ORIGINAL RESEARCHES

https://doi.org/10.52418/moldovan-med-j.64-4.21.01
UDC: 616.12-089.168.1-06:616.94-022.36

Post-cardiac surgery bacterial contamination

Aliona Nastas

Department of Preventive Medicine, Epidemiology Discipline
Nicolae Testemitanu State University of Medicine and Pharmacy, Chisinau, the Republic of Moldova

Author's ORCID iD, academic degrees and contribution are available at the end of the article

Corresponding author – Aliona Nastas, e-mail: aliona.nastas@usmf.md
Manuscript received July 20, 2021; revised manuscript October 06, 2021; published online October 12, 2021

Abstract

Background: Septic purulent nosocomial infections (SPNI) are one of the most significant healthcare challenges of post-surgical procedures. SPNI are associated with increased morbidity, mortality and admission costs. It is a priority to determine the level of nosocomial infections (NI). This study aims to evaluate the bacterial contaminations after cardiac surgery within the Department of Acquired Heart Defects (DAHD).
Material and methods: A cross-sectional study was designed and the medical records of 1189 patients who underwent cardiac surgery within the DAHD of a multiprofile hospital were retrospectively analyzed. The data were collected and stored in a Microsoft Excel spreadsheet.
Results: The incidence rate of SPNI following cardiac surgery was 317.57‰ compared to 15.02‰ officially reported (p <0.001). Of the most common infections among the total of 418 cases of SPNI studied, 32.06% were surgical site infections, 23.18% were associations of infections, 19.14% – respiratory tract infections. A patient with SPNI has an average of 22.25 days/bed spent in hospital, compared with the average for a patient without SPNI of 12.27 days/bed. The etiological structure includes 28 species of microorganisms including gram-positive (61.92%) and gram-negative (38.08%).
Conclusions: Given the relatively high incidence of the SPNI and its impact, it is imperative to take more serious measures to prevent and control these infections.
Key words: cardiac surgery, nosocomial healthcare-associated infections, microorganisms.

Cite this article
Nastas A. Post-cardiac surgery bacterial contamination. *Mold Med J.* 2021;64(4):5-9. https://doi.org/10.52418/moldovan-med-j.64-4.21.01.

Introduction

Nosocomial infections (NI) represent a serious problem in the medical facilities. They are associated with substantial morbidity, prolonged hospitalizations and possible higher mortality [1]. Several studies have examined the incidence and risk factors of NI after open heart surgery. Postoperative infection has been reported to occur in 5-21% of cardiac surgery patients in various institutions [1, 2].

The number of reported nosocomial infections in the Republic of Moldova contradicts the findings of this study. As compared to other European countries, the actual number of cases of NI is much higher in Moldova, indicating that infections are not detected or are detected but not reported.

The actual number of patients with septic purulent nosocomial infections (SPNI) in the Institute of Neurology and Neurosurgery was 32.2 per 1000 operated patients, this is 7.32 times higher than the officially reported number of 4.4‰ [3]. The actual incidence of 156.42 per 1000 operated was detected at the Traumatology and Orthopedics Hospital but only five cases (1.06%) of SPNI were officially declared. This shows the actual number to be 14.75 times higher than the officially reported number [4].

Healthcare-associated infections (HCAI) caused additional 6.1 days of hospitalization. The incidence of patients with HCAI in Spanish hospitals was relevant and similar to those found in studies in Canada and New Zealand [5].

The study which looked at critically ill patients in the hospital, found that morbidity attributed to nosocomial bacteremia increased the length of stay in a hospital by 14 days [6].

Of particular interest is the study of the etiological structure and peculiarities in septic-purulent nosocomial infections in cardiac surgery departments.

From an etiological point of view, NI are characterized by their constant evolution over time. The analysis demonstrates a high variation in the etiology of NI in the surgery departments, but also in terms of the location of the infection. Therefore, in cardiac surgery the predominant pathogens isolated were *S. epidermidis* (32.1%), *S. aureus* (28.4%), the gram-negative isolates were *Enterobacter* species (10.1%): *E. coli* (6.4%), *Seratia* species (4.6%), *P. aeruginosa* (4.6%), *K.*

pneumonia (4.6%) [1].

Although gram-positive microorganisms are the main bacteria involved, gram-negative bacilli, especially *Enterobacteriaceae*, are frequently involved in cardiac surgery, according to Jolivet S. et al., the main *Enterobacteriaceae* (36.5%) were *E. coli* (29%) and *E. cloacae* (15%) [7].

It is necessary to minimize infections, this in addition to reducing mortality, reduces the duration of hospital stay, and reduces the cost of treatment [8].

Hypothesis of the study: Considering the importance of timely diagnosis and treatment of infections, it is extremely important to concentrate on prevention by investigating and evaluating bacterial infections after cardiac surgery at the Department of Acquired Heart Defects (DAHD).

Material and methods

In this cross-sectional study, the research population included all patients undergoing cardiac surgery in the DAHD. Data was collected and stored in a Microsoft Excel spreadsheet.

An infection was classified as nosocomial when developed within the hospital and became clinically apparent while the patient was still hospitalized, according to the Patient Safety Component Manual [9].

Sample size. At the time of the study, 423 cases of infection were registered, indicating a sufficient sample size to determine connections.

Site pathogens and medical records. In order to determine the etiological structure of SPNI, the results of microbiological investigations within the medical records of post-cardiac surgery patients performed in the bacteriological laboratory of the multiprofile hospital were tabulated and analyzed. This resulted in detection of 281 strains of microorganisms.

Results

Following the retrospective analysis of 1332 patients treated in the DAHD, it was found that 423 of them developed SPNI, the frequency index being 317.57 per 1000 hospitalized patients.

Out of 423 cases registered in the DAHD, only 20 cases (4.73%) were reported to the Chisinau Public Health Center. The incidences of SPNI following cardiac surgery were 317.57 per 1000 inpatients compared to 15.02 per 1000 inpatients reported to the Chisinau Public Health Center or being 21.15 times lower than the actual number, t=5.03, p <0.001, the statistical link is highly significant (confidence 99.9%) (fig. 1).

Out of the total 418 cases of post-cardiac surgery SPNI, surgical site infection (SSI) represents the majority and constitutes 134 cases (32.06%), associations of infection (AI) are 97 cases (23.18%), respiratory tract infections (RTI) – 80 cases (19.14%), cardiovascular system infections (CV) – 74 cases (17.71%), bone and joint infections (BJI) – 16 cases (3.83%), bloodstream infections (BSI) – 6 cases (1.44%), eye, ear, nose, throat, or mouth infections (EENT) – 4 cases

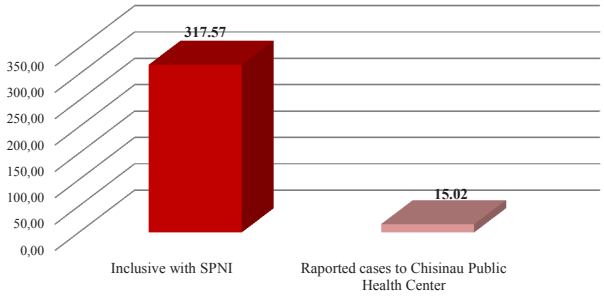

Fig. 1. General incidence due to cardiosurgical SPNI

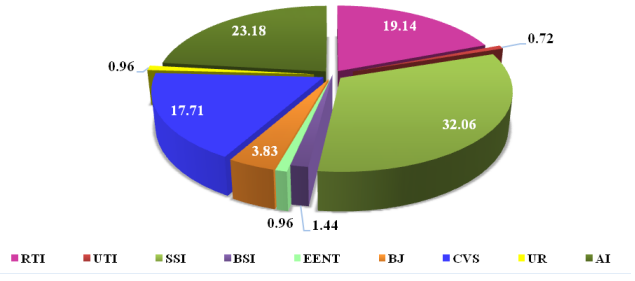

Fig. 2. The structure of post-cardiac SPNI according to the group of infections (%)

(0.96%), upper respiratory tract infections (UR) – 4 cases (0.96%) and urinary tract infections (UTI) – 3 cases (0.72%) (fig. 2).

During the studied period, 1189 patients were in the hospital 32920 days/bed, of which 418 patients with SPNI spent 14402 days in the hospital or 44.26% of all days spent in the hospital by all patients. On average, length of stay (LOS) beginning with hospitalization, for each patient with SPNI was 34.44 days/bed compared to 23.97 days/bed for patients without SPNI or 10.47 days/bed less (fig. 3).

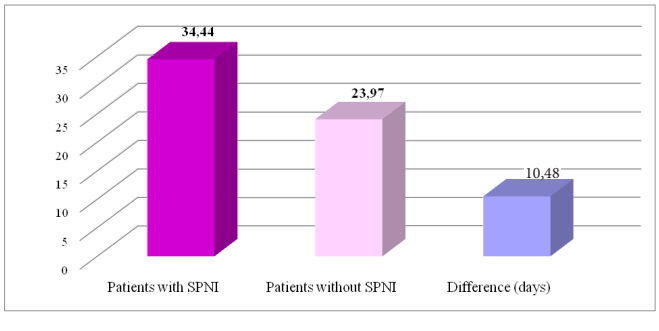

Fig. 3. The length of stay (beginning with hospitalization), (days)

For 1189 patients operated during the studied period, a total of 18691 days/bed were used. Therefore, 418 patients with SPNI used 9270 days/bed (49.93%) of the total days/bed. The length of stay (LOS) starting with surgery on average for a patient with SPNI was 22.25 days/bed, with 9.98 days/bed more than the average for a patient without SPNI which was 12.27 days/bed (fig. 4).

In the etiological structure of cardiosurgical ISPN, gram-positive microorganisms with 174 strains prevail (61.92%), with a wide spectrum of bacterial species: *S. epi-*

dermidis (27.40%), *S. viridans* (6.76%), *S. aureus* (6.05%), *S. saprophyticus* (5.34%), *E. faecalis* (7.47%), *E. faecium* (4.60%), *Enterococcus* spp. (4.02%), *S. haemolyticus* (1.72%), *Corynebacterium* spp. (1.72%), *Bacillus* spp. (1.72%), *Sarcina* spp. (1.72%), other gram-positive microorganisms (1.72%), *S. pyogenes* (0.57%), *S. agalactiae* (0.57%), *S. pneumoniae* (0.57%) (fig. 5).

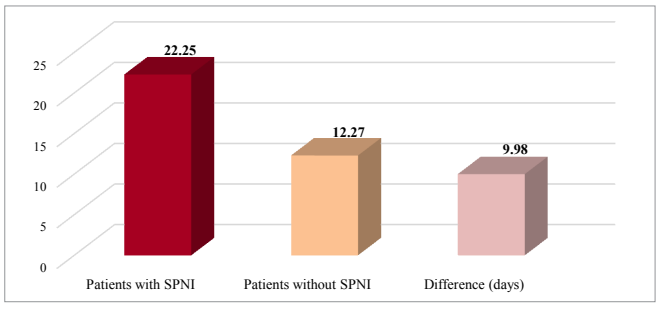

Fig. 4. The length of stay (starting with surgery), (days)

At the same time, 107 strains (38.08%) of gram-negative microorganisms were isolated, including *P. aeruginosa* (30.84%), *E. aerogenes* (28.97%), *A. baumannii* (11.21%), *E. coli* (10.28%), *K. pneumoniae* (6.54%), *K. oxytoca* (2.80%), *C. freundii* (1.87%), *P. mirabilis* (1.87%), other gram-negative microorganisms (1.87%), *E. cloacae* (0.93%), *P. vulgaris* (0.93%), *Neisseria* spp. (0.93%), *Branhamella* spp. (0.93%) (fig. 5).

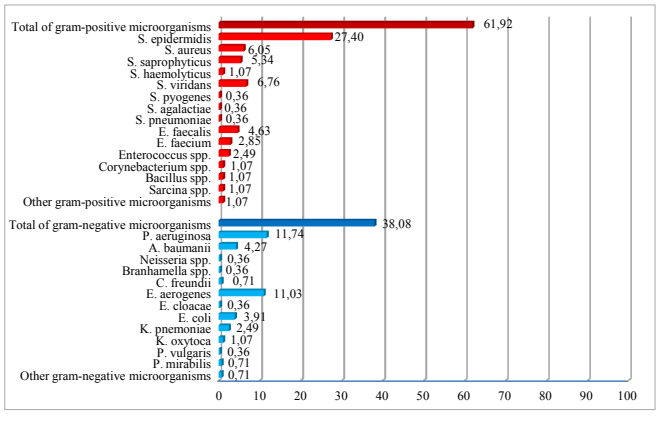

Fig. 5. The etiological distribution of cardiosurgical SPNI

Of the 281 strains isolated from patients with cardiac surgery for the study period, 112 were staphylococcal strains (*S. aureus*, *S. epidermidis*, *S. saprophyticus* and *S. haemolyticus*), which accounted for 64.36% of the total strains, 31 strains of streptococci (*S. agalactiae*, *S. pyogenes*, *S. pneumoniae*) and enterococci (*E. faecalis* and *E. faecium*) representing 17.81%, 13 strains (12.14%) of gram-negative cocci from the family Moraxellaceae (*Branhamella* spp. and *A. baumannii*), 58 strains of gram-negative microorganisms from the family Enterobacteriaceae – *E. coli*, *C. freundii*, *K. pneumoniae*, *K. oxytoca*, *P. vulgaris*, *P. mirabilis*, *E. aerogenes* and *E cloacae*, which constituted 54.20%, 33 strains of *P. aeruginosa* which constituted 30.84% of the total isolated strains (fig. 5).

The structure of microorganisms detected in cardiac surgery patients according to the investigated bio substrate shows that gram-positive bacteria predominate in samples taken from the content of the wound (41.38%), tracheal catheter (25.86%), valve vegetation (9.20%), while the share of microorganism's gram-negative amounts to 18.69%, 42.06%, 2.80% (fig. 6).

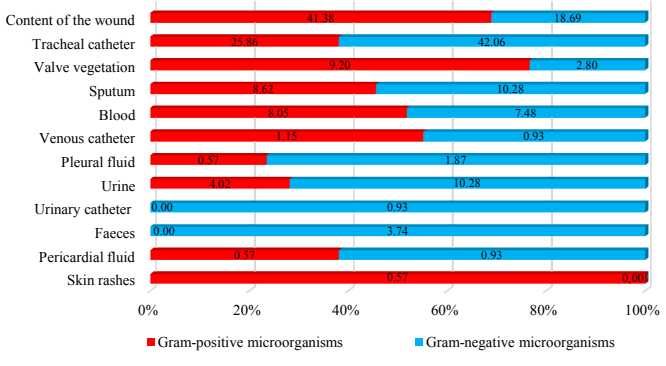

Fig. 6. Structure of microorganisms detected in cardiac surgery patients with SPNI according to the investigated bio substrate

Gram-negative microorganisms are more frequently isolated from tracheal catheter (42.06%), sputum (10.28%), urine (10.28%), while the share of gram-positive microorganisms is 25.86%, 8.62%, 4.02% (fig. 6).

An approximately equal rate of isolation of gram-positive and gram-negative bacteria was observed from blood (8.05%/7.48%), venous catheter (1.15%/0.93%), pericardial fluid (0.57%/0.93%) (fig. 6).

Only gram-negative bacteria were isolated from faeces (3.74%) and urinary catheter (0.93%), and only gram-positive microorganisms (0.57%) were identified in the skin rashes samples (fig. 6).

Discussion

According to the World Health Organization (WHO), healthcare-associated infections are the most frequent adverse event in healthcare delivery worldwide [10]. According to the WHO, seven of every 100 hospitalized patients acquire HCAI, with the infections causing approximately 99000 deaths per year in the United States [11, 12].

In various national and multicenter studies, including dozens of countries, it was determined that 3.5 to 12% of the patients were affected with at least one nosological form of SPNI [11].

Postoperative infections have been reported to occur in 5-21% of cardiac surgery patients in various institutions [1].

Different studies have shown that HCAI rates can range from 6% to 24% [8]. Therefore, Damavandi D. et al., reported being between 17% and 23% [8], as well as Ferreira G. et al., reported a similar range of 22.6% [13]. In the present study, the incidence of post-cardiac surgery SPNI is 31.76%, which is higher than normal limits.

Also, cardiac surgery involves superficial and deep sternal infections (SSI) [8]. Currently, it is considered that most SSI originate from the bacteria that enter the wound during

surgery [8].

In actual research, SSI represent the majority and constitute 32.06%, AI – 23.18%, RTI – 19.14% were the most common infections. Although in the other studies pneumonia (51.2%), SSI (22.0%), UTI (17.9%) and sepsis (14.6%) were the most common types of infection [8]. At the same time, Michalopoulos A. et al., established that the majority of NI were RTI (45.7%), CLABSI (25.2%) and wound infection (17.7%) [1]. Stanisławska M. indicated that the most frequent site of NI were pneumonia (44.4%), sepsis (42.0%) and SSI (33.3%), however every infected patient had 1-4 clinical forms [14], concurring with the present research.

One way to analyze the impact that the occurrence of infections has on LOS is to evaluate patients who remained more than nine days, which is considered as the ideal LOS for heart disease stays [13]. In the present study, a patient with SPNI has an average of stay in the hospital of 22.25 days/bed, with 9.98 days/bed more than the average for a patient without SPNI which was 12.27 days/bed.

Ferreira G. et al., demonstrated that patients who developed HCAI remained 1.5 times longer than those without infection, a 14-day increase in hospitalization after cardiac surgery [13].

Among hospital survivors, cardiac surgery patients acquiring NI had longer hospital LOS compared to patients without NI (20.1±13.0 days vs 9.7±4.5 days) [2].

From an etiological point of view, NI are characterized by their constant evolution over time. The analysis demonstrates a high variation in the etiology of NI in the surgery departments, but also in terms of the location of the infection.

In the actual research, gram-positive microorganisms are 61.92% and gram-negative microorganisms are 38.08%. Highlighted from the group of gram-positive microorganisms were *S. epidermidis* (27.40%), *S. viridans* (6.76%), *S. aureus* (6.05%), *S. saprophyticus* (5.34%), *E. faecalis* (7.47%), *E. faecium* (4.60%), *Enterococcus* spp. (4.02%), *S. haemolyticus* (1.72%), *Corynebacterium* spp. (1.72%), *Bacillus* spp. (1.72%), *Sarcina* spp. (1.72%), other gram-positive microorganisms (1.72%), *S. pyogenes* (0.57%), *S. agalactiae* (0.57%), *S. pneumoniae* (0.57%).

Of the group of gram-negative microorganisms, the largest share is manifested by *P. aeruginosa* (30.84%) followed by *E. aerogenes* (28.97%), *A. baumannii* (11.21%), *E. coli* (10.28%), *K. pneumoniae* (6.54%), *K. oxytoca* (2.80%), *C. freundii* (1.87%), *P. mirabilis* (1.87%), other gram-negative microorganisms (1.87%), *E. cloacae* (0.93%), *P. vulgaris* (0.93%), *Neisseria* spp. (0.93%), *Branhamella* spp. (0.93%).

In other studies, gram-positive cocci bacteria and gram-negative bacilli were the most common pathogens with a prevalence of 30.8% and 28.4% respectively [8]. *Acinetobacter* (48.6%), *Enterobacteriaceae* (37.1%), *P. aeruginosa* (17.1%) [8], the results of a Mazzeffi M. et al., study were similar [15]. Whereas Stanisławska M. has shown that the most common etiological factors of infection in cardiac surgery were gram-negative microorganisms such as *E. cloacae* and *P. aeruginosa* [14].

Although gram-positive microorganisms are the main bacteria involved, gram-negative bacilli, especially Enterobacteriaceae (36.5%), are frequently involved in cardiac surgery according to the results of Jolivet S. et al. [7]. In another research, the scientists found that gram-positive cocci were 67.9% and 30.7% were gram-negative bacteria [1].

In actual research, the structure of microorganisms detected in cardiac surgery patients according to the investigated bio substrate shows that gram-positive bacteria predominate in samples taken from the wound (41.38%), tracheal catheter (25.86%), valve vegetation (9.20%), while the share of microorganism's gram-negative amounts to 18.69%, 42.06%, 2.80%.

Gram-negative microorganisms are more frequently isolated from tracheal catheter (42.06%), sputum (10.28%), urine (10.28%), while the share of gram-positive microorganisms is 25.86%, 8.62%, 4.02%.

An approximately equal rate of isolation of gram-positive and gram-negative bacteria was observed from blood (8.05%/7.48%), venous catheter (1.15%/0.93%), pericardial fluid (0.57%/0.93%).

Only gram-negative bacteria were isolated from faeces (3.74%) and urinary catheter (0.93%), and only gram-positive microorganisms (0.57%) were identified in the rash samples.

Similar results obtained Liu Z. et al., (2021) recording the results of microbiological investigations of the sputum, blood, faeces and catheters [16]. Therefore, 73.13% out of all microorganisms were isolated from sputum (73.13%), blood (23.18%) and only 0.75% from urine [16].

This data suggests the urgency to take action in preventing SPNI following cardiac surgery that could decrease the incidence of the infections and allowing the patient a shorter possible stay in the hospital which will reduce healthcare costs for both the patient and the hospital.

Conclusions

1. According to the results of this study, SSI (32.06%) and AI (23.18%) represent the majority of recorded microbial infections.

2. A patient with SPNI spends an average of 22.25 days/bed in the hospital, which is 9.98 days/bed more than the 12.27 days/bed for a patient without SPNI.

3. The etiological structure of cardiac surgery SPNI is varied and includes 28 species of microorganisms. Gram-positive microorganisms are 61.92% and gram-negative microorganisms are 38.08%.

References

1. Michalopoulos A, Geroulanos S, Rosmarakis ES, Falagas ME. Frequency, characteristics, and predictors of microbiologically documented nosocomial infections after cardiac surgery. Eur J Cardiothorac Surg. 2006;29(4):456-60. doi: 10.1016/j.ejcts.2005.12.035.
2. Kollef MH, Sharpless L, Vlasnik J, Pasque C, Murphy D, Fraser VJ. The impact of nosocomial infections on patient outcomes following cardiac surgery. Chest. 1997;112(3):666-75. doi: 10.1378/chest.112.3.666.
3. Leu E. Epidemiologia şi prevenirea infecţiilor nosocomiale în staţionarele neurochirurgicale [Epidemiology and prevention of nosocomial infections in neurosurgical unit] [dissertation]. Chisinau: *Nicolae Testemit-*

anu State University of Medicine and Pharmacy; 2009. 141 p. Romanian.
4. Baranețchi I. Optimizarea supravegherii epidemiologice a infecțiilor nosocomiale septico-purulente în staționarele de profil Traumatologie și Ortopedie [Optimizing the epidemiological surveillance of septic-purulent nosocomial infections in the Traumatology and Orthopedics outpatient clinics] [dissertation]. Chisinau: *Nicolae Testemitanu* State University of Medicine and Pharmacy; 2016. 112 p. Romanian.
5. Aranaz-Andrés JM, Aibar-Remón C, Vitaller-Murillo J, Ruiz-López P, Limón-Ramírez R, Terol-García E. Incidence of adverse events related to health care in Spain: results of the Spanish National Study of Adverse Events. J Epidemiol Community Health. 2008;62(12):1022-9. doi: 10.1136/jech.2007.065227.
6. Pittet D, Tarara D, Wenzel RP. Nosocomial bloodstream infection in critically ill patients. Excess length of stay, extra costs, and attributable mortality. JAMA. 1994;271(20):1598-601. doi: 10.1001/jama.271.20.1598.
7. Jolivet S, Lescure FX, Armand-Lefevre L, Raffoul R, Dilly MP, Ghodbane W, Nataf P, Lucet JC. Surgical site infection with extended-spectrum β-lactamase-producing Enterobacteriaceae after cardiac surgery: incidence and risk factors. Clin Microbiol Infect. 2018;24(3):283-8. doi: 10.1016/j.cmi.2017.07.004.
8. Damavandi DS, Javan M, Moshashaei H, Forootan M, Darvishi M. Microbial contamination after cardiac surgery in a hospital cardiac surgery ward. J Med Life. 2020;13(3):342-348. doi: 10.25122/jml-2019-0071.
9. Centers for Disease Control and Prevention, National Healthcare Safety Network (NHSN). Patient Safety Component Manual [Internet]. Washington: CDC; 2021 [cited 2021 Jul 16]. Available from: https://www.cdc.gov/nhsn/pdfs/pscmanual/pcsmanual_current.pdf
10. World Health Organization; Ducel G, Fabry J, Nicolle L, editors. Prevention of hospital-acquired infections: a practical guide. 2nd ed. [Internet] Geneva: WHO; 2002 [cited 2021 Jul 16]. Available from: http://www.who.int/emc
11. World Health Organization. Healthcare-associated infections: Fact sheet [Internet]. Geneva: WHO [cited 2021 Jul 19]. Available from: https://www.who.int/gpsc/country_work/gpsc_ccisc_fact_sheet_en.pdf
12. Haque M, McKimm J, Sartelli M, Dhingra S, Labricciosa FM, Islam S, et al. Strategies to prevent healthcare-associated infections: a narrative overview. Risk Manag Healthcare Policy. 2020;13:1765-1780. doi: 10.2147/RMHP.S269315.
13. Ferreira GB, Sava Donadello JC, Mulinari LA. Healthcare-associated infections in a cardiac surgery service in Brazil. Brazilian J Cardiovasc Surg. 2020;35(5):614-8. doi: 10.21470/1678-9741-2019-0284.
14. Stanisławska M. [Monitoring of hospital infections in cardiac surgery ward]. Ann Acad Med Stetin. 2013;59(1):37-48. Polish.
15. Mazzeffi M, Gammie J, Taylor B, Cardillo S, Haldane-Lutterodt N, Amoroso A, Harris A, Thom K. Healthcare-associated infections in cardiac surgery patients with prolonged intensive care unit stay. Ann Thorac Surg. 2017;103(4):1165-70. doi: 10.1016/j.athoracsur.2016.12.041.
16. Liu Z, Zhang X, Zhai Q. Clinical investigation of nosocomial infections in adult patients after cardiac surgery. Medicine (Baltimore). 2021;100(4):e24162. doi: 10.1097/MD.0000000000024162.

Author's ORCID iD and academic degrees
Aliona Nastas, MD, PhD Applicant, Assistant Professor – https://orcid.org/0000-0002-3992-9242

Author's contribution
AN conceptualized the idea, conducted literature review, collected the data, interpreted the data, and wrote the manuscript.

Funding
This study was supported by *Nicolae Testemitanu* State University of Medicine and Pharmacy. The trial was the author's initiative. The author is independent and takes responsibility for the integrity of the data and accuracy of the data analysis.

Ethics approval and consent to participate
The study was approved by the Research Ethics Committee of *Nicolae Testemitanu* State University of Medicine and Pharmacy (Protocol No 47 of 17.04.2013). An informed consent from all participants in the study was obtained.

Conflict of Interests
There is no known conflict of interests to declare.