness of interventions and provides information which may be used for benchmarking comparison [12]. Due to high morbidity and mortality caused by these infections, early diagnosis and treatment of these infections with appropriate antibiotics is essential.

Knowledge on the antimicrobial susceptibility status of circulating pathogens in hospitals is important for better management of infectious pathogens particularly where routine culture and sensitivity testing is not practiced [13, 14].

To identify HAI prevention targets and reduce thus disparities between countries, ongoing surveillance is necessary. However, resources are severely limited in Ukraine, creating difficulties implementing surveillance and establishing effective measures for infection control and HAI prevention. In Ukraine, efforts to improve infection control training and begin HAI surveillance have been underway. However, previous reports of SSIs in Ukraine were limited and did not address all types SSI and antimicrobial resistance their pathogens.

THE AIM

The objective of the current study was to determine the incidence of SSIs and estimates antimicrobial resistance of the major responsible pathogens in Kyiv city hospitals.

MATERIALS AND METHODS

STUDY DESIGN AND SETTING

This retrospective study was based on surveillance data for SSIs of 9,162 patients in Kyiv city hospitals (2 general and 1 women's hospitals), Ukraine. The sample was all patients hospitalized in 3-year (from January 1, 2011 to December 31, 2013). We have included hospitals that are similar in terms of medical equipment, personnel, and laboratory facilities. The hospitals had 1150 beds. All participating hospitals were required to have at least one full-time infection-control professional, a clinical microbiology laboratory with the capacity to process cultures. The exclusion criteria were patients with a community acquired infection. The follow-up of each patient was continued until discharge.

ETHICS

The data was collected as a part of the hospital's infection prevalence survey. According to the Health Research Act of Ukraine, quality assurance projects, surveys and evaluations that are intended to ensure that diagnosis and treatment actually produce the intended results do not need ethical committee approval and patient consent is not required.

DEFINITIONS AND DATA COLLECTION

Surveillance data on all SSIs, both in patients, and their causative pathogens were collected retrospective on a specifically designed form by the investigators using medical records comprising charts, daily flow sheets, laboratory (microbiology) results. The collected data included demographics; date of infection onset; clinical signs; and isolated

pathogens with antibiogram results. Healthcare workers in hospitals screened patients for signs and symptoms of SSI during clinical rounds. SSIs were identified according to a simplified version of the definitions developed and recommended by the CDC/NHSN [15].

MICROBIOLOGICAL SAMPLING

The identification and antimicrobial susceptibility of the cultures were determined, using automated microbiology system (Vitek-2™; bioMérieux, France). Some antimicrobial susceptibility test used Kirby – Bauer antibiotic testing. Interpretative criteria were those suggested by the Clinical and Laboratory Standards Institute (USA).

STATISTICAL ANALYSIS

We analyzed by all types of SSIs. The analysis of statistical data was performed using Microsoft Excel for Windows. Comparisons were carried out using the Student's t-test, χ^2 . Values of $p < 0.05$ were considered statistically significant.

RESULTS

PATIENT CHARACTERISTICS AND INCIDENCE OF SSI

During the study period 9,162 patients were included, 1,912 (20.9%) patients had SSIs. The incidence of the most frequently recorded types of SSI was for Appendectomy 29.8 % [95% CI 27.6 – 32.0], Gastric and small bowel 28.4% [95% CI 25.9 – 30.9], Cholelithiasis 25.7% [95% CI 22.6 – 28.8], and Orthopedic procedures 22.9 % [95% CI 20.1 – 25.7]. A minority of SSIs were Excision of Dermoid cysts, lipoma 5.3 % [95% CI 3.9 – 6.7] and Lower segment caesarean structure (LSCS) 6.5 % [95% CI 4.3 – 8.7] (Table I).

Fifty-two percent of the patients were females. The overall incidence of SSI was higher in males than in females (12.7 % vs. 10%) and increased with age. For the oldest patients

Table I. Incidence of SSI after surgical procedures in Kyiv hospitals, Ukraine, 2011-2013 ($p < 0.05$)

Surgical procedure	Number of patients	Number of cases infected	% (95 % CI)
Orthopedic procedures	841	193	22.9 (20.1 – 25.7)
Gastric and small bowel	1269	361	28.4 (25.9 – 30.9)
Appendectomy	1651	492	29.8 (27.6 – 32.0)
Cholelithiasis (hepatobiliary)	767	197	25.7 (22.6 – 28.8)
Excision of Dermoid cysts, lipomas	989	52	5.3 (3.9 – 6.7)
Hernia	2384	459	19.3 (17.7 – 20.9)
Lower segment caesarean structure	475	31	6.5 (4.3 – 8.7)
Uterus and adnexa	284	34	12.0 (8.2 – 15.8)
Urinary tract and genitalia	502	93	18.5 (15.1 – 21.9)
Total	9162	1912	20.9 (20.1 – 21.7)

Table II. Microorganisms isolated from SSI in Kyiv city hospitals, Ukraine, 2011-2013 (n = 2179)

Microorganisms	Number of strains	Proportion, %
Gram-positive coccus		
<i>Staphylococcus aureus</i>	601	27,8
<i>Coagulase-negative staphylococci</i>	135	6,2
<i>Enterococcus faecalis</i>	253	11,6
<i>Enterococcus faecium</i>	89	4,1
<i>Streptococcus</i> spp.	28	1,3
Gram-negative bacilli		
<i>Escherichia coli</i>	408	18,4
<i>Enterobacter</i> spp.	139	6,4
<i>Klebsiella</i> spp.	116	5,3
<i>Proteus</i> spp.	53	2,4
<i>Pseudomonas aeruginosa</i>	259	11,9
<i>Acinetobacter</i> spp.	48	2,2
Other*	18	0,8
<i>Candida</i> spp.	33	1,5

Note: *"Other" includes 11 different organisms.

(>74 years old), we found incidence of 79.4 % vs. 20.6 % for the youngest patients (18-25 years). Acute admission patients had a higher incidence of SSI than those with elective admission, 62.1% and 37.9 %, respectively.

MICROORGANISMS CAUSING SSIS

Among all 9,162 SSIs, a total of 2,179 organisms were identified. Considering all SSI types together, *Staphylococcus aureus*, were most commonly reported, accounting for 27,8% of all organisms, followed by *Escherichia coli* (18,4% of organisms), *Pseudomonas aeruginosa* (11,9% of organisms), and *Enterococcus faecalis* (11,6% of organisms). The etiological role was lower for *Streptococcaceae* (1.3 %) and *Acinetobacter* spp.(2.2%). (Table II).

Patients with SSIs *Staphylococcus* had the highest proportion of conditionally pathogenic microorganisms (CPM) (34.0 %) followed by *Enterobacteriaceae* (32.8 %). 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.

ANTIMICROBIAL RESISTANCE

Prevailing causal agents of SSIs were resistant to many antimicrobials used in the hospitals. The antimicrobial-resistance in the isolates associated with SSIs showed, among the Gram-positive bacteria, that 43.8% and 4.7% of Coagulase-negative staphylococci isolates were β -lactam (oxacillin) - and glycopeptide (teicoplanin) - resistant, respectively. Vancomycin resistance was reported in 12.6% of isolated enterococci (VRE). Among the Gram-negative

bacteria third-generation cephalosporins (cefotaxime or ceftazidime) resistance was found in 52.2% of *Klebsiella* spp. and 33.9% of *E.coli* isolates. Carbapenem resistance was reported in 8.1% of all included *Enterobacteriaceae*, also highest in *Klebsiella* spp., and in 47.4% of *P. aeruginosa* isolates and 63.7% of *Acinetobacter* spp. isolates.

Antibiotic susceptibility testing showed that all the strains of *S. aureus* resistant to penicillin. The most active antibiotics found in the study were linezolid and tigecycline, 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, 98.7 % to trimethoprim/sulphamethoxazole, 98 % — to fusidic acid, 97.1 % to mupirocin, 95.9 % — to teicoplanin, 95.0 % — to fosfomycin, 91.2 % — to gentamycin, 90.7 % — to vancomycin, 90.2 % — to tobramycin, 90,6 % — to vancomycin, and 88.1 % — to levofloxacin. Meticillin resistance was reported in 35.7 % of *S. aureus* (MRSA) isolates (Table III).

DISCUSSION

Our study demonstrated that 20.9 % patients developed postoperative SSI in Kyiv hospitals. The most frequently recorded of SSI was for Appendectomy 29.8 %, Gastric and small bowel 28.4%, Cholelithiasis 25.7%, and Orthopedic procedures 22.9 %. According to the literature reports, SSIs are the most frequent post-surgical complications in Ukraine with incidences from 13.3 % to 35 % [4, 13, 14, 16]. However, only 0.07 % cases of SSIs are officially registered per year [4, 14]. Results of our investigation revealed a much higher SSIs incidence rate that reported in the official statistical data. The proportion of SSI European

Table III. Antimicrobial susceptibility of *S. aureus* in Kyiv city hospitals, 2011-2013 (n = 601)

Antibiotic	Division by susceptibility, %		
	Susceptible	Intermediate	Resistant
Cefoxitin	71.4	0	28.6
Benzylpenicillin	0	0	100.0
Oxacillin	64.3	0	35.7
Gentamycin	91.2	0	8.8
Tobramycin	90.2	0	9.8
Levofloxacin	88.1	2.0	9.9
Moxifloxacin	84.1	1.0	14.9
Erythromycin	73.4	0	26.6
Clindamycin	70.8	0	29.2
Linezolid	100.0	0	0
Teicoplanin	95.9	0	4.1
Vancomycin	90.6	0	9.4
Tetracycline	76.6	0	23.4
Tigecycline	100.0	0	0
Fosfomycin	95.0	0	5.0
Nitrofurantoin	99.0	0	1.0
Fusidic acid	98.0	1.0	1.0
Mupirocin	97.1	0	2.9
Rifampicin	76.1	3.0	20.9
Trimethoprim/sulphamethoxazole	98.7	0	1.3

Union region varied between 8.8% in Luxembourg and 29.0% in Spain [2].

Results our study showed that 2,179 strains bacteria were isolated from patients during the 2011-2013, the Gram-negative bacilli was 49.2 %, Gram-positive cocci was 50.8 %. Considering all SSI types together, *S. aureus*, were most commonly reported, accounting for 27,8% of all organisms, followed by *E.coli* (18,4%), *P. aeruginosa* (11,9%), and *E.faecalis* (11,6%). The etiological role was lower for *Streptococcaceae* (1.3 %) and *Acinetobacter* spp.(2.2%). 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 [2, 4, 5, 13, 14, 16-22]. This proves the necessity of carrying out microbiological monitoring in every hospital.

In the present study, the high level of resistance to multiple antibiotics is of great concern. Prevailing causal agents of SSIs were resistant to many antimicrobials used in the Kyiv city hospitals. The antimicrobial-resistance in the isolates associated with SSIs showed, among the Gram-positive bacteria, that 43.8% and 4.7% of Coagulase-negative staphylococci isolates were β -lactam (oxacillin) - and glycopeptide (teicoplanin) - resistant, respectively. Vancomycin resistance was reported in 12.6% of isolated enterococci (VRE). Among the Gram-negative bacteria third-generation cephalosporins (cefotaxime or ceftazidime) resistance was found in 52.2% of *Klebsiella* spp. and 33.9%

of *E.coli* isolates. Carbapenem resistance was reported in 8.1% of all included *Enterobacteriaceae*, also highest in *Klebsiella* spp., and in 47.4% of *P. aeruginosa* isolates and 63.7% of *Acinetobacter* spp. isolates. Meticillin resistance was reported in 35.7 % of *S. aureus* (MRSA) isolates. The resistance to antimicrobials distribution of various groups of microorganisms varies considerably [2, 4, 5, 14, 18-24].

Results of this investigation indicate that official statistical data fail to report the actual scale of HAI transmission in Ukrainian 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 [4, 17].

CONCLUSION

SSIs and antimicrobial resistance of the responsible pathogens is an actually problem. One essential step in the prevention of SSIs is to implement a national system for their surveillance, as such a system provides an overview of the specific national situation and allows healthcare authorities to identify priorities and implement effective prevention measures. Antibiotics application tactics should be determined in accordance with the local data of resistance to them.

REFERENCES

- World Health Organization. Report on the burden of endemic health care-associated infection worldwide. WHO Document Production Services, Geneva [Switzerland]; 2011. Available from: http://apps.who.int/iris/bitstream/10665/80135/1/9789241501507_eng.pdf.
- European Centre for Disease Prevention and Control. Point prevalence survey of healthcare-associated infections and antimicrobial use in European acute care hospitals. Stockholm: ECDC; 2013. Available from: <https://ecdc.europa.eu/sites/portal/files/media/en/publications/Publications/healthcare-associated-infections-antimicrobial-use-PPS.pdf>. (Accessed January 11, 2018).
- Magill SS, Hellinger W, Cohen J, Kay R, Bailey C, Boland B, et al. Prevalence of healthcare-associated infections in acute care hospitals in Jacksonville, Florida. *Infection Control Hospital Epidemiology*, 2012 Mar; 33 (3):283-91. doi:10.1086/664048.
- Salmanov AG. Antimicrobial resistance and healthcare-associated infections in Ukraine. Epidemiological report of the multicenter study (2010—2014). Kyiv: AgrarMediaGroup, 2015:452 p. [In Ukrainian].
- Yunzhou Fan, Zhaoxia Wei, Weiwei Wang, Li Tan, Hongbo Jiang, Lihong Tian, et al. The Incidence and Distribution of Surgical Site Infection in Mainland China: A Meta-Analysis of 84 Prospective Observational Studies. *Sci Rep*. 2014;4:6783. doi: 10.1038/srep06783.
- Awad SS. Adherence to surgical care improvement project measures and post-operative surgical site infections. *Surg Infect (Larchmt)*. 2012 Aug;13(4):234-7. doi: 10.1089/sur.2012.131.
- Badia JM, Casey AL, Petrosillo N, Hudson PM, Mitchell SA, Crosby C. Impact of surgical site infection on healthcare costs and patient outcomes: a systematic review in six European countries. *J Hosp Infect*. 2017 May;96(1):1-15. doi: 10.1016/j.jhin.2017.03.004.
- O'Keeffe, A.B., Lawrence, T., and Bojanic, S. Oxford craniotomy infections database: a cost analysis of craniotomy infection. *Br J Neurosurg*. 2012 Apr;26(2):265-9. doi: 10.3109/02688697.2011.626878.
- Brown J, Doloresco FIII, Mylotte JM. "Never events": not every hospital-acquired infection is preventable. *Clin Infect Dis*. 2009; 49:743-6. doi: 10.1086/604719.
- Harbarth S, Sax H, Gastmeier P. The preventable proportion of nosocomial infections: an overview of published reports. *J Hosp Infect*. 2003;54:258-266. doi: 10.1016/S0195-6701(03)00150-6.
- Van Bunnik BA, Ciccolini M, Gibbons CL, Edwards G, Fitzgerald R, McAdam PR, et al. Efficient national surveillance for health-care-associated infections. *BMC Public Health*. 2015;15:832. doi: 10.1186/s12889-015-2172-9.
- Mitchell BG, Russo PL. Preventing healthcare-associated infections: the role of surveillance. *Nurs Stand*. 2015 Feb 10; 29(23):52-8. doi: 10.7748/ns.29.23.52.e9609.
- Salmanov A., Voizianov S., Kryzhevsky V., Litus O., Drozdova A., et al. Prevalence of healthcare-associated infections and antimicrobial resistance in Kyiv acute care hospitals, Ukraine. *J Hosp Infect*. 2019 Mar 22. pii: S0195-6701(19)30112-4. <https://doi.org/10.1016/j.jhin.2019.03.008>
- Salmanov AG, Shkorbotun VO, Shkorbotun YV. Antimicrobial resistance of Staphylococcus aureus causing of surgical site infections in ear, nose and throat surgery. *Wiad Lek*. 2019;72(2):154-158. Available from: <https://www.ncbi.nlm.nih.gov/pubmed/30903764>
- Horan TC, Andrus M, Dudeck MA. CDC/ NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control*. 2008 Jun; 36(5):309-32. doi: 10.1016/j.ajic.2008.03.002.
- Salmanov AG, Usenko AYU. Intraabdominal infections and resistance of their causative agents towards antibiotics in surgical stationaries in the City of Kyiv. *Klinichna khirurgiia*. 2018 Sept;85(9):42-49. doi: 10.26779/2522-1396.2018.09.42. [In Russian]
- Salmanov AG. Occurrence of surgical site infections detected by standard criteria of diseases. *Ukrainian Journal of Extreme Medicine named after G.O. Mozhaeva*. 2007;8(4):49-51. [In Ukrainian].
- Maehara Y, Shirabe K, Kohnoe S, Emi Y, Oki E, Kakeji Y, et al. Impact of intra-abdominal absorbable sutures on surgical site infection in gastrointestinal and hepato-biliarypancreatic surgery: results of a multicenter, randomized, prospective, phase II clinical trial. *Surg Today*. 2017 Sep;47(9):1060-71. doi: 10.1007/s00595-017-1480-3.
- Aga E, Keinan-Boker L, Eithan A, Mais T, Rabinovich A, Nassar F. Surgical site infections after abdominal surgery: incidence and risk factors. A prospective cohort study. *Infect Dis (Lond)*. 2015;47(11):761-7. doi: 10.3109/23744235.2015.1055587.
- Owens CD, Stoessel K. Surgical site infections: epidemiology, microbiology and prevention. *J Hosp Infect*. 2008 Nov;70 Suppl 2:3-10. doi: 10.1016/S0195-6701(08)60017-1.
- Baker AW, Dicks KV, Durkin MJ, Weber DJ, Lewis SS, Moehring RW et al. Epidemiology of Surgical Site Infection in a Community Hospital Network. *Infect Control Hosp Epidemiol*. 2016 May;37(5):519-26. doi: 10.1017/ice.2016.13.
- Qiyun Fu, Shaotong Zheng. The analyses of distribution and antimicrobial resistance of pathogens isolated from neurosurgery ward for three years. *Life Sci J*. 2013;10(4):1620-3.
- Salmanov A.G., Marievsky V.F. Antibiotic resistance of nosocomial strains of Staphylococcus aureus in the Ukraine: the results of multicenter study. *Novosti Khirurgii*. 2013;21 (4):78-83 [In Russian].
- Sanchez G, Master R, Clark R, Fyyaz M, Duvvuri P, et al. Klebsiella pneumoniae antimicrobial drug resistance, United States, 1998-2010. *Emerg Infect Dis*. 2013;9(1):33-136. doi: 10.3201/eid1901.120310.

Acknowledgment: The authors wish to express their grateful acknowledgement to all the microbiologists, physicians and nurses who contributed to this study.

Authors' contributions:

According to the order of the Authorship

Conflict of interest:

The Authors declare no conflict of interest

CORRESPONDING AUTHOR**Aidyn Salmanov**

Shupyk National Medical Academy of Postgraduate Education,
St. Dorohozhytska 9, 04112 Kyiv, Ukraine
tel: +380667997631
e-mail: mozsago@gmail.com

Received: 15.03.2019

Accepted: 23.04.2019