Arthroplasty Today 18 (2022) 107–111

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original Research

The Cost-Effectiveness of Normal-Saline Pulsed Lavage for Infection Prophylaxis in Total Joint Arthroplasty

Trevor Luck, BS [a,*], Peter Zaki, BS [a], Ryan Michels, MD [b], Eric M. Slotkin, DO [b]

[a] *Drexel University College of Medicine, Philadelphia, Pennsylvania*
[b] *Reading Hospital, Orthopaedic Associates of Reading, Wyomissing, Pennsylvania*

A R T I C L E I N F O

Article history:
Received 25 August 2022
Accepted 22 September 2022
Available online xxx

Keywords:
Total joint arthroplasty
Total knee arthroplasty
Total hip arthroplasty
Prosthetic joint infection
Pulsed saline lavage
Pulsed irrigation

A B S T R A C T

Background: Prosthetic joint infection (PJI) is a well-described complication after total joint arthroplasty which imposes a substantial burden of morbidity and mortality on the individual, as well as cost to the health-care system. This study used a break-even analysis to investigate the cost-effectiveness of pulsed saline lavage (PSL) for PJI prophylaxis after a primary total knee arthroplasty (TKA) and total hip arthroplasty (THA).

Methods: An established model was used to calculate the minimum cost-effective absolute risk reduction of PSL for infection prophylaxis after a total joint arthroplasty. Baseline infection rates of TKA and THA and the cost of a revision surgery for PJI were derived from the literature while the cost of PSL implementation was obtained from institutional data.

Results: PSL is cost-effective at an initial infection rate of 1.10%, revision costs of $32,132 for TKA PJI, and a protocol cost of $38.28 if it reduces infection rates by 0.12% or prevents infection in 1 out of 839 patients. PSL is cost-effective at an initial infection rate of 1.63% and a revision cost of $39,713 for THA PJI if it reduces infection rates by 0.10% or prevents infection in 1 out of 1037 patients. The absolute risk reduction needed for economic viability did not change with varying baseline infection rates and did not exceed 0.38% for infection treatment costs as low as $10,000 and remained less than 0.47% even if PSL cost was as high as $150.

Conclusions: The use of PSL is a cost-effective protocol for PJI prophylaxis after TKAs and THAs.

Introduction

Prosthetic joint infection (PJI) is a well-described complication of total joint arthroplasty (TJA) which imposes significant morbidity on the patient and added costs to the health-care system [1–3]. PJI can result in reduced functionality, decreased quality of life, and possible mortality following TJA [4,5]. The standard treatment for PJI varies; however, both single-staged and 2-staged revision operations are widely utilized and accepted and can carry additional costs as much as 6 times that of the original surgery [3,6]. In the context of an aging population where the demand for total hip arthroplasty (THA) and total knee arthroplasty (TKA) is projected to increase by 174% and 673%, respectively, by 2030, the burden of PJI will likely increase [7]. Coupled with the increasing emphasis on value-based care and the implementation of bundled payments [8–10], infection prophylaxis protocols following TJAs have become an increasingly important topic of research [11].

One method for PJI prophylaxis that has been widely adopted is the pulsed lavage of 0.9% saline (PSL) [12]. Compared to the historical use of bulb syringe or gravity lavage, PSL has shown considerable efficacy in reducing surgical site infection rates across multiple surgical subspecialties [13–19]. While the volume used in PSL varies depending on the anatomy of interest and surgeon preference, a few studies suggest 4 liters is optimal for TKA [20,21], but none have specific volume recommendations for PJI.

Despite this growing body of evidence in support of PSL's efficacy, there is a paucity of information on the cost-effectiveness of PSL for PJI prophylaxis following TJA. Therefore, the objective of this study was to perform a break-even analysis of PSL in the prevention of PJI after TKAs and THAs. Specifically, we sought to identify the absolute risk reduction (ARR) of infection rates at which the cost of

* Corresponding author. Drexel University College of Medicine, 613 Sandstone Drive, Wyomissing, PA 19610, USA. Tel.: +1 207 590 8513.
E-mail address: Tg127@drexel.edu

https://doi.org/10.1016/j.artd.2022.09.014

$$S_{total} \times C_t \times IR_i = \left(S_{total} \times C_p\right) + \left(S_{total} \times C_t \times IR_f\right)$$

Solving for IR_f yields:

$$IR_f = \frac{(IR_i \times C_t) - C_p}{C_t}$$

Where: S_{total} = total annual surgeries; C_t = total cost of treating an infection; C_p = cost of pulsed saline lavage; IR_i = initial infection rate; IR_f = break-even infection rate

Adapted from 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(3):472-477.

Figure 1. Economic model used to calculate the break-even infection rate. C_p, cost of pulsed saline lavage; C_t, total cost of treating an infection; IR_f, break-even infection rate; IR_i, initial infection rate; S_{total}, total annual surgeries.[22]

implementing a universal PSL protocol would be redeemed by the cost-savings from reduced PJI rates. We hypothesized that the implementation of PSL would be cost-effective across a wide range of scenarios.

Material and methods

In order to determine the cost-effectiveness of PSL prophylaxis for PJI, we used a break-even economic model originally described by Hatch et al. (Fig. 1) [22]. This equation has been applied in several other studies to determine the cost-effectiveness of various PJI prophylaxis protocols [23–26]. Using the initial infection rate, the total cost of treating an infection, and the cost of the prevention protocol, this model determines the point at which the cost of implementing the infection prevention protocol is equal to the reduction in cost of PJI. These variables can be manipulated as needed for individuals to determine applicability to their practice.

A review of the literature determined the appropriate values of the initial infection rate and cost of treatment, while our institutional purchasing records gave us the cost of implementing the pulsed lavage protocol. The ARR was calculated using the break-even infection rate to show the percentage by which implementation of the prevention protocol needs to reduce PJI to be cost-effective. From the ARR, the number needed to treat was also determined to give the number of patients receiving PSL of which at least 1 case of PJI would need to be prevented for PSL to be cost-effective.

A further review of the literature demonstrated a range of values for baseline infection rates after TJA, which were as high as 2.18% for both TKA and THA and as low as 1.10% and 1.63% for TKA and THA, respectively, [2,27,28]. To be as conservative as possible, we used the lower baseline infection rates in our computation. As for the cost of a single-stage revision, values ranged from $24,200 to $25,692 for TKA [2,3] and from $30,300 to $31,753 for THA [2,3]. In order to provide the best cost-estimate, we used the higher values of these estimates and adjusted them using the consumer price index inflation calculator to current values (as of this study, June 2022) [3,29]. Since 2-stage revision can be even more costly, using the cost of a single-stage revision provided a higher theoretical threshold for PSL to be cost-effective. The cost of PSL was based on our institution's purchasing records of the combined cost of 1 single-use pulsed lavage device and a standard 3-liter bag of irrigation saline ($38.28).

Since the volume of irrigation fluid used and cost of the PSL materials can vary by institution, we conducted a sensitivity analysis across a range of hypothetical costs of the protocol. In addition, we also performed this analysis for variations in the cost of treatment, as well as differences in baseline infection rates to determine the effect of each of these variables on the ARR and NNT for cost-effectiveness. Since this study was noninterventional and did not access protected health information, institutional review board approval was not required.

Results

At a cost of $38.28, an initial infection rate of 1.10% for TKA and 1.63% for THA, and a revision cost of $32,132 for TKA and $39,713 for THA, PSL would be cost-effective at an ARR of 0.12% for TKA and 0.10% for THA (Table 1). To be economically viable under these conditions, the protocol would need to prevent 1 case of PJI

Table 1
Cost-effectiveness of prophylactic 0.9% NaCl pulsed lavage for total joint arthroplasty[a]

0.9% NaCl pulsed lavage cost (USD)	Total knee arthroplasty			Total hip arthroplasty		
	Break-even infection rate (%)	ARR (%)	NNT	Break-even infection rate (%)	ARR (%)	NNT
20.00	1.04	0.06	1607	1.58	0.05	1986
30.00	1.01	0.09	1071	1.55	0.08	1324
38.28[b]	0.98	0.12	839	1.53	0.10	1037
40.00	0.98	0.12	803	1.53	0.10	993
50.00	0.94	0.16	643	1.50	0.13	794
75.00	0.87	0.23	428	1.44	0.19	530
100.00	0.79	0.31	321	1.38	0.25	397
125.00	0.71	0.39	257	1.32	0.31	318
150.00	0.63	0.47	214	1.25	0.38	265

USD, US dollars; NNT, 1/ARR.
[a] Assumes a baseline infection rate of 1.10% for TKA and 1.63% for THA and treatment costs of $32,132 for TKA and $39,713 for THA infection (adjusted for inflation from 2015 estimates).
[b] Actual cost at our institution.

Table 2
Break-even analysis of prophylactic 0.9% NaCl pulsed lavage in preventing prosthetic joint infection at different initial infection rates[a]

Initial infection rate (%)	Total knee arthroplasty			Total hip arthroplasty		
	Break-even infection rate (%)	ARR (%)	NNT	Break-even infection rate (%)	ARR (%)	NNT
0.50	0.38	0.12	839	0.40	0.10	1037
1.00	0.88	0.12	839	0.90	0.10	1037
2.00	1.88	0.12	839	1.90	0.10	1037
3.00	2.88	0.12	839	2.90	0.10	1037
4.00	3.88	0.12	839	3.90	0.10	1037
5.00	4.88	0.12	839	4.90	0.10	1037
6.00	5.88	0.12	839	5.90	0.10	1037
7.00	6.88	0.12	839	6.90	0.10	1037
8.00	7.88	0.12	839	7.90	0.10	1037
9.00	8.88	0.12	839	8.90	0.10	1037
10.00	9.88	0.12	839	9.90	0.10	1037

USD, US dollars; NNT, 1/ARR.
[a] Assumes a baseline infection rate of 1.10% for TKA and 1.63% for THA and PSL cost of $38.28 and treatment costs of $32,132 for TKA and $39,713 for THA infection (adjusted for inflation from 2015).

requiring revision of the 839 patients undergoing TKA and 1037 patients undergoing THA (Table 1). At the hypothetical most inexpensive cost of $20.00, to be cost-effective, the ARR would be 0.06% and 0.05% with a NNT of 1607 and 1986 for TKA and THA, respectively, (Table 1). At hypothetical upper limit of $150.00 for implementing PSL, the ARR required for cost-effectiveness would be 0.47% and 0.38% with NNTs of 214 and 265 for TKA and THA, respectively, (Table 1).

To determine the effect of varying baseline infection rates on the model, Table 2 shows the results of the model at a fixed protocol cost of $38.28 and costs of revision of $32,132 for TKA and $39,713 for THA. These computations demonstrated that the initial infection rate has no effect on the break-even ARR or NNT, even when the initial infection rate is as high as 10%. At all possible initial infection rate values, the ARR and NNT remained 0.12% and 839, respectively, for TKA and 0.10% and 1037, respectively, for THA (Table 2).

To assess the extent of the effect varying costs of PJI requiring revision have on the cost-effectiveness of implementing PSL, Table 3 demonstrates the results of the model at a fixed protocol cost of $38.28 and fixed initial infection rate of 1.10% for TKA and 1.63% for THA. At a hypothetical lowest cost of $10,000, the ARR for both TKA and THA would need to be 0.38% with a NNT of 261. At a hypothetical upper cost of $400,000 for infections requiring revision, the ARR would be 0.01% for both TKA and THA, and PSL would need to prevent only 1 infection in 10,449 patients undergoing TJA (Table 3).

Discussion

There is an increasingly salient emphasis on cost minimization in the world of arthroplasty [8–10]. PJI remains one of the costliest complications of TJA, and concerted efforts must be made to minimize its occurrence [30,31]. There has been much innovation in the PJI prophylaxis space, including protocols such as the use of antiseptic solutions and dressings, dissolvable antimicrobial beads, and even antimicrobial cement [32].

PSL has been demonstrated to be a safe and effective protocol, with some studies suggesting that it is superior to standard bulb syringe or gravity lavage not only in tissue and implant penetration but also in infection prevention [12,33–35]. Within orthopedics, several studies have demonstrated the efficacy of PSL. In a prospective randomized trial on hip hemiarthroplasty for femoral neck fractures, a 2-liter PSL had a total infection rate of 5.5% compared to 15.6% for a 2-liter normal-saline gravity or bulb syringe lavage ($P = .002$) [15]. Additionally, in 2 studies on spinal fusion surgeries, the infection rate of PSL vs bulb syringe lavage was 1.6% compared to 10.1% ($P = .046$) and 2.5% compared to 20% ($P < .001$) [13,14]. While efficacy data on the true ARR of PSL are sparse, what is available in the literature suggests that PSL is at least noninferior if not superior to historical lavage methods.

Although the cost-effectiveness of several PJI prophylaxis protocols have been investigated, a break-even analysis of PSL has not yet been reported [22–26]. Therefore, this study is the first to outline the wide-ranged cost-effectiveness of PSL for infection

Table 3
Break-even analysis of prophylactic 0.9% NaCl pulsed lavage in preventing prosthetic joint infection at different costs of treating infection[a]

Cost of treating infection (USD)	Total knee arthroplasty			Total hip arthroplasty		
	Break-even infection rate (%)	ARR (%)	NNT	Break-even infection rate (%)	ARR (%)	NNT
10,000.00	0.72	0.38	261	1.25	0.38	261
15,000.00	0.84	0.26	392	1.37	0.26	392
20,000.00	0.91	0.19	522	1.44	0.19	522
25,000.00	0.95	0.15	653	1.48	0.15	653
32,132.00[a]	0.98	0.12	839	1.51	0.12	839
39,713.00[a]	1.00	0.10	1037	1.53	0.10	1037
40,000.00	1.00	0.10	1045	1.53	0.10	1045
50,000.00	1.02	0.08	1306	1.55	0.08	1306
75,000.00	1.05	0.05	1959	1.58	0.05	1959
100,000.00	1.06	0.04	2612	1.59	0.04	2612
400,000.00	1.09	0.01	10,449	1.62	0.01	10,449

USD, US dollars; NNT, 1/ARR.
[a] Assumes a baseline infection rate of 1.10% for TKA and 1.63% for THA and PSL cost of $38.28 and treatment costs of $32,132 for TKA and $39,713 for THA infection (adjusted for inflation from 2015).

prophylaxis following TJA. We show that PSL may be cost-effective in PJI prophylaxis for TJA across a broad range of implementation costs, PJI baseline rates, and PJI costs. This study reveals a low ARR threshold for which implementation of PSL may be economically feasible. While there is no study reporting the estimated ARR for TJA, the aforementioned studies provide a general ARR range of 8.5%-17.5% for orthopedics. Even if the true ARR of PSL in TJA was as low as one-tenth of the lower end of this estimate, it would still be cost-effective by the thresholds of our study. Since trials on infection rates following TJAs are highly cost-prohibitive due to the need for a very large sample size, we believe this study is especially helpful because it provides a framework for physicians and hospitals to calculate the break-even point for the use of PSL.

There are several limitations to this study. There are limited data on the efficacy of PSL despite it being a widely used method in orthopedics for not only infection prophylaxis but also acute treatment. There is also no consensus on the optimal irrigation solution for PJI management [36]. While the true efficacy of PSL vs other irrigation methods and solutions is uncertain, we believe that the merit of this study lies in our finding that it has an extremely low threshold for cost-efficacy. Individual centers and surgeons may use the methods and ARRs outlined here as a benchmark for which to perform their own cost analysis based on their local infection rate data.

Moreover, the PJI infection rates and cost estimations are based on literature review and may vary between institutions. While modeling is useful for averages, it does not consider outlier cases or complex patients with multiple medical comorbidities that have a higher individualized risk of complications and associated costs. In addition, computation of the true cost of implementing infection prophylaxis protocols is a complicated process that would include not only material cost but also costs such as additional operation time and staffing costs which are difficult to represent in a simple economic model. Nonetheless, we believe this model still provides a valuable method of rapidly assessing the cost-effectiveness of adding PSL to a TJA pathway. Much of this variability in cost may come from the volume of saline used, which only accounts for about one-third of the cost of the protocol. Even if twice the amount of saline were used (bringing the cost to about $50), the required ARR would not be significantly affected, and this larger volume (6 liters) would exceed that mentioned in the few studies in the literature [20,21].

In addition, we recognize that our infection rate data are based on national estimates, which can vary depending on patient populations. However, we used a conservative approach in our estimates which may underestimate rates in real-world practice. Furthermore, we demonstrated that initial infection rates do not alter the necessary ARR for cost-effectiveness.

As for the cost of treating infection, we recognize that these estimates are of total hospital costs and cannot delineate the multitude of variations that can occur between 2 different hospital stays, nor the additional cost of noncovered charges, future operations and complications, readmissions, and follow-up visits. As a result, the values we used may in fact underestimate the true cost of PJI. Since we have demonstrated cost-effectiveness at such a low-cost threshold, implementing PSL may in fact be more economically viable than this study predicts.

Conclusions

This break-even analysis demonstrates that PSL is widely cost-effective in the prevention of PJI after TJAs. At our institutional cost of $38.28, PSL would be cost-effective if the difference from baseline infection rate has an ARR of 0.12% for TKA and 0.10% for THA, making it economically justified if it prevents infection in just 1 out of 839 and 1037 cases, respectively. The cost-effectiveness remains similar across a broad range of initial infection rates as well as a range of costs for both the protocol and infection treatment. Notably, the required ARR does not change with variations in the initial infection rate, nor does it vary widely with costs associated with infection. Even with realistic variations in the volume of saline used, the required ARR for cost-effectiveness was not widely altered. This model may be tailored by physicians and hospitals seeking to determine the unique break-even points for infection prophylaxis protocols. While future studies will need to determine the true ARR of PSL following TJAs, this study demonstrates that PSL has a low threshold to break even.

Conflicts of interest

Dr. R. Michels is a paid speaker and a paid consultant for SI-BONE pelvic trauma implants. E. M. Slotkin receives royalties from Corin; is in the speakers' bureau of or gave paid presentations for Corin, Naviswiss, Ortho Development, DePuy, and Phillips; is a paid consultant for Corin, Naviswiss, Ortho Development, DePuy, and Phillips; and has stock or stock options in Corin, Naviswiss, ROMTech, Efferent Health, and Radlink. The other 2 authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2022.09.014.

References

[1] Ong KL, Kurtz SM, Lau E, Bozic KJ, Berry DJ, Parvizi J. Prosthetic joint infection risk after total hip arthroplasty in the medicare population. J Arthroplasty 2009;24(Supplement):105–9.
[2] Kurtz SM, Lau E, Watson H, Schmier JK, Parvizi J. Economic burden of periprosthetic joint infection in the United States. J Arthroplasty 2012;27:61–65.e1.
[3] Kamath AF, Ong KL, Lau E, Chan V, Vail TP, Rubash HE, et al. Quantifying the burden of revision total joint arthroplasty for periprosthetic infection. J Arthroplasty 2015;30:1492–7.
[4] Lum ZC, Natsuhara KM, Shelton TJ, Giordani M, Pereira GC, Meehan JP. Mortality during total knee periprosthetic joint infection. J Arthroplasty 2018;33:3783–8.
[5] Cahill J, Shadbolt B, Scarvell J, Smith P. Quality of life after infection in total joint replacement. J Orthopaedic Surg 2008;16:58–65.
[6] Klouche S, Sariali E, Mamoudy P. Total hip arthroplasty revision due to infection: a cost analysis approach. Orthopaedics Traumatol Surg Res 2010;96:124–32.
[7] 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. JBJS 2007;89:780–5.
[8] Whitcomb WF, Lagu T, Krushell RJ, Lehman AP, Greenbaum J, McGirr J, et al. Experience with designing and implementing a bundled payment program for total hip replacement. Joint Comm J Qual Patient Saf 2015;41:406–13.
[9] Elbuluk AM, O'Neill OR. Private bundles: the nuances of contracting and managing total joint arthroplasty episodes. J Arthroplasty 2017;32:1720–2.
[10] Siddiqi A, White PB, Mistry JB, Gwam CU, Nace J, Mont MA, et al. Effect of bundled payments and health care reform as alternative payment models in total joint arthroplasty: a clinical review. J Arthroplasty 2017;32:2590–7.
[11] Ratto N, Arrigoni C, Rosso F, Bruzzone M, Dettoni F, Bonasia DE, et al. Total knee arthroplasty and infection: how surgeons can reduce the risks. EFORT Open Rev 2016;1:339–44.
[12] Bath MF, Suresh R, Davies J, Machesney MR. Does pulsed lavage reduce the risk of surgical site infection? A systematic review and meta-analysis. J Hosp Infect 2021;118:32–9.
[13] Ahn DK, Lee S, Moon SH, Kim DG, Hong SW, Shin WS. Bulb syringe and pulsed irrigation: which is more effective to remove bacteria in spine surgeries? Clin Spine Surg 2016;29:34–7.
[14] Fei J, Gu J. Comparison of lavage techniques for preventing incision infection following posterior lumbar interbody fusion. Med Sci Monit 2017;23:3010–8.
[15] Hargrove R, Ridgeway S, Russell R, Norris M, Packham I, Levy B. Does pulse lavage reduce hip hemiarthroplasty infection rates? J Hosp Infect 2006;62:446–9.
[16] Bath MF, Powell J, Ismail I, Machesney MR. Use of pulsed lavage reduces the rate of surgical site infection after laparotomy. J Surg Res 2021;266:300–5.
[17] Nikfarjam M, Weinberg L, Fink MA, et al. Pressurized pulse irrigation with saline reduces surgical-site infections following major hepatobiliary and pancreatic surgery: randomized controlled trial. World J Surg 2014;38:447–55.

[18] Nikfarjam M, Kimchi ET, Gusani NJ, Avella DM, Shereef S, Staveley-O'Carroll KF. Reduction of surgical site infections by use of pulsatile lavage irrigation after prolonged intra-abdominal surgical procedures. Am J Surg 2009;198:381–6.
[19] Dineen SP, Pham TH, Murray BW, Parker BJ, Hartless K, Anthony T, et al. Feasibility of subcutaneous gentamicin and pressurized irrigation as adjuvant strategies to reduce surgical site infection in colorectal surgery: results of a pilot study. Am Surg 2015;81:573–9.
[20] Weng WJ, Zhang HL, Hua W, Qiu XS, Xu ZH. [Study on how much sterile saline should be used for efficient lavage during total knee arthroplasty]. Zhongguo Gu Shang 2009;22:421–2.
[21] Niki Y, Matsumoto H, Otani T, Tomatsu T, Toyama Y. How much sterile saline should be used for efficient lavage during total knee arthroplasty? Effects of pulse lavage irrigation on removal of bone and cement debris. J Arthroplasty 2007;22:95–9.
[22] 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.
[23] Lipson S, Pagani NR, Moverman MA, Puzzitiello RN, Menendez ME, Smith EL. The cost-effectiveness of extended oral antibiotic prophylaxis for infection prevention after total joint arthroplasty in high-risk patients. J Arthroplasty 2022;37:1961–6.
[24] Kerbel YE, Sunkerneni AR, Kirchner GJ, Prodromo JP, Moretti VM. The cost-effectiveness of preoperative Staphylococcus aureus screening and decolonization in total joint arthroplasty. J Arthroplasty 2018;33:S191–5.
[25] Toppo AJ, Pagani NR, Moverman MA, Puzzitiello RN, Menendez ME, Kavolus JJ. The cost-effectiveness of silver-impregnated occlusive dressings for infection prevention after total joint arthroplasty. J Arthroplasty 2021;36:1753–7.
[26] Kerbel YE, Kirchner GJ, Sunkerneni AR, Lieber AM, Moretti VM. The cost effectiveness of dilute betadine lavage for infection prophylaxis in total joint arthroplasty. J Arthroplasty 2019;34:S307–11.
[27] Pulido L, Ghanem E, Joshi A, Purtill JJ, Parvizi J. Periprosthetic joint infection: the incidence, timing, and predisposing factors. Clin Orthopaedics Relat Research® 2008;466:1710–5.
[28] Kurtz SM, Ong KL, Lau E, Bozic KJ, Berry D, Parvizi J. Prosthetic joint infection risk after TKA in the medicare population. Clin Orthopaedics Relat Research® 2010;468:52–6.
[29] CPI Inflation Calculator. Washington, DC: U.S. Bureau of Labor Statistics.
[30] Courville XF, Tomek IM, Kirkland KB, Birhle M, Kantor SR, Finlayson SRG. Cost-effectiveness of preoperative nasal mupirocin treatment in preventing surgical site infection in patients undergoing total hip and knee arthroplasty: a cost-effectiveness analysis. Infect Control Hosp Epidemiol 2012;33:152–9.
[31] Stambough JB, Nam D, Warren DK, Keeney JA, Clohisy JC, Barrack RL, et al. Decreased hospital costs and surgical site infection incidence with a universal decolonization protocol in primary total joint arthroplasty. J Arthroplasty 2017;32:728–734.e1.
[32] Suleiman LI, Mesko DR, Nam D. Intraoperative considerations for treatment/prevention of prosthetic joint infection. Curr Rev Musculoskelet Med 2018;11:401–8.
[33] Maistrelli GL, Antonelli L, Fornasier V, Mahomed N. Cement penetration with pulsed lavage versus syringe irrigation in total knee arthroplasty. Clin Orthop Relat Res 1995;312:261–5.
[34] Budnar VM, Amirfeyz R, Ng M, Bannister GC, Blom AW. Primary total knee replacement: is suction a portal of infection? Ann R Coll Surg Engl 2009;91:224–5.
[35] Breusch SJ, Norman TL, Schneider U, Reitzel T, Blaha JD, Lukoschek M. Lavage technique in total hip arthroplasty: jet lavage produces better cement penetration than syringe lavage in the proximal femur. J Arthroplasty 2000;15:921–7.
[36] Siddiqi A, Abdo ZE, Rossman SR, Kelly MA, Piuzzi NS, Higuera CA, et al. What is the optimal irrigation solution in the management of periprosthetic hip and knee joint infections? J Arthroplasty 2021;36:3570–83.