ISSN 2218-5836 (online)

World Journal of *Orthopedics*

World J Orthop 2023 August 18; 14(8): 589-661

Published by Baishideng Publishing Group Inc

World Journal of Orthopedics

Contents

Monthly Volume 14 Number 8 August 18, 2023

World Journal of Orthopedics

Monthly Volume 14 Number 8 August 18, 2023

Contents

NAME OF JOURNAL
World Journal of Orthopedics

ISSN
ISSN 2218-5836 (online)

LAUNCH DATE
November 18, 2010

FREQUENCY
Monthly

EDITORS-IN-CHIEF
Massimiliano Leigheb, Xiao-Jian Ye

EDITORIAL BOARD MEMBERS
http://www.wjgnet.com/2218-5836/editorialboard.htm

PUBLICATION DATE
August 18, 2023

COPYRIGHT
© 2023 Baishideng Publishing Group Inc

PUBLISHING PARTNER
The Minimally Invasive Spine Surgery Research Center Of Shanghai Jiaotong University

INSTRUCTIONS TO AUTHORS
https://www.wjgnet.com/bpg/gerinfo/204

GUIDELINES FOR ETHICS DOCUMENTS
https://www.wjgnet.com/bpg/GerInfo/287

GUIDELINES FOR NON-NATIVE SPEAKERS OF ENGLISH
https://www.wjgnet.com/bpg/gerinfo/240

PUBLICATION ETHICS
https://www.wjgnet.com/bpg/GerInfo/288

PUBLICATION MISCONDUCT
https://www.wjgnet.com/bpg/gerinfo/208

ARTICLE PROCESSING CHARGE
https://www.wjgnet.com/bpg/gerinfo/242

STEPS FOR SUBMITTING MANUSCRIPTS
https://www.wjgnet.com/bpg/GerInfo/239

ONLINE SUBMISSION
https://www.f6publishing.com

PUBLISHING PARTNER's OFFICIAL WEBSITE
https://www.shtrhospital.com/zkjs/info_29.aspx?itemid=647

World Journal of Orthopedics

Submit a Manuscript: https://www.f6publishing.com

World J Orthop 2023 August 18; 14(8): 589-597

DOI: 10.5312/wjo.v14.i8.589

ISSN 2218-5836 (online)

MINIREVIEWS

Use of topical vancomycin powder in total joint arthroplasty: Why the current literature is inconsistent?

Fabio Mancino, Piers J Yates, Benjamin Clark, Christopher W Jones

Specialty type: Orthopedics

Provenance and peer review: Invited article; Externally peer reviewed.

Peer-review model: Single blind

Peer-review report's scientific quality classification
Grade A (Excellent): 0
Grade B (Very good): B
Grade C (Good): 0
Grade D (Fair): D
Grade E (Poor): 0

P-Reviewer: Mazzotti A, Italy; Nalunkuma R, Uganda

Received: December 28, 2022
Peer-review started: December 28, 2022
First decision: February 21, 2023
Revised: March 28, 2023
Accepted: April 20, 2023
Article in press: April 20, 2023
Published online: August 18, 2023

Fabio Mancino, Piers J Yates, Christopher W Jones, Department of Orthopaedics, Fiona Stanley Hospital, Perth 6150, Australia

Piers J Yates, Christopher W Jones, Department of Orthopaedics, The Orthopaedic Research Foundation of Western Australia, Perth 6010, Australia

Piers J Yates, Department of Orthopaedics, University of Western Australia, Perth 6009, Australia

Benjamin Clark, Department of Infectious Diseases, Fiona Stanley Hospital, Perth 6150, Australia

Christopher W Jones, Department of Orthopaedics, Curtin University, Perth 6102, Australia

Corresponding author: Fabio Mancino, MD, Doctor, Department of Orthopaedics, Fiona Stanley Hospital, 11 Robin Warren, Perth 6150, Australia. fabio_mancino@yahoo.com

Abstract

Periprosthetic joint infection (PJI) is a rare but terrible complication in hip and knee arthroplasty, and the use of topical vancomycin powder (VP) has been investigated as a tool to potentially reduce its incidence. However, there remains no consensus on its efficacy. Therefore, the aim of this review is to provide an overview on the application of topical vancomycin in orthopaedic surgery focusing on the recent evidence and results in total joint arthroplasty. Several systematic reviews and meta-analyses on topical VP in hip and knee arthroplasty have been recently published reporting sometimes conflicting results. Apart from all being limited by the quality of the included studies (mostly level III and IV), confounding variables are often included potentially leading to biased conclusions. If taken into consideration the exclusive use of VP in isolation, the available data, although very limited, suggest that it does not reduce the infection rate in routine primary hip and knee arthroplasty. Therefore, we still cannot advise for a routinary application. A properly powered randomized-controlled trial would be necessary to clarify the role of VP in hip and knee arthroplasty. Based on the analysis of the current evidence, the use of topical VP appears to be safe when used locally in terms of systemic adverse reactions, hence, if proven to be effective, it could bring great benefits due to its low cost and accessibility.

Key Words: Periprosthetic joint infection; Vancomycin powder; Total knee arthroplasty;

Total hip arthroplasty; Infection; antibiotic

Core Tip: Vancomycin powder is widely used in orthopaedic surgery and it has been recently investigated in total joint arthroplasty (TJA), however, results are often conflicting. The aim of this study was to report on the use of vancomycin powder in orthopaedic surgery focusing on its application in TJA.

Citation: Mancino F, Yates PJ, Clark B, Jones CW. Use of topical vancomycin powder in total joint arthroplasty: Why the current literature is inconsistent? *World J Orthop* 2023; 14(8): 589-597
URL: https://www.wjgnet.com/2218-5836/full/v14/i8/589.htm
DOI: https://dx.doi.org/10.5312/wjo.v14.i8.589

INTRODUCTION

Periprosthetic joint infection (PJI) is one of the leading causes of revision in total joint arthroplasty (TJA) and its incidence has been reported between 1% to 4% after primary total knee arthroplasty (TKA) and 1% to 2% after primary total hip arthroplasty (THA) [1,2]. According to the available projections, the number of revisions is expected to grow proportionally to the number of primary implants performed every year[3] showing and increase of revision for PJI by 176% between 2014 and 2030 in THA, and by 170% in TKA[4]. Economic-based studies have reported that the yearly cost associated with PJI in the United States was approximately one billion United States dollars in 2017, and projected to reach almost two billion United States dollars by 2030[5].

Multiple strategies have been pursued to try to reduce the PJI rate in TJA, including preoperative screening, patient optimization, modified intraoperative techniques, and enhanced postoperative surveillance[6]. Vancomycin is a widely adopted and effective antibiotic in orthopaedic surgery, and its topical application has been investigated in different fields including spine surgery, trauma, and sport medicine to reduce the incidence of infection by providing a high concentration of antibiotic in a specific surgical site. Therefore, it has also been studied to reduce the PJI rate in TJA, reporting however conflicting conclusions.

The aim of this review is to provide an overview on the applications of topical vancomycin in orthopaedic surgery focusing on the use in TJA summarizing the results reported in the literature in order to clarify the current evidence for the use of topical VP.

The United States National Library of Medicine (PubMed/MEDLINE), EMBASE, and the Cochrane Database of Systematic Reviews were queried for publications utilizing various combinations of the search terms "VP", "vancomycin powder", "orthopaedic surgery", "orthopedic surgery" "arthroplasty", in combination with the Boolean operators (AND, OR, *) since January 2020 to December 2022. Two authors (Fabio Mancino and Christopher W Jones) independently conducted all the searches and screened the titles and abstracts to identify relevant studies. Differences were resolved by consulting a third senior reviewer (Piers J Yates). Only abstracts that evaluated the outcomes of VP in orthopaedic surgery were reviewed. If the title and abstract of each study contained insufficient information, the full manuscript was reviewed. An additional search was conducted by screening the references list of each selected article. Inclusion criteria were any systematic review and/or meta-analysis that pooled the results on the application of VP in orthopaedic surgery and TJA, analyzing the outcomes in terms of infection rate. Exclusion criteria were cohort studies, clinical trials, case reports, surgical technique reports, expert opinions, letters to editors, biomechanical reports, instructional course lectures, studies on animals, cadaver or *in vitro* investigations, book chapters, abstracts from scientific meetings, unpublished reports, and studies written in a non-English language. Two independent reviewers (Fabio Mancino and Christopher W Jones) separately examined all the identified studies and extracted data. During the initial review of the data, the following information was collected for each study: Title, first author, year of publication, study design, number of studies included, number of patients included, type of surgery, methods of application of VP, complications related to VP, superficial and deep infection rates.

BURDEN OF PERIPROSTHETIC JOINT INFECTION

PJI is a relatively rare complication. However, it is associated with a significantly greater morality when compared with patients undergoing aseptic revisions, up to five times higher at one year[7,8,9]. In addition, after the first case of PJI, the reinfection rate is up to 8.5% in THA and up to 16% in TKA[9], showing that the long-term consequences can be devastating. Kapadia *et al*[10], reported that patients with PJI had a significantly higher number of readmissions (3.6 *vs* 1.2; $P < 0.001$), length of hospitalization, clinic visits and sum-total episode cost than patients who had a non-infected primary implant (US$96,166 *vs* US$21,654; $P < 0.001$). When considering the economic burden, the cost of a revision for PJI is up to five times higher than a primary TJA ($116,382 *vs* $28,249)[11]. Moreover, managing this complication often

requires a two-stage revision strategy, costing approximately US$60,000 more than revisions for mechanical failure and/or aseptic loosening[12].

Currently, the only consensus recommendation for the use of antibiotics in TJA by international authorities is systemic perioperative administration[13].

VANCOMYCIN POWDER IN ORTHOPAEDIC SURGERY AND TJA

Gram-positive bacteria, particularly staphylococcal species, are the most common pathogenic organisms involved in post-operative orthopaedic infections[14]. Vancomycin is a tricyclic glycopeptide antibiotic with activity against gram-positive bacteria initially derived in 1953 from a compound produced by *Amycolatopsis orientalis*, a soil bacterium discovered within mud collected from a Borneo forest. The compound nicknamed "*Mississippi mud*" because of its appearance prior to purification became vancomycin (after the word "*vanquish*") and nearly 70 years later still retains antimicrobial activity against the majority of gram-positive organisms and remains the most commonly used antibiotic in the United States for the treatment of serious gram-positive infections, including those caused by methicillin-resistant Staphylococcus aureus (MRSA)[15].

The topical application of this antibiotic has been widely adopted in different fields of orthopaedic surgery with promising results. Sweet *et al*[16], demonstrated a significant reduction in postoperative deep wound infection rates (0.2% *vs* 2.6%; $P < 0.0001$) in posterior instrumented thoracolumbar spinal fusions with the adjunctive application of 2 g of VP before wound closure. Similar findings were reported by O'Neill *et al*[17], when analyzing 110 patients that underwent posterior spinal stabilization of traumatic injuries. The authors noted that the infection rate was significantly reduced (13% *vs* 0%; $P = 0.02$) when 1 g of vancomycin was applied before wound closure. Moreover, similarly reduced infection rates were reported both by Molinari *et al*[18] and by Bakhsheshian *et al*[19] when studying the effect of topical VP in instrumented and uninstrumented spine surgery.

The use of VP has been also investigated in tibial fractures, considered to be at high risk of infection, in an open-label multicentre randomized clinical trial reporting that the application of 1 g of VP was associated with a reduced risk of deep surgical site infection due to gram-positive organisms (risk difference, -3.7%; 95%CI, -6.7% to -0.8%; $P = 0.02$), in line with the activity of the antibiotic[20].

In addition, when VP was used in 422 shoulder arthroplasty, it has been associated with a significant reduction in PJI with no increased rate of aseptic wound complications, however, literature on shoulder surgery is limited and results are mostly based on retrospective analysis[21].

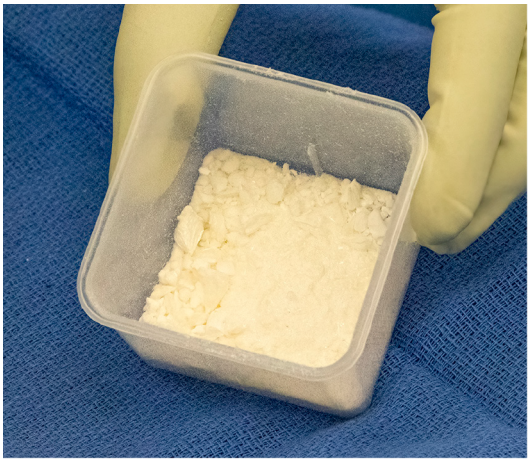
Similarly, studies on the application of topical VP in foot and ankle surgery and in total ankle arthroplasty (TAA) are limited, however, the economic viability has been investigated by Nam *et al*[22]. At their institutional cost of UD$3.06 per gram and a TAA PJI rate of 3%, VP would be cost-effective for TAA revision costs with an absolute risk reduction of 0.02% (number needed to treat = 5304). In addition, the authors showed that VP, when considered at their institutional price, would remain cost-effective even if the initial PJI rate was as low as 0.05%, and that if the PJI rate was held constant at 4%, VP would remain cost effective even within a range of price from US$2.50 to US$100.00 per gram. Nevertheless, the power analysis performed by the authors to confirm such results in a clinical trial shows the main limit of the investigations on VP.

Moreover, topical vancomycin is frequently used in anterior cruciate ligament reconstruction (ACLR) by wrapping the graft in a swab saturated with 5mg/mL vancomycin solution[23] and it has been associated with reduced incidence of postoperative septic arthritis[24]. In fact, Xiao *et al*[25], reported in a survey on the ACL Study Group members that 37.9% of the members pre-soak their ACL graft in vancomycin prior to implantation. In addition, Naendrup *et al*[24], pooled the results on 5075 ACLR showing a significant reduction in septic arthritis with no differences in clinical outcomes, biomechanical tendon properties, or cartilage integrity. Despite having many clinicians concerns regarding the potential toxicity on chondroblasts and osteoblasts, it has been proven *in-vitro* that when used at concentrations up to 5mg/mL, the vancomycin levels reached within the first 24-hours remain below the toxicity threshold for chondroblasts and osteoblasts [26].

Recently, vancomycin application has also been investigated in intraosseous (IO) infusion in THA at the concentration of 500mg/100cc of normal saline showing increased local tissue and decreased systemic concentrations when compared with standard prophylactic intravenous (IV) administration[27]. Similar findings have also been reported in a high body mass index (BMI) population that underwent TKA showing local concentrations up to 9-times higher than systemic administration[28].

Considering these promising results, VP is used in TJA with the hope of significantly reducing the risk of PJI (Figure 1). Weight-based (15 mg/Kg) IV vancomycin is already widely adopted as a second-line prophylaxis instead of first- or second-generation cephalosporin in case of allergies to penicillin, history of MRSA, or positive preoperative MRSA nasal-swab colture[29]. However, considering the better results associated with cephalosporins, the International Consensus on PJI recommended that these antibiotics can be safely used in case of non-anaphylactic penicillin allergy[30] since the cross-reactivity risk has been proven to be as low as 1%[31].

Topical application of VP allows higher concentrations in the surgical area while minimizing the systemic adverse effects[32]. In a rat model, the use of intra-articular VP combined with IV antibiotics resulted in the complete eradication of MRSA bacteria from contaminated implants[33]. Johnson *et al*[32] studied vancomycin concentration both locally and systemically after the administration of 1 g of intra-articular VP and 1 g after closure of the fascia in the superficial tissues in 34 THA reporting the different serum levels at 90 min, 3 h, 12 h, and 24 h, and the local levels at 3 h, 12 h, and 24 h. The authors reported that the mean serum concentration peaked at 12 h (4.7 mcg/mL; max observed 12.7 mcg/mL at 3 h)



DOI: 10.5312/wjo.v14.i8.589

Figure 1 Vancomycin powder used in 1-st stage revision total knee arthroplasty.

while the systemic therapeutic levels of 15-20 mcg/mL were never reached in any of the time-points. In addition, the intra-wound half-life was estimated to be 7.2 h with mean wound levels > 900 mcg/mL at 3 h while maintaining the local concentration over 200 mcg/mL for 24 h. Finally, the authors estimated that it would take up to 64 h for intrawound levels to drop below the minimum inhibitory concentration for *S. aureus* of 2 mcg/mL (Table 1).

Despite the potential benefits, there are also theoretical drawbacks. Firstly, the low systemic concentration of vancomycin may induce the development of resistant species of gram-positive bacteria colonizing the body. The Infectious Disease Society of America recommended serum levels > 10 mcg/mL to avoid the potential development of resistance[34]. Given the short half-life of the antibiotic when administered parenterally (4-6 h), this is not problematic when administered as a single dose of prophylactic IV antibiotic providing coverage for the first 24 h, but maybe a factor during ongoing and prolonged systemic absorption of intra-articular antibiotics. Secondly, a potential third body wear mechanism has been hypothesized between crystalline vancomycin and implant components since the solubility of vancomycin may vary in an intra-articular environment compared to saline solution. Nevertheless, Qadir *et al*[35] reported no appreciable difference in wear rates after 10 million simulated cycles between ultra-high-molecular-weight-polyethylene and Cobalt-Chrome alloy with the addition of VP. Lastly, vancomycin may have negative effects on the proliferation of viable cells including osteoblasts. Braun *et al*[36], reported the *in-vitro* effect of vancomycin on osteoblasts, endothelial cells, fibroblasts and skeletal muscle cells showing that the toxic effects were time (from day-3) and concentration-dependent (> 0.01 mg/mL). However, such results are yet to be proven *in-vivo*, and as shown by Johnson, no such concentrations have been reported at the 3-d mark. Therefore, based on the aforementioned studies, topical administration of VP can reasonably be considered clinically safe when used in TJA. Finally, if proven to significantly impact the PJI rate, VP would be highly cost-effective as its price has been reported from $2.50 to the highest of $44.00 per gram[37].

CURRENT LITERATURE FOR VP IN TKA AND THA

Overall, seven systematic reviews and/or meta-analyses were identified and analyzed[38-44] (Table 2).

Movassaghi *et al*[38], reported that intrawound VP may reduce the risk of PJI in primary and revision TJA while not leading to systemic complications. The authors included in their analysis 16 studies and 17164 TJA that received intrawound VP reporting an overall decreased rate of PJI (OR 0.46, $P < 0.05$), a decreased rate when considering TKA and THA separately (OR 0.41, $P < 0.05$ and OR 0.45, $P < 0.05$, respectively), and a decreased rate when considering primary implants only (OR 0.44, $P < 0.05$). Most of their results came from the outcomes of 14262 primary TKA (of 17164 joints, 83%) and that among them, 9884 cases (69% of primary knees) came from a study[44] where the so-called "VIP protocol" was used by mixing VP and 0.35% povidone-iodine (PI) solution (17.5 mL in 500 mL saline).

Regarding PI lavage, Kim *et al*[46], reported in a systematic review on 7 studies and 8861 TJA no difference between PI and saline in reducing the PJI rate. However, more recent studies showed efficacy in revision TJA reducing the PJI rate from 3.4% to 0.4% ($P = 0.038$, 478 revisions)[47], and efficacy in reducing the rate of any infection over 3232 TJA (OR 0.45, $P < 0.05$) or superficial site infections (SSI, OR 0.3, $P < 0.05$)[47]. Finally, Shohat *et al*[49] recently reported on the outcomes of 31331 cases showing a 2.34 times lower rate of PJI when comparing PI lavage with saline in TJA (0.6% *vs* 1.3%) with an absolute risk reduction of 0.73% and a number needed to treat of 137 patients. Therefore, the positive outcomes reported by Movassaghi *et al*[38] may have been influenced by the inclusion of iodine lavage.

Similarly, Liao *et al*[43], published in strong favor of VP suggesting that VP has a clear effect on preventing PJI in primary TKA. The authors reported on 11292 TKA where VP was used with a Risk Ratio (RR) of 0.41 (95%CI 0.29 to 0.58, $P < 0.001$) when compared to cases where VP was not used. However, as previously mentioned, 46.7% of of the cases analyzed came from studies[45,50] where VP was used in combination with a PI solution, potentially having once again a significant effect on the final results.

Table 1 Serum and local levels of vancomycin at different post-wound closure collection times

Procedure	Serum levels after wound closure of VP intrawound administration (g/mL)				
	1.5 h (mean ± SD; max)	3 h (mean ± SD; max)	12 h (mean ± SD; max)	24 h (mean ± SD; max)	Highest level observed across the 24-h period
THA (n = 15)	3.8 ± 3.9; 9.5	4.9 ± 4.5; 12.7	5.1 ± 3.3; 8.4	3.5 ± 3.5; 8.0	6.6 ± 3.8; 12.7
TKA (n = 19)	1.0 ± 2.5; 8.7	1.8 ± 3.2; 9.8	4.4 ± 3.1; 7.3	3.5 ± 3.6; 10.4	5.2 ± 3.4; 10.4
THA + TKA (n = 34)	2.2 ± 3.4; 9.5	3.2 ± 4.1; 12.7	4.7 ± 3.2; 8.4	3.5 ± 3.5; 10.4	5.8 ± 3.6; 12.7
	Local levels after wound closure of VP intrawound administration, n (g/mL)				
	-	**3 h (mean ± SD)**	**12 h (mean ± SD)**	**24 h (mean ± SD)**	-
THA	-	988 ± 628 (12)	769 ± 1059 (11)	280 ± 436 (11)	-
TKA	-	877 ± 455 (18)	288 ± 203 (16)	163 ± 220 (18)	-
THA + TKA	-	922 ± 523 (30)	484 ± 716 (27)	207 ± 317 (29)	-

VP: Vancomycin powder; THA: Total hip arthroplasty; TKA: Total knee arthroplasty. Adapted from: Johnson JD, Nessler JM, Horazdovsky RD, Vang S, Thomas AJ, Marston SB. Serum and Wound Vancomycin Levels After Intrawound Administration in Primary Total Joint Arthroplasty. *J Arthroplasty* 2017 Mar; 32(3): 924-928.

Table 2 Main characteristics and results of the recent literature on the topic vancomycin powder

Ref.	Type of study	No. of studies	No. of cases (control/intervention)	PJI Rate/RR (control *vs* intervention)	SSI/Aseptic wound complications (control *vs* intervention)	Authors' conclusions
Martin *et al* [36], 2022	Systematic review and meta-analysis	7/7	144724/8029	RR 0.39 (95%CI 0.27-0.56, P < 0.001)	6.48% *vs* 3.79%	VP ± PI lavage reduced PJI rate in primary and revision THA/TKA. Associated with reduced aseptic wound complications
Liao *et al*[35], 2022	Systematic review and meta-analysis	14	7720/1292	RR 0.41 (95%CI 0.29-0.58, P < 0.001)	-	VP recommended in primary TKA
Movassaghi *et al*[30], 2022	Systematic review and meta-analysis	16	3731/17164	1.65% *vs* 0.87% (P < 0.05)	-	Local VP may reduce the risk of PJI in primary and revision TJA
Wong *et al* [31], 2021	Systematic review	9	6255/3371	-	No difference	Recommend the surgeons not to use VP in routine THA and TKA
Peng *et al*[32], 2021	Systematic review and meta-analysis	9	4512/2354	RR 0.37 (95%CI 0.23-0.60, P < 0.001)	RR = 0.40, 95%CI 0.27-0.61 (P < 0.001)	Local VP could significantly decrease the rate of SSI and PJI in primary TJA
Saidahmed *et al*[33], 2021	Systematic review and meta-analysis	9	3714/1985	3.5% *vs* 1.6%, RR 0.53 (95%CI 0.35-0.79, P = 0.002, I^2 = 0.0%)	No difference 1.6% *vs* 0.7%, RR = 0.61, 95%CI 0.17-2.12, (P = 0.43, I^2 = 0.0%)	Local antibiotic application results in a moderate reduction in deep infection rates in primary TJA, with no significant impact on SSI rate
Xu *et al*[34], 2020	Systematic review and meta-analysis	9	4607/2497	2.75% *vs* 1.20% (OR 0.44, 95%CI 0.28-0.69, I^2 = 0.0%)	No difference 1.60% *vs* 0.67% (OR 0.60, 95%CI 0.17-2.12, I^2 = 0.0%)	VP used in primary hip and knee arthroplasty may reduce the incidence of PJI but it may increase the risk of aseptic wound complications

RR: Relative risk; SSI: Superficial site infection; VP: Vancomycin powder; PI: Povidone iodine; PJI: Periprosthetic joint infection; THA: Total hip arthroplasty; TKA: Total knee arthroplasty; TJA: Total joint arthroplasty; OR: Odds ratio.

Moreover, Peng *et al*[40], stated that "the local application of VP could significantly decrease the rate of SSI and PJI in primary TJA" recommending its topical administration before wound closure. The meta-analysis included nine studies and three of those[49,51,52], representing a weight on the result of 44%, did not involve only the application of topical VP, therefore, their inclusion could be misleading. One of these[50], reported on the combined application of PI lavage and

VP showing that administration of local antibiotics was preventative for PJI only in the primary TKA (OR 0.28, 95%CI 0.09–0.89). The other two[51,53], reported on the application of VP on the surface of cementless implants in THA and TKA and not in the soft tissue deep or superficial to the fascia/capsule, therefore, a completely different way of using VP.

Xu *et al*[42], reported that "the current literature suggests that intrawound vancomycin used in primary hip and knee arthroplasty may reduce the incidence of PJI, but it may also increase risk of aseptic wound complications". Nine studies were included in their final analysis with 4605 TJA, 2497 of which were treated with VP. The authors reported a reduced PJI rate in the VP group (1.20% *vs* 2.75%) with an OR of 0.44 (95%CI 0.28 to 0.69, $I^2 = 0.0\%$), a comparable risk of SSI (OR 0.60, 95%CI 0.17 to 2.12), and a higher incidence of aseptic wound complications (2.15% *vs* 0.96%, OR 2.39, 95%CI 1.09 to 5.23). However, when considering the aseptic wound complications, only four of the nine studies reported on such events (1069 treated cases), and all of them had different methodology protocols in terms of the amount of VP used, placement of the VP (deep to the fascia, superficial, or both), and the application of a drain for up to 48 h post-operative. Therefore, the conclusion that VP is associated with an increased risk of aseptic wound complications, based on such results, may require stronger evidence.

Saidahmed *et al*[41], stated that topical antibiotics led to a moderate reduction in PJI in primary TJA, with no significant impact on SSI rates but that it may be associated with a moderate increase in aseptic wound complication. However, once again, four of the nine studies reported mixed results considering the combined activity of PI lavage and VP[50], the application on cementless implants[52,53], or did not consider only the application of VP in TJA but more generally the use of topical antibiotics[54].

On the other hand, Wong *et al*[39] discouraged the application of VP in primary TJA after systematically analysing the outcomes of 9 studies and 3371 TJA in which VP was used compared with 2884 in which it was not. Only studies with similar procedures and those limited to the application of VP were included. The authors reported that only one of the studies included[51] was associated with significant improvement while the remaining eight had OR that broadly bracketed the line of no difference (range, 0.09 to 1.97). In addition, the authors noted insufficient evidence on the question of safety, therefore, their final statement was against the use of topical VP in routine THA and TKA unless adequately powered, multicentre, prospective trials demonstrate clear evidence. However, despite the methodology and the inclusion criteria being well defined to include only studies using topical VP in isolation, no statistical analysis was performed to verify the results.

Lastly, Martin *et al*[44] recently pooled together the studies using VP alone (7 studies) and in combination with PI lavage (7 studies) reporting a significant reduction of PJI rate (RR 0.39, 95%CI 0.27 to 0.56, $P < 0.001$) in primary and revision THA and TKA when compared with a control group. However, there remain doubts on the contribution of the PI lavage as we are still missing clear results on the VP alone used with standardized methods and compared with a control group. Interestingly, the authors reported a reduced aseptic wound complication rate in the treatment pool (110/2903, 3.79% *vs* 98/1512, 6.48%), though, still considering the combined effect of VP and PI lavage.

CONCLUSION

PJI in TJA is certainly one of the biggest challenges that the orthopaedic community is now facing with tremendous impact on the patient, the treating multi-disciplinary team, and the health care system. Despite the topical application of VP appears to be safe in terms of systemic complications, there are potential risks regarding the development of antimicrobial resistance following the administration of VP and most importantly, from the available data, we cannot conclude that when used in isolation it is effective in reducing the PJI rate. Evidence remains lacking with varying methodologies and important technical differences (amount of VP, placement deep or superficial to the fascia, use of drain). In fact, positive outcomes appear only to have been reported when the additional application of PI is considered together with VP. It must also be noted that the use of intraoperative antimicrobial irrigation (*e.g.* deep or subcutaneous tissues), or the application of antimicrobial agents (*e.g.* ointments, solutions, or powders) to the surgical incision for the prevention of SSI are not currently recommended by The Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection[55]. Moreover, evidence supports the perceived increased risk of aseptic wound complications, which should be further investigated.

Therefore, despite the multiple studies recently published, the efficacy of VP in TJA for reducing PJI is still essentially unknown. To overcome this issue, a randomized controlled trial with homogeneous methodology and exclusion of additional confounding variables (such as PI lavage) would be necessary.

ACKNOWLEDGEMENTS

The Orthopaedic Research Foundation of Western Australia (ORFWA) for providing research support.

FOOTNOTES

Author contributions: Mancino F, Jones CW conceptualization; Yates PJ, Jones CW supervision and validation; Mancino F wrote the original draft; Yates PJ, Jones CW, Clark B, review and editing; and all the authors gave final approval of the version to be published.

Conflict-of-interest statement: All the authors report no relevant conflicts of interest for this article.

Country/Territory of origin: Australia

ORCID number: Fabio Mancino 0000-0003-3080-0052.

S-Editor: Liu XF
L-Editor: A
P-Editor: Yuan YY

REFERENCES

1 **Kurtz SM**, Lau EC, Son MS, Chang ET, Zimmerli W, Parvizi J. Are We Winning or Losing the Battle With Periprosthetic Joint Infection: Trends in Periprosthetic Joint Infection and Mortality Risk for the Medicare Population. *J Arthroplasty* 2018; **33**: 3238-3245 [PMID: 29914821 DOI: 10.1016/j.arth.2018.05.042]
2 **Kapadia BH**, Berg RA, Daley JA, Fritz J, Bhave A, Mont MA. Periprosthetic joint infection. *Lancet* 2016; **387**: 386-394 [PMID: 26135702 DOI: 10.1016/S0140-6736(14)61798-0]
3 **Kurtz S**, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg Am* 2007; **89**: 780-785 [PMID: 17403800 DOI: 10.2106/JBJS.F.00222]
4 **Schwartz AM**, Farley KX, Guild GN, Bradbury TL Jr. Projections and Epidemiology of Revision Hip and Knee Arthroplasty in the United States to 2030. *J Arthroplasty* 2020; **35**: S79-S85 [PMID: 32151524 DOI: 10.1016/j.arth.2020.02.030]
5 **Premkumar A**, Kolin DA, Farley KX, Wilson JM, McLawhorn AS, Cross MB, Sculco PK. Projected Economic Burden of Periprosthetic Joint Infection of the Hip and Knee in the United States. *J Arthroplasty* 2021; **36**: 1484-1489.e3 [PMID: 33422392 DOI: 10.1016/j.arth.2020.12.005]
6 **Jones C**, Clarke B, Yates P. Strategies for Preventing Infections in Total Hip & Total Knee Arthroplasty. 2017: 77-126
7 **Berend KR**, Lombardi AV Jr, Morris MJ, Bergeson AG, Adams JB, Sneller MA. Two-stage treatment of hip periprosthetic joint infection is associated with a high rate of infection control but high mortality. *Clin Orthop Relat Res* 2013; **471**: 510-518 [PMID: 22983683 DOI: 10.1007/s11999-012-2595-x]
8 **Zmistowski B**, Karam JA, Durinka JB, Casper DS, Parvizi J. Periprosthetic joint infection increases the risk of one-year mortality. *J Bone Joint Surg Am* 2013; **95**: 2177-2184 [PMID: 24352771 DOI: 10.2106/JBJS.L.00789]
9 **Leung F**, Richards CJ, Garbuz DS, Masri BA, Duncan CP. Two-stage total hip arthroplasty: how often does it control methicillin-resistant infection? *Clin Orthop Relat Res* 2011; **469**: 1009-1015 [PMID: 21161741 DOI: 10.1007/s11999-010-1725-6]
10 **Kapadia BH**, McElroy MJ, Issa K, Johnson AJ, Bozic KJ, Mont MA. The economic impact of periprosthetic infections following total knee arthroplasty at a specialized tertiary-care center. *J Arthroplasty* 2014; **29**: 929-932 [PMID: 24140271 DOI: 10.1016/j.arth.2013.09.017]
11 **Kurtz SM**, Lau E, Watson H, Schmier JK, Parvizi J. Economic burden of periprosthetic joint infection in the United States. *J Arthroplasty* 2012; **27**: 61-5.e1 [PMID: 22554729 DOI: 10.1016/j.arth.2012.02.022]
12 **Parvizi J**, Pawasarat IM, Azzam KA, Joshi A, Hansen EN, Bozic KJ. Periprosthetic joint infection: the economic impact of methicillin-resistant infections. *J Arthroplasty* 2010; **25**: 103-107 [PMID: 20570103 DOI: 10.1016/j.arth.2010.04.011]
13 **Parvizi J**, Gehrke T, Chen AF. Proceedings of the International Consensus on Periprosthetic Joint Infection. *Bone Joint J* 2013; **95-B**: 1450-1452 [PMID: 24151261 DOI: 10.1302/0301-620X.95B11.33135]
14 **Tyllianakis ME**, Karageorgos ACh, Marangos MN, Saridis AG, Lambiris EE. Antibiotic prophylaxis in primary hip and knee arthroplasty: comparison between cefuroxime and two specific antistaphylococcal agents. *J Arthroplasty* 2010; **25**: 1078-1082 [PMID: 20381287 DOI: 10.1016/j.arth.2010.01.105]
15 **Levine DP**. Vancomycin: a history. *Clin Infect Dis* 2006; **42** Suppl 1: S5-12 [PMID: 16323120 DOI: 10.1086/491709]
16 **Sweet FA**, Roh M, Sliva C. Intrawound application of vancomycin for prophylaxis in instrumented thoracolumbar fusions: efficacy, drug levels, and patient outcomes. *Spine (Phila Pa 1976)* 2011; **36**: 2084-2088 [PMID: 21304438 DOI: 10.1097/BRS.0b013e3181ff2cb1]
17 **O'Neill KR**, Smith JG, Abtahi AM, Archer KR, Spengler DM, McGirt MJ, Devin CJ. Reduced surgical site infections in patients undergoing posterior spinal stabilization of traumatic injuries using vancomycin powder. *Spine J* 2011; **11**: 641-646 [PMID: 21600853 DOI: 10.1016/j.spinee.2011.04.025]
18 **Molinari RW**, Khera OA, Molinari WJ 3rd. Prophylactic intraoperative powdered vancomycin and postoperative deep spinal wound infection: 1,512 consecutive surgical cases over a 6-year period. *Eur Spine J* 2012; **21** Suppl 4: S476-S482 [PMID: 22160172 DOI: 10.1007/s00586-011-2104-z]
19 **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**: 816-823 [PMID: 25535069 DOI: 10.1016/j.wneu.2014.12.033]
20 **Major Extremity Trauma Research Consortium (METRC)**, O'Toole RV, Joshi M, Carlini AR, Murray CK, Allen LE, Huang Y, Scharfstein DO, O'Hara NN, Gary JL, Bosse MJ, Castillo RC, Bishop JA, Weaver MJ, Firoozabadi R, Hsu JR, Karunakar MA, Seymour RB, Sims SH, Churchill C, Brennan ML, Gonzales G, Reilly RM, Zura RD, Howes CR, Mir HR, Wagstrom EA, Westberg J, Gaski GE, Kempton LB, Natoli RM, Sorkin AT, Virkus WW, Hill LC, Hymes RA, Holzman M, Malekzadeh AS, Schulman JE, Ramsey L, Cuff JAN, Haaser S, Osgood GM, Shafiq B, Laljani V, Lee OC, Krause PC, Rowe CJ, Hilliard CL, Morandi MM, Mullins A, Achor TS, Choo AM, Munz JW, Boutte SJ, Vallier HA, Breslin MA, Frisch HM, Kaufman AM, Large TM, LeCroy CM, Riggsbee C, Smith CS, Crickard CV, Phieffer LS, Sheridan E, Jones CB, Sietsema DL, Reid JS, Ringenbach K, Hayda R, Evans AR, Crisco MJ, Rivera JC, Osborn PM, Kimmel J, Stawicki SP,

Nwachuku CO, Wojda TR, Rehman S, Donnelly JM, Caroom C, Jenkins MD, Boulton CL, Costales TG, LeBrun CT, Manson TT, Mascarenhas DC, Nascone JW, Pollak AN, Sciadini MF, Slobogean GP, Berger PZ, Connelly DW, Degani Y, Howe AL, Marinos DP, Montalvo RN, Reahl GB, Schoonover CD, Schroder LK, Vang S, Bergin PF, Graves ML, Russell GV, Spitler CA, Hydrick JM, Teague D, Ertl W, Hickerson LE, Moloney GB, Weinlein JC, Zelle BA, Agarwal A, Karia RA, Sathy AK, Au B, Maroto M, Sanders D, Higgins TF, Haller JM, Rothberg DL, Weiss DB, Yarboro SR, McVey ED, Lester-Ballard V, Goodspeed D, Lang GJ, Whiting PS, Siy AB, Obremskey WT, Jahangir AA, Attum B, Burgos EJ, Molina CS, Rodriguez-Buitrago A, Gajari V, Trochez KM, Halvorson JJ, Miller AN, Goodman JB, Holden MB, McAndrew CM, Gardner MJ, Ricci WM, Spraggs-Hughes A, Collins SC, Taylor TJ, Zadnik M. Effect of Intrawound Vancomycin Powder in Operatively Treated High-risk Tibia Fractures: A Randomized Clinical Trial. *JAMA Surg* 2021; **156**: e207259 [PMID: 33760010 DOI: 10.1001/jamasurg.2020.7259]

21 **Garofalo R**, Fontanarosa A, De Giorgi S, Lassandro N, De Crescenzo A. Vancomycin powder embedded in collagen sponge decreases the rate of prosthetic shoulder infection [published online ahead of print, 2023 Mar 24]. *J Shoulder Elbow Surg* 2023; **32**: 1638-1644 [PMID: 36967057 DOI: 10.1016/j.jse.2023.02.129]

22 **Nam HH**, Martinazzi BJ, Kirchner GJ, Adeyemo A, Mansfield K, Dopke K, Ptasinski A, Bonaddio V, Aynardi MC. Vancomycin Powder Is Highly Cost-Effective in Total Ankle Arthroplasty. *Foot Ankle Spec* 2023; **16**: 283-287 [PMID: 37340880 DOI: 10.1177/19386400221136374]

23 **Vertullo CJ**, Quick M, Jones A, Grayson JE. A surgical technique using presoaked vancomycin hamstring grafts to decrease the risk of infection after anterior cruciate ligament reconstruction. *Arthroscopy* 2012; **28**: 337-342 [PMID: 22112612 DOI: 10.1016/j.arthro.2011.08.301]

24 **Naendrup JH**, Marche B, de Sa D, Koenen P, Otchwemah R, Wafaisade A, Pfeiffer TR. Vancomycin-soaking of the graft reduces the incidence of septic arthritis following ACL reconstruction: results of a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2020; **28**: 1005-1013 [PMID: 30656372 DOI: 10.1007/s00167-019-05353-1]

25 **Xiao M**, Sherman SL, Safran MR, Abrams GD. Surgeon practice patterns for pre-soaking ACL tendon grafts in vancomycin: a survey of the ACL study group. *Knee Surg Sports Traumatol Arthrosc* 2021; **29**: 1920-1926 [PMID: 32902684 DOI: 10.1007/s00167-020-06265-1]

26 **Grayson JE**, Grant GD, Dukie S, Vertullo CJ. The in vitro elution characteristics of vancomycin from tendons. *Clin Orthop Relat Res* 2011; **469**: 2948-2952 [PMID: 21246314 DOI: 10.1007/s11999-011-1768-3]

27 **Harper KD**, Park KJ, Brozovich AA, Sullivan TC, Serpelloni S, Taraballi F, Incavo SJ, Clyburn TA. Otto Aufranc Award: Intraosseous Vancomycin in Total Hip Arthroplasty - Superior Tissue Concentrations and Improved Efficiency. *J Arthroplasty* 2023; **38**: S11-S15 [PMID: 37088221 DOI: 10.1016/j.arth.2023.04.028]

28 **Chin SJ**, Moore GA, Zhang M, Clarke HD, Spangehl MJ, Young SW. The AAHKS Clinical Research Award: Intraosseous Regional Prophylaxis Provides Higher Tissue Concentrations in High BMI Patients in Total Knee Arthroplasty: A Randomized Trial. *J Arthroplasty* **33(7S)**: S13-S18 [PMID: 29655497 DOI: 10.1016/j.arth.2018.03.013]

29 **Kheir MM**, Tan TL, Azboy I, Tan DD, Parvizi J. Vancomycin Prophylaxis for Total Joint Arthroplasty: Incorrectly Dosed and Has a Higher Rate of Periprosthetic Infection Than Cefazolin. *Clin Orthop Relat Res* 2017; **475**: 1767-1774 [PMID: 28401341 DOI: 10.1007/s11999-017-5302-0]

30 **Hansen E**, Belden K, Silibovsky R, Vogt M, Arnold WV, Bicanic G, Bini SA, Catani F, Chen J, Ghazavi MT, Godefroy KM, Holham P, Hosseinzadeh H, Kim KI, Kirketerp-Møller K, Lidgren L, Lin JH, Lonner JH, Moore CC, Papagelopoulos P, Poultsides L, Randall RL, Roslund B, Saleh K, Salmon JV, Schwarz EM, Stuyck J, Dahl AW, Yamada K. Perioperative antibiotics. *J Arthroplasty* 2014; **29**: 29-48 [PMID: 24355256 DOI: 10.1016/j.arth.2013.09.030]

31 **Campagna JD**, Bond MC, Schabelman E, Hayes BD. The use of cephalosporins in penicillin-allergic patients: a literature review. *J Emerg Med* 2012; **42**: 612-620 [PMID: 21742459 DOI: 10.1016/j.jemermed.2011.05.035]

32 **Johnson JD**, Nessler JM, Horazdovsky RD, Vang S, Thomas AJ, Marston SB. Serum and Wound Vancomycin Levels After Intrawound Administration in Primary Total Joint Arthroplasty. *J Arthroplasty* 2017; **32**: 924-928 [PMID: 27633945 DOI: 10.1016/j.arth.2015.10.015]

33 **Edelstein AI**, Weiner JA, Cook RW, Chun DS, Monroe E, Mitchell SM, Kannan A, Hsu WK, Stulberg SD, Hsu EL. Intra-Articular Vancomycin Powder Eliminates Methicillin-Resistant S. aureus in a Rat Model of a Contaminated Intra-Articular Implant. *J Bone Joint Surg Am* 2017; **99**: 232-238 [PMID: 28145954 DOI: 10.2106/JBJS.16.00127]

34 **Rybak M**, Lomaestro B, Rotschafer JC, Moellering R Jr, Craig W, Billeter M, Dalovisio JR, Levine DP. Therapeutic monitoring of vancomycin in adult patients: a consensus review of the American Society of Health-System Pharmacists, the Infectious Diseases Society of America, and the Society of Infectious Diseases Pharmacists. *Am J Health Syst Pharm* 2009; **66**: 82-98 [PMID: 19106348 DOI: 10.2146/ajhp080434]

35 **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**: 1449-1456 [PMID: 24636904 DOI: 10.1016/j.arth.2014.02.012]

36 **Braun J**, Eckes S, Rommens PM, Schmitz K, Nickel D, Ritz U. Toxic Effect of Vancomycin on Viability and Functionality of Different Cells Involved in Tissue Regeneration. *Antibiotics (Basel)* 2020; **9** [PMID: 32397094 DOI: 10.3390/antibiotics9050238]

37 **Kerbel YE**, Kirchner GJ, Sunkerneni AR, Lieber AM, Moretti VM, Khalsa AS, Levine MJ. The Cost-Effectiveness of Vancomycin Powder in Lumbar Laminectomy. *Global Spine J* 2021; **11**: 28-33 [PMID: 32875834 DOI: 10.1177/2192568219888451]

38 **Movassaghi K**, Wang JC, Gettleman BS, Mayfield CK, Oakes DA, Lieberman JR, Heckmann ND. Systematic Review and Meta-Analysis of Intrawound Vancomycin in Total Hip and Total Knee Arthroplasty: A Continued Call for a Prospective Randomized Trial. *J Arthroplasty* 2022; **37**: 1405-1415.e1 [PMID: 35314283 DOI: 10.1016/j.arth.2022.03.047]

39 **Wong MT**, Sridharan SS, Davison EM, Ng R, Desy NM. Can Topical Vancomycin Prevent Periprosthetic Joint Infection in Hip and Knee Arthroplasty? A Systematic Review. *Clin Orthop Relat Res* 2021; **479**: 1655-1664 [PMID: 33929342 DOI: 10.1097/CORR.0000000000001777]

40 **Peng Z**, Lin X, Kuang X, Teng Z, Lu S. The application of topical vancomycin powder for the prevention of surgical site infections in primary total hip and knee arthroplasty: A meta-analysis. *Orthop Traumatol Surg Res* 2021; **107**: 102741 [PMID: 33257290 DOI: 10.1016/j.otsr.2020.09.006]

41 **Saidahmed A**, Sarraj M, Ekhtiari S, Mundi R, Tushinski D, Wood TJ, Bhandari M. Local antibiotics in primary hip and knee arthroplasty: a systematic review and meta-analysis. *Eur J Orthop Surg Traumatol* 2021; **31**: 669-681 [PMID: 33104869 DOI: 10.1007/s00590-020-02809-w]

42 **Xu H**, Yang J, Xie J, Huang Z, Huang Q, Cao G, Pei F. Efficacy and safety of intrawound vancomycin in primary hip and knee arthroplasty. *Bone Joint Res* 2020; **9**: 778-788 [PMID: 33135425 DOI: 10.1302/2046-3758.911.BJR-2020-0190.R2]

43 **Liao S**, Yang Z, Li X, Chen J, Liu JG. Effects of different doses of vancomycin powder in total knee and hip arthroplasty on the periprosthetic joint infection rate: a systematic review and meta-analysis. *J Orthop Surg Res* 2022; **17**: 546 [PMID: 36527075 DOI:

10.1186/s13018-022-03445-2]
44 **Martin VT**, Zhang Y, Wang Z, Liu QL, Yu B. A systematic review and meta-analysis comparing intrawound vancomycin powder and povidone iodine lavage in the prevention of periprosthetic joint infection of hip and knee arthroplasties. *J Orthop Sci* 2022 [PMID: 36470703 DOI: 10.1016/j.jos.2022.11.013]
45 **Buchalter DB**, Kirby DJ, Teo GM, Iorio R, Aggarwal VK, Long WJ. Topical Vancomycin Powder and Dilute Povidone-Iodine Lavage Reduce the Rate of Early Periprosthetic Joint Infection After Primary Total Knee Arthroplasty. *J Arthroplasty* 2021; **36**: 286-290.e1 [PMID: 32919848 DOI: 10.1016/j.arth.2020.07.064]
46 **Kim CH**, Kim H, Lee SJ, Yoon JY, Moon JK, Lee S, Yoon PW. The Effect of Povidone-Iodine Lavage in Preventing Infection After Total Hip and Knee Arthroplasties: Systematic Review and Meta-Analysis. *J Arthroplasty* 2020; **35**: 2267-2273 [PMID: 32229147 DOI: 10.1016/j.arth.2020.03.004]
47 **Calkins TE**, Culvern C, Nam D, Gerlinger TL, Levine BR, Sporer SM, Della Valle CJ. Dilute Betadine Lavage Reduces the Risk of Acute Postoperative Periprosthetic Joint Infection in Aseptic Revision Total Knee and Hip Arthroplasty: A Randomized Controlled Trial. *J Arthroplasty* 2020; **35**: 538-543.e1 [PMID: 31575448 DOI: 10.1016/j.arth.2019.09.011]
48 **Muwanis M**, Barimani B, Luo L, Wang CK, Dimentberg R, Albers A. Povidone-iodine irrigation reduces infection after total hip and knee arthroplasty. *Arch Orthop Trauma Surg* 2023; **143**: 2175-2180 [PMID: 35488919 DOI: 10.1007/s00402-022-04451-z]
49 **Shohat N**, Goh GS, Harrer SL, Brown S. Dilute Povidone-Iodine Irrigation Reduces the Rate of Periprosthetic Joint Infection Following Hip and Knee Arthroplasty: An Analysis of 31,331 Cases. *J Arthroplasty* 2022; **37**: 226-231.e1 [PMID: 34742876 DOI: 10.1016/j.arth.2021.10.026]
50 **Winkler C**, Dennison J, Wooldridge A, Larumbe E, Caroom C, Jenkins M, Brindley G. Do local antibiotics reduce periprosthetic joint infections? A retrospective review of 744 cases. *J Clin Orthop Trauma* 2018; **9**: S34-S39 [PMID: 29628696 DOI: 10.1016/j.jcot.2017.08.007]
51 **Crawford DA**, Berend KR, Adams JB, Lombardi AV. Decreased Incidence of Periprosthetic Joint Infection in Total Hip Arthroplasty with Use of Topical Vancomycin. ReconRev. Oct 16, 2018 [DOI: 10.15438/rr.8.1.201]
52 **Assor M**. Noncemented total knee arthroplasty with a local prophylactic anti-infection agent: a prospective series of 135 cases. *Can J Surg* 2010; **53**: 47-50 [PMID: 20100413]
53 **Cohen EM**, Marcaccio S, Goodman AD, Lemme NJ, Limbird R. Efficacy and Cost-effectiveness of Topical Vancomycin Powder in Primary Cementless Total Hip Arthroplasty. *Orthopedics* 2019; **42**: e430-e436 [PMID: 30913295 DOI: 10.3928/01477447-20190321-05]
54 **Oliveira CLT**, Elias FA, Ribacionka ADS, Picado CHF, Garcia FL. DOES TOPICAL USE OF GENTAMICIN REDUCE THE INFECTION RATE IN PRIMARY TOTAL HIP ARTHROPLASTY? *Acta Ortop Bras* 2019; **27**: 197-201 [PMID: 31452619 DOI: 10.1590/1413-785220192704219177]
55 **Berríos-Torres SI**, Umscheid CA, Bratzler DW, Leas B, Stone EC, Kelz RR, Reinke CE, Morgan S, Solomkin JS, Mazuski JE, Dellinger EP, Itani KMF, Berbari EF, Segreti J, Parvizi J, Blanchard J, Allen G, Kluytmans JAJW, Donlan R, Schecter WP; Healthcare Infection Control Practices Advisory Committee. Centers for Disease Control and Prevention Guideline for the Prevention of Surgical Site Infection, 2017. *JAMA Surg* 2017; **152**: 784-791 [PMID: 28467526 DOI: 10.1001/jamasurg.2017.0904]

Published by **Baishideng Publishing Group Inc**
7041 Koll Center Parkway, Suite 160, Pleasanton, CA 94566, USA
Telephone: +1-925-3991568
E-mail: bpgoffice@wjgnet.com
Help Desk: https://www.f6publishing.com/helpdesk
https://www.wjgnet.com