Use of Vancomycin Powder in Shoulder Arthroplasty: Preliminary Results

Uso de Vancomicina em Pó na Artroplastia do Ombro: Resultados Preliminares

Joana Maria Tavares Almeida[1]*, Maria J. Leite[1,2], Bernardo Nunes[1], Manuel R. Silva[2,3], Manuel Gutierres[1,3], João M. Torres[1,3]

1. Orthopedics Department, São João University Hospital, Porto, Portugal
2. Orthopedics Department, CUF Porto Hospital, Porto, Portugal
3. Porto Medical School, Porto University, Porto, Portugal

https://doi.org/10.82189/spot.47

ABSTRACT

Introduction: The use of intraoperative vancomycin powder as prophylaxis in spine surgery, as well as in knee and hip surgery, has been well established in the literature, but evidence is lacking regarding the role of its use in shoulder arthroplasty. This study aims to compare the infection rates between patients undergoing shoulder arthroplasty with intraoperative use of vancomycin powder and those managed with the standard protocol without local antibiotic application.

Methods: We designed a retrospective controlled study, including all patients submitted to shoulder arthroplasty in our Orthopedics Department between 2018 and 2020. We divided them into two groups: the intervention group, which received the powder, and a control group. The intervention technique consisted of using 1 g of vancomycin powder directly between all bone and metal interfaces and between all implant interfaces during surgery, and deeply into the muscular planes, before wound closure. Data contained in clinical files were collected, summarily, use of vancomycin powder, need for revision, and suspected infection, according to clinical and analytical criteria (EBJIS).

Results: Ninety-five patients were included, divided into an intervention group of 39 patients and a control group of 56 patients. Mean surgery duration in the study group was 103 ± 30 minutes, and in the control group was 145 ± 40 minutes (p>0.05). The rate of infection was 2.11%, occurring in the control group, concerning trauma cases. No infections were found in the vancomycin group. An association between infection and the absence of prophylactic vancomycin powder use was not statistically significant (p=0.514).

Conclusion: The use of local vancomycin powder might be a reasonable option for infection prevention in shoulder arthroplasty.

Keywords: Antibiotic Prophylaxis; Arthroplasty, Replacement, Shoulder; Postoperative Complications/prevention & control; Powders; Prosthesis-Related Infections/prevention & control; Shoulder Joint; Vancomycin/therapeutic use

*Autor Correspondente/Corresponding Author: Joana Maria Tavares Almeida [joana17almeida17@gmail.com], Orthopedics Department, São João University Hospital, Alameda Professor Hernâni Monteiro, 4200-319 Porto, Portugal

Recebido/Received: 2024/03/13 **Aceite/Accepted:** 2026/07/16 **Publicado online/Published online:** 2026/08/31 **Publicado / Published:** 2026/11/03

© 2026 Orthopedic SPOT. Este é um artigo de acesso aberto sob a licença CC BY-NC 4.0. Reutilização permitida de acordo com CC BY-NC 4.0. Nenhuma reutilização comercial.
© 2026 Orthopedic SPOT. This is an open-access article under the CC BY-NC 4.0. Re-use permitted under CC BY-NC 4.0. No commercial re-use.

RESUMO

Introdução: O uso intraoperatório de vancomicina em pó como medida profilática na cirurgia da coluna vertebral, bem como na cirurgia do joelho e da anca, encontra-se bem estabelecido na literatura. Contudo, a evidência relativa ao seu papel na artroplastia do ombro é ainda escassa. Este estudo teve como objetivo comparar as taxas de infeção entre doentes submetidos a artroplastia do ombro com aplicação intraoperatória de vancomicina em pó e doentes tratados segundo o protocolo convencional, sem aplicação local de antibiótico.

Métodos: Foi realizado um estudo retrospetivo controlado, que incluiu todos os doentes submetidos a artroplastia do ombro no nosso Serviço de Ortopedia entre 2018 e 2020. Os doentes foram divididos em dois grupos: um grupo de intervenção, no qual foi usada vancomicina em pó, e um grupo de controlo. A técnica de intervenção consistiu na aplicação de 1 g de vancomicina em pó diretamente em todas as interfaces entre o osso e os componentes metálicos e entre as diferentes interfaces dos implantes durante a cirurgia, bem como em profundidade nos planos musculares, antes do encerramento da ferida cirúrgica. Foram recolhidos dados dos processos clínicos, nomeadamente relativos ao uso de vancomicina em pó, à necessidade de cirurgia de revisão e à suspeita de infeção, de acordo com critérios clínicos e analíticos da European Bone and Joint Infection Society (EBJIS).

Resultados: Foram incluídos 95 doentes, dos quais 39 integraram o grupo de intervenção e 56 o grupo de controlo. A duração média da cirurgia foi de 103 ± 30 minutos no grupo de intervenção e de 145 ± 40 minutos no grupo de controlo (p > 0,05). A taxa global de infeção foi de 2,11%, tendo todos os casos ocorrido no grupo de controlo e em doentes submetidos a cirurgia por traumatismo. Não foram registadas infeções no grupo em que foi utilizada vancomicina em pó. A associação entre a ocorrência de infeção e a ausência de utilização profilática de vancomicina em pó não foi estatisticamente significativa (p = 0,514).

Conclusão: A aplicação local de vancomicina em pó poderá constituir uma opção para a prevenção da infeção em doentes submetidos a artroplastia do ombro.

Palavras-chave: Articulação do Ombro; Artroplastia do Ombro; Complicações Pós-Operatórias/prevenção & controlo; Infeções Relacionadas com Prótese/prevenção & controlo; Pós; Profilaxia Antibiótica; Vancomicina/uso terapêutico

INTRODUCTION

Infection after shoulder arthroplasty, although relatively uncommon with reported rates between 0.6% and 2.5%, represents a serious complication associated with increased morbidity, prolonged hospitalization, and significant functional impairment, emphasizing the critical need for effective prophylactic strategies.[1-3] Given the increasing prevalence of shoulder arthroplasty procedures in aging populations and younger, more active patients, there is a growing imperative to optimize perioperative strategies that minimize infection risk while preserving functional outcomes and implant longevity.

Suspicion for infection should be raised when a patient presents with a stiff and painful shoulder, even if cultures obtained after arthrocentesis fail to identify a pathogen, inflammatory markers remain within normal limits, and radiographs are inconclusive.[4] Therefore, diagnosing infection in shoulder arthroplasty patients is often challenging, as clinical signs may be subtle or absent despite persistent infection. To aid the diagnosis, the European Bone and Joint Infection Society (EBJIS) criteria[5] classify infection as unlikely, likely, or confirmed based on clinical signs, synovial fluid analysis, and microbiology. Key indicators include sinus tract presence, elevated synovial white cell count, positive cultures from multiple samples, and histopathological evidence. This approach helps distinguish infection from aseptic failure and supports clinical decisions.

Equally important as identifying periprosthetic joint infections is implementing evidence-based prevention strategies to reduce infection risk. Various approaches have been described to mitigate the risk of infection, including preoperative optimization and strict aseptic techniques.[6,7] Local antibiotic prophylaxis has emerged as a promising adjunct to conventional infection prevention measures.[4] Specifically, intraoperative vancomycin powder has demonstrated well-established efficacy as a prophylactic agent in spine, knee, and hip surgery.[8-10] However, evidence remains limited regarding the efficacy and safety of local vancomycin application in shoulder arthroplasty.[11] To further investigate this area, this study was designed to evaluate the impact of intraoperative local vancomycin powder on the incidence of postoperative infections following shoulder arthroplasty. The main outcome was defined as the rate of periprosthetic joint infections occurring within the specified follow-up period,

assessed by established clinical and laboratory criteria to determine the effectiveness of intraoperative local vancomycin powder application in reducing infection incidence after shoulder arthroplasty.

MATERIAL AND METHODS

We conducted a retrospective controlled study, including all patients submitted to shoulder arthroplasty in our Orthopedics Department at a tertiary hospital, between January 2018 and January 2020. The study groups were defined based on the surgeon and treatment approach: the intervention group consisted of patients operated on by a single surgeon who applied intraoperative vancomycin powder, while the control group included patients operated on by two different surgeons who did not use vancomycin powder. All 3 surgeons are specialized shoulder surgeons and follow similar aseptic techniques.

The minimum required follow-up period for enrollment was 6 months, ensuring adequate monitoring. This postoperative window enabled the detection of both early and late periprosthetic joint infections. No distinction was made between deep and superficial infections. The distinction between superficial and deep infections was not made, as they share the same risk factors and have similar clinical implications.

The dose of vancomycin powder was standardized at 1 g for all cases, regardless of patient size or implant type. Vancomycin powder was applied in its pure form directly to all bone-metal and implant interfaces during surgery, with particular attention given to delivering the powder deeply into the muscular planes before wound closure. The powder was not diluted nor used with any carrier such as calcium sulphate. After the application, the wound was left dry, and the suction drain was clamp-sealed for 30 minutes, then opened without vacuum and removed after 12 hours. Although 1 g may seem limited to distribute across all surfaces, this standardized dosing was chosen to maintain consistency and avoid excessive local concentrations.

Data contained in clinical files was collected, namely: age, sex, comorbidities, surgery duration (in which we included some steps before incision such as anesthesia procedures, disinfection of the entire arm and shoulder from the neck to the fingertips and application of all drapes), length of hospitalized stay, surgery indication, need for revision and existence of infection, according to clinical, radiographic and analytical criteria.[1,5] Additionally, an active search for toxicity and vancomycin-related allergies was also performed.

All statistical analyses were performed using SPSS software (version 26; IBM, Armonk, NY, USA). For all continuous and categorical variables, descriptive statistics were calculated. Continuous variables were reported as weighted mean and estimated standard deviation or median and interquartile range (IQR), based on normal distribution, whereas categorical variables were reported as frequencies with percentages. Categorical variables were processed using Fisher's exact test or the chi-square test, depending on the count of cells. The independent or paired t-test for normally distributed variables and the nonparametric Mann–Whitney U test, or Wilcoxon signed-rank test, were used to compare categorical and continuous variables. Continuous variables were assessed through the Spearman or Pearson test. To adjust for potential confounders, a simple logistic regression analysis was considered. The value of p <0.05 was considered statistically significant.

Although formal submission to the Ethics Committee was waived, given the retrospective nature and minimal risk of this study, institutional approval for the anonymous use of patient data was obtained in accordance with institutional and ethical guidelines.

RESULTS

A total of 95 patients underwent shoulder arthroplasty.

The intervention group consisted of 39 patients, while the control group included 56 patients. The sample comprised 70 (73.7%) female and 25 (26.3%) male patients. The mean age was 70 years ± 10 years. These two characteristics were similar between the two groups.

The mean duration of surgery in the study group was 103 ± 30 minutes, and the median length of stay in the hospital was 6 (interquartile range (IQR) 7) days. In the control group, the mean surgery duration was 145 ± 40 minutes, and the median length of stay was 2 (IQR 4) days. No significant correlation was found between surgery duration *(p=0.94) or length* of hospital stay *(p=0.484)*. Table 1 summarizes the demographic data.

Tabela 1. Demographic data.

	Study Group (Vancomycin)	Control Group (No Vancomycin)
Patients	39	56
Mean Surgery Duration (minutes)	103 ± 30	145 ± 40
Median Length of Hospital Stay (days)	6 IQR 7	2 IQR 4
Infection Cases	0	2

Of the total cases, 46 (48.2%) were performed for proximal humerus fractures; among these, 22 (47.8%) were classified as Neer 4-part fractures, 14 (30.4%) as 3-part fractures, and 9 (19.6%) as 2-part fractures. The remaining 49 arthroplasties included 44 (46.6%) cases of rotator cuff arthropathy, 3 (3.1%) cases performed for avascular necrosis, and 2 (2.1%) for chronic shoulder dislocation. No correlation was found between surgical indication or fracture classification and the presence of infection (p>0.05). Table 2 gathers this information.

Tabela 2. Surgical indications for performing shoulder arthroplasty.

	Number of Cases	Additional Details
Proximal Humerus Fractures	46	Neer 4-part: 22 Neer 3-part: 14 Neer 2-part: 9
Rotator Cuff Arthropathy	44	
Avascular Necrosis	3	
Inveterate Shoulder Dislocation	2	

There were four revision cases in our series. One for aseptic loosening, another for instability, and the remaining two were the result of infection, both belonging to the control group and referring to trauma cases. Samples were collected and sent for microbiological culture, which identified the presence of *Propionibacterium acne.*

No cases of infection were observed in the control group treated. However, the association between the absence of vancomycin prophylaxis and arthroplasty infection did not reach statistical significance (p=0.514). A simple logistic regression was performed, adjusting for key confounders, such as surgery duration and fracture versus non-fracture indication. We found that surgery duration was slightly longer in the control group (OR 1.01, 95% CI 1.00–1.02, p>0.05) and that trauma cases possibly had a higher odd for infection compared to non-fracture cases (OR 3.5, 95% CI 1.2–10.2, p>0.05).

No adverse effects, specifically hepatic or kidney toxicity, were documented from the direct use of the vancomycin powder. Also, no cases of hypersensitivity were described.

DISCUSSION

Our findings suggest that infection risk is increased in trauma cases, and with longer surgery duration, aligning with the already published literature. Trauma-related shoulder arthroplasty has been associated with nearly a threefold increased risk of infection compared to elective procedures, likely due to factors such as soft tissue injury and hematoma formation.[12] Similarly, prolonged operative time has been recognized as a contributing factor to surgical site infections, increasing exposure to potential contaminants and tissue ischemia.[13] The authors' idea of using intrawound vancomycin powder was based on the published effective decreased rate of infection in other surgical sites like the spine, hip, or knee.[9,14-16] In fact, there is a recent paper performed *in vitro* that showed that vancomycin powder was effective in eradicating *C. acnes* strains in high concentrations.[17] Sustained by the evidence available in literature, we hypothesized that it could be used in shoulder arthroplasties as prophylaxis.[18] Shoulder arthroplasty infections are mainly caused by *Staphylococcus aureus, Staphylococcus epidermidis*, and *Propionibacterium acne (*or *Cutibacterium acne* as it has been recently named*),* the latter being the most isolated.[3,19] Unlike the others, *C. acne* is a commensal skin bacterium that is not found in other shoulder tissues.[20] This suggests that infections caused by this microorganism likely originate from skin contamination. Therefore, one key preventive strategy is to minimize contact between the metallic joint components and the skin,[21] which is why vancomycin powder was applied to all implant interfaces during surgery. All of these bacteria are Gram-positive, so vancomycin is an effective antibiotic against them. Its chemical properties allow it to achieve high local bactericidal concentrations, while exhibiting poor systemic absorption, which reduces the risk of developing resistance.[16] This is particularly

important given that antibiotic resistance is a major public health concern. Moreover, this is one of the reasons why systemic complications are reduced. In fact, in a recent meta-analysis,[22] no adverse events were described. Notably, *in vitro* studies assessing minimum inhibitory concentrations have demonstrated that *C. acnes* exhibits greater susceptibility to vancomycin[18] than staphylococcal species, which are more commonly implicated in infections at other surgical sites. This increase *in vitro* susceptibility suggests that vancomycin may be particularly effective in preventing infections caused by *C. acnes* in the context of shoulder arthroplasty. An additional important consideration is that the application of vancomycin powder does not involve any extra procedural steps, thereby not extending the duration of surgery.[23] Besides, vancomycin powder is a low-cost and highly cost-effective option,[18,21,24,25] compared to other available options, such as antibiotic-loaded bone cement. This helps explain there are high expectations surrounding its use in clinical practice.

In this study, the rate of infection was 2.11% which is in line with the published literature,[3,11] and it is not excessive to emphasize that in the study group, no cases of infection were found. To our knowledge, this is the first clinical study to raise the question of whether vancomycin powder can be used as a prophylactic agent with positive results. This study's strengths lie in addressing an important yet underexplored topic with a substantial patient cohort and consistent vancomycin application protocol. Comprehensive data on demographics, comorbidities, and surgical details were collected, and standardized infection criteria were used to ensure validity. However, it has some important limitations. The first one is related to the relatively small sample size that limits the statistical power to detect significant differences in infection rates. Furthermore, given the relatively low baseline infection rate in primary total shoulder arthroplasty, the number of patients necessary to enroll in any prospective study to demonstrate the effect of the powder application is unreasonable,[24] which can underpower the results. Ultimately, the results are exploratory rather than confirmatory, and the paper analysis has to be made with caution. The second limitation pertains to the study's retrospective and non-randomized design, which introduces potential bias due to patient allocation by surgeon. Specifically, the intervention and control groups were treated by different surgeons who may vary in surgical technique and infection control protocols, thereby confounding the observed outcomes and limiting the internal validity of the study. Thirdly, the retrospective design inherently restricts control over confounding variables and data completeness. Overall, we consider that this paper can be an important guide for future research on this field, though the appointed factors restrict the strength of its conclusions. More robust prospective, randomized, and adequately powered studies are needed to definitively assess the safety and efficacy of local vancomycin powder in shoulder arthroplasty infection prevention.

CONCLUSION

As shown by these preliminary results, the use of local vancomycin powder appears to be a reasonable option for preventing infections in shoulder arthroplasty, and it is not related to medical complications.

Responsabilidades Éticas

Conflitos de Interesse: Os autores declaram a inexistência de conflitos de interesse na realização do presente trabalho.
Fontes de Financiamento: Não existiram fontes externas de financiamento para a realização deste artigo.
Confidencialidade dos Dados: Os autores declaram ter seguido os protocolos da sua instituição acerca da publicação dos dados de doentes.
Proteção de Pessoas e Animais: Os autores declaram que os procedimentos seguidos estavam de acordo com os regulamentos estabelecidos pela Comissão de Ética responsável e de acordo com a Declaração de Helsínquia revista em 2024 e da Associação Médica Mundial.
Proveniência e Revisão por Pares: Não comissionado; revisão externa por pares.

Ethical Disclosures

Conflicts of Interest: The authors have no conflicts of interest to declare.
Financing Support: This work has not received any contribution, grant or scholarship
Confidentiality of Data: The authors declare that they have followed the protocols of their work center on the publication of patient data.
Protection of Human and Animal Subjects: The authors declare that the procedures followed were in accordance with the regulations of the relevant clinical research ethics committee and those of the Code of Ethics of the World Medical Association (Declaration of Helsinki as revised in 2024).
Provenance and Peer Review: Not commissioned; externally peer-reviewed.

Declaração de Contribuição

JA: Conceção e desenho do estudo e redação da primeira versão do manuscrito.
MJL e BN: Recolha de dados clínicos e organização da informação.

MRS: Orientação da estrutura do artigo e revisão linguística do manuscrito.

MG: Responsável por assegurar a precisão e a exatidão do trabalho.

JT: Participação na redação do manuscrito, revisão das diferentes versões e análise crítica do conteúdo intelectual; aprovação da versão final.

Todos os autores aprovaram a versão final do manuscrito para publicação e assumem responsabilidade por todos os aspetos do trabalho, garantindo a exatidão e a integridade dos dados apresentados.

Contributorship Statement

JA: Study conception and design; drafting of the first version of the manuscript.

MJL and BN: Collection of clinical data and organization of information.

MRS: Guidance on the structure of the article and linguistic review of the manuscript.

MG: Responsible for ensuring the precision and accuracy of the work.

JT: Contributed to the drafting of the manuscript, reviewed the various versions, and provided critical analysis of the intellectual content; approved the final version.

All authors approved the final version of the manuscript for publication and assume responsibility for all aspects of the work, en suring the accuracy and integrity of the data presented.

REFERENCES

1. Fink B, Sevelda F. Periprosthetic Joint Infection of Shoulder Arthroplasties: Diagnostic and Treatment Options. BioMed Res Int. 2017;2017:4582756. doi: 10.1155/2017/4582756.
2. Coste JS, Reig S, Trojani C, Berg M, Walch G, Boileau P. The management of infection in arthroplasty of the shoulder. J Bone Joint Surg Br. 2004;86:65-9.
3. Saltzman MD, Marecek GS, Edwards SL, Kalainov DM. Infection after shoulder surgery. J Am Acad Orthop Surg. 2011;19:208-18. doi: 10.5435/00124635-201104000-00005.
4. Bohsali KI, Bois AJ, Wirth MA. Complications of Shoulder Arthroplasty. J Bone Joint Surg Am. 2017;99:256-69. doi: 10.2106/jbjs.16.00935.
5. McNally M, Sousa R, Wouthuyzen-Bakker M, Chen AF, Soriano A, Vogely HC, et al. The EBJIS definition of periprosthetic joint infection. Bone Joint J. 2021; 103-b: 18-25. doi: 10.1302/0301-620x.103b1.Bjj-2020-1381.R1.
6. Parada SA, Shaw KA, Eichinger JK, Stadecker MJ, Higgins LD, Warner JJ. Survey of shoulder arthroplasty surgeons' methods for infection avoidance of Propionibacterium. J Orthop. 2018;15:177-180. doi: 10.1016/j.jor.2018.01.052.
7. Clark JJ, Abildgaard JT, Backes J, Hawkins RJ. Preventing infection in shoulder surgery. J Shoulder Elbow Surg. 2018;27:1333-41. doi: 10.1016/j.jse.2017.12.028.
8. O'Neill KR, Smith JG, Abtahi AM, Archer KR, Spengler DM, McGirt MJ, et al. Reduced surgical site infections in patients undergoing posterior spinal stabilization of traumatic injuries using vancomycin powder. Spine J. 2011;11:641-6. doi: 10.1016/j.spinee.2011.04.025.
9. Patel NN, Guild GN, 3rd, Kumar AR. Intrawound vancomycin in primary hip and knee arthroplasty: a safe and cost-effective means to decrease early periprosthetic joint infection. Arthroplast Today. 2018;4:479-83. doi: 10.1016/j.artd.2018.07.011.
10. Sweet FA, Roh M, Sliva C. Intrawound application of vancomycin for prophylaxis in instrumented thoracolumbar fusions: efficacy, drug levels, and patient outcomes. Spine. 2011;36:2084-8.doi: 10.1097/BRS.0b013e3181ff2cb1.
11. Weber P, Utzschneider S, Sadoghi P, Andress HJ, Jansson V, Müller PE. Management of the infected shoulder prosthesis: a retrospective analysis and review of the literature. Int Orthop. 2011;35:365-373. . doi: 10.1007/s00264-010-1019-3.
12. Richards J, Inacio MC, Beckett M, Navarro RA, Singh A, Dillon MT, et al. Patient and procedure-specific risk factors for deep infection after primary shoulder arthroplasty. Clin Orthop Relat Res. 2014;472:2809-15. doi: 10.1007/s11999-014-3696-5.
13. Seok HG, Park JJ, Park SG. Risk factors for periprosthetic joint infection after shoulder arthroplasty: systematic review and meta-analysis. J Clin Med. 2022;11. . doi: 10.3390/jcm11144245.
14. Bakhsheshian J, Dahdaleh NS, Lam SK, Savage JW, Smith ZA. The use of vancomycin powder in modern spine surgery: systematic review and meta-analysis of the clinical evidence. World Neurosurg. 2015;83:816-23. doi: 10.1016/j.wneu.2014.12.033.
15. Brazilian Society of Neurosurgery - Spine Department; Joaquim AF, Milano JB, Daniel JW, Dantas FL, Onishi FJ, et al. Spine surgery - the use of vancomycin powder in surgical site for postoperative infection prevention. Rev Assoc Med Bras.2018;64:663-9. doi: 10.1590/1806-9282.64.08.663.
16. Yan H, He J, Chen S, Yu S, Fan C. Intrawound application of vancomycin reduces wound infection after open release of post-traumatic stiff elbows: a retrospective comparative study. J Shoulder Elbow Surg. 2014;23:686-92. doi: 10.1016/j.jse.2014.01.049.
17. Miquel J, Huang TB, Athwal GS, Faber KJ, O›Gorman DB. Vancomycin is effective in preventing Cutibacterium acnes growth in a mimetic shoulder arthroplasty. J Shoulder Elbow Surg.2022;31:159-64. doi: 10.1016/j.jse.2021.06.015.
18. Hosack LW, Overstreet DJ, Lederman ES. In vitro susceptibility of Propionibacterium acnes to simulated intrawound vancomycin concentrations. JSES Open Access. 2017;1:125-. doi: 10.1016/j.jses.2017.08.001.
19. Horneff JG, Hsu JE, Huffman GR. Propionibacterium acnes infections in shoulder surgery. Orthop Clin North Am. 2014;45:515-21. doi: 10.1016/j.ocl.2014.06.004.
20. Qiu B, Al K, Pena-Diaz AM, Drosdowech D, Faber KJ, Burton JP, et al. Cutibacterium acnes and the shoulder microbiome. J Shoulder Elbow Surg. 2018;27:1734-9. doi: 10.1016/j.jse.2018.04.019.
21. Smith ML, Gotmaker R, Hoy GA, Ek ET, Carr A, Flynn JN,et al. Minimizing Propionibacterium acnes contamination in shoulder arthroplasty: use of a wound protector. ANZ J Surg. 2018;88:1178-81. doi: 10.1111/ans.14821.
22. Evaniew N, Khan M, Drew B, Peterson D, Bhandari M, Ghert M. Intrawound vancomycin to prevent infections after spine surgery: a systematic review and meta-analysis. Eur Spine J. 2015;24:533-42. doi: 10.1007/s00586-014-3357-0.
23. Murphy EP, Curtin M, Shafqat A, Byrne F, Jadaan M, Rahall E. A review of the application of vancomycin powder to posterior spinal fusion wounds with a focus on side effects and infection. A prospective study. Eur J Orthop Surg Traumatol. 2017;27:187-91. doi: 10.1007/s00590-016-1878-4.
24. Hatch MD, Daniels SD, Glerum KM, Higgins LD. The cost effectiveness of vancomycin for preventing infections after shoulder arthroplasty: a break-even analysis. J Shoulder Elbow Surg. 2017;26:472-7. doi: 10.1016/j.jse.2016.07.071.
25. Qadir R, Ochsner JL, Chimento GF, Meyer MS, Waddell B, Zavatsky JM. Establishing a role for vancomycin powder application for prosthetic joint infection prevention-results of a wear simulation study. J Arthroplasty. 2014;29:1449-56. doi: 10.1016/j.arth.2014.02.012.