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Local administration of vancomycin powder in orthopaedic fracture surgery: current practice and trends

Lucas S. Marchand, MD[a,*], Sheila Sprague, PhD[b,c], Nathan N. O'Hara, PhD[d], Chuan Silvia Li, MSc[b], Robert V. O'Toole, MD[d], Manjari Joshi, MBBS[e], Darius Viskontas, MD, FRCSC[f], Nicholas Romeo, DO[g], Robert A. Hymes, MD[h], William T. Obremskey, MD[i], Thomas F. Higgins, MD[a], Gorden D. Potter, MD[j], Patrick F. Bergin, MD[k], Mark Gage, MD[l], Joshua L. Gary, MD[m], Mohit Bhandari, MD, PhD, FRCSC[b,c], Gerard P. Slobogean, MD[d], PREP-IT Investigators

Abstract

Objectives: Surgical site infections in orthopaedic trauma are a significant problem with meaningful patient and health care system–level consequences. Direct application of antibiotics to the surgical field has many potential benefits in reducing surgical site infections. However, to date, the data regarding the local administration of antibiotics have been mixed. This study reports on the variability of prophylactic vancomycin powder use in orthopaedic trauma cases across 28 centers.

Methods: Intrawound topical antibiotic powder use was prospectively collected within three multicenter fracture fixation trials. Fracture location, Gustilo classification, recruiting center, and surgeon information were collected. Differences in practice patterns across recruiting center and injury characteristics were tested using chi-square statistic and logistic regression. Additional stratified analyses by recruiting center and individual surgeon were performed.

Results: A total of 4941 fractures were treated, and vancomycin powder was used in 1547 patients (31%) overall. Local administration of vancomycin powder was more frequent in open fractures 38.8% (738/1901) compared with closed fractures 26.6% (809/3040) ($P < 0.001$). However, the severity of the open fracture type did not affect the rate at which vancomycin powder was used ($P = 0.11$). Vancomycin powder use varied substantially across the clinical sites ($P < 0.001$). At the surgeon level, 75.0% used vancomycin powder in less than one-quarter of their cases.

Conclusions: Prophylactic intrawound vancomycin powder remains controversial with varied support throughout the literature. This study demonstrates wide variability in its use across institutions, fracture types, and surgeons. This study highlights the opportunity for increased practice standardization for infection prophylaxis interventions.

Level of Evidence: Prognostic—III.

Keywords: antibiotics, orthopaedic fracture surgery, surgical site infections, vancomycin powder

[a] Department of Orthopaedic Surgery, University of Utah, Salt Lake City, UT, [b] Department of Surgery, McMaster University, Hamilton, ON, Canada, [c] Department of Health Research Methods, Evidence, and Impact, Hamilton, McMaster University, ON, Canada, [d] Department of Orthopaedics, R Adams Cowley Shock Trauma Center, University of Maryland School of Medicine, Baltimore, MD, [e] Department of Infectious Disease, R Adams Cowley Shock Trauma Center, Baltimore, MD, [f] Royal Columbian Hospital, New Westminster, BC, Canada, [g] MetroHealth, Cleveland, OH, [h] Inova Fairfax Medical Centre, Falls Church, VA, [i] Vanderbilt University Medical Center, Nashville, TN, [j] Sanford Health, Sioux Falls, SD, [k] University of Mississippi Medical Center, Jackson, MS, [l] Duke University, Durham, NC, and [m] McGovern Medical School at UTHealth, Houston, TX.

**Corresponding author. Address: Lucas S. Marchand, MD, Department of Orthopaedic Surgery, University of Utah, 590 Wakara Way, Salt Lake City, UT 84108. E-mail address: lucas.marchand@hsc.utah.edu.*

PREP-IT Investigators are listed in Appendix 1.

The PREP-IT trials are registered at ClinicalTrials.gov (Aqueous-PREP: NCT03385304; PREPARE: NCT03523962).

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1. Introduction

Surgical site infections (SSIs) in orthopaedic trauma are a significant problem that can have devastating consequences for patients and result in substantial costs to the health care system.[1,2] Intravenous (IV) antibiotics have been demonstrated to be beneficial regarding infection prevention in orthopaedic trauma surgery.[3,4] However, systemic administration of antibiotics may not be the best route of administration because concentration must be limited to avoid systemic toxicity. Therefore, local antibiotic application has gained traction in recent years because of several potential advantages over systemic antibiotic administration.

Direct antibiotic application to the surgical field enables the delivery of higher antibiotic concentrations.[5] This route may ensure that the minimum inhibitory concentration for pathogens is surpassed, increasing infection prevention efficacy.[5] Soft tissue injury secondary to both direct trauma and iatrogenic surgical injury may also limit the amount of IV antibiotics directly available at the surgical site, another problem circumvented by local antibiotic application.

Multiple studies have described the use of vancomycin powder to reduce SSIs. A bulk of this work has been accomplished in the area of spine surgery with data suggesting questionable efficacy of local antibiotic administration.[5–18] Recently, the utility of local administration of vancomycin powder use in patients with fracture was investigated.[19] Specifically, a multicenter, randomized controlled trial compared local antibiotics therapy with vancomycin powder versus no powder to prevent SSIs in patients with high-risk tibia fractures (VANCO Trial).[20] The results of this trial found that locally administered vancomycin powder reduced gram-positive SSIs by 50% (relative risk: 0.49, 95% confidence interval [CI], 0.27–0.88, $P = 0.02$).[20]

The routine local administration of vancomycin powder in orthopaedic surgery remains in question given that investigations have demonstrated both benefit and no benefit to local antibiotic use. While surgeons are motivated to lower SSI rates among patients with fracture, many surgeons may be hesitant to use local antibiotic powder because of antibiotic resistance concerns, the possibility of nephrotoxicity, or the lack of clear data to suggest a benefit of this practice. No previous work has described the rate at which antibiotic powder is being used in fracture surgery across multiple institutions. This study aimed to characterize the variability of vancomycin powder use in patients with fracture across 28 level-1 trauma centers. Specifically, we sought to determine whether there is variability in vancomycin powder use across different injury patterns, hospitals, and individual surgeons. We hypothesized that more severe soft tissue injuries and periarticular surgeries would be associated with increased use of locally administered vancomycin powder. Similarly, we hypothesized that there would be substantial variability in practice patterns between hospitals and surgeons.

2. Methods

2.1. Study Design

We performed a secondary analysis of data collected as part of the Program of Randomized Trials to Evaluate Pre-operative antiseptic skin solutions in orthopaedic Trauma (PREP-IT) over a 1.5-year study period (2018–2020). This program has been previously described in detail.[21] In brief, PREP-IT includes two separate ongoing multicenter cluster crossover randomized trials from which data were obtained. The trials include the Aqueous-PREP trial (A Pragmatic Randomized trial Evaluating Pre-operative aqueous antiseptic skin solutions in open fractures) and the PREPARE Trial trial (A Pragmatic Randomized trial Evaluting Pre-operative Alcohol skin solutions in FRactured Extremities). The overall objective of these trials is to compare the effectiveness of iodophor and chlorhexidine antiseptic skin preparation solutions for the prevention of SSI after extremity fracture surgery. The PREP-IT trials are registered at ClinicalTrials.gov (Aqueous-PREP: NCT 03385304; PREPARE: NCT03523962). Ethics approval has been obtained from the Hamilton Integrated Research Ethics Board (REB) (Aqueous-PREP: 4336; PREPARE: 4913 for the Methods Centre, the Advarra Central Institutional Review Board (IRB) (PREPARE: Pro00028360; Aqueous-PREP: Pro00023709), and each clinical site's local IRB/REB, for centers not using the central IRB.

2.2. Study Participants

Patients were included in PREP-IT if they were aged 18 years or older, had an open or closed fracture meeting the PREP-IT

Dr. Sprague reports editorial or governing board for BMC Women's Health, employment from Global Research Solutions Inc., and employment from McMaster University, all outside the submitted work. Dr. O'Hara reports stock or stock options from Arbutus Medical Inc. and editorial or governing board for Pilot and Feasibility Studies, all outside the submitted work. Dr. O Toole reports stock or stock options and paid consultant for Imagen, IP royalties from Lincotek (formerly Coorstek), paid consultant for Stryker, and paid presenter or speaker for Zimmer, all outside the submitted work. Dr. Joshi reports editorial or governing board for IDCP, all outside the submitted work. Dr. Viskontas reports stock or stock options and unpaid consultant for Precision OS, all outside the submitted work. Dr. Hymes reports paid consultant and research support for Stryker and research support from Synthes, all outside the submitted work. Dr. Obremskey reports editorial or governing board for Journal of Bone and Joint Surgery American, editorial or governing board for Journal of Orthopaedic Trauma, editorial or governing board for Journal of the American Academy of Orthopaedic Surgeons, and board or committee member for Southeastern Fracture Consortium, all outside the submitted work. Dr. Higgins reports paid consultant for DePuy Synthes, IP royalties from DePuy, A Johnson & Johnson Company, paid consultant for Globus Medical, stock or stock options from Imagen, stock or stock options from NT nPhase, stock or stock options from Orthogrid, board or committee member for Orthopaedic Trauma Association, and paid consultant and stock or stock options from Osteocentric, all outside the submitted work. Dr. Bergin reports board or committee member for Orthopaedic Trauma Association and paid consultant for Synthes, all outside the submitted work. Dr. Gage reports research support from AO, IP royalties, paid consultant, and research support from Arthrex, Inc, publishing royalties, financial or material support from Elsevier, research support from Foundation for Orthopaedic Trauma, paid consultant for Metalogix, paid consultant for Restor3D, paid consultant for TrackX, all outside the submitted work. Dr. Gary reports board or committee member and research support for AO North America, editorial or governing board for Journal of Bone and Joint Surgery American, editorial or governing board for Journal of the American Academy of Orthopaedic Surgeons, board or committee member for Orthopaedic Trauma Association, paid presenter or speaker for Smith & Nephew, paid presenter or speaker for Stryker, stock or stock options from Summitt Medventures, paid presenter or speaker for Synthes, editorial or governing board for Wolters Kluwer Health - Lippincott Williams & Wilkins, all outside the submitted work. Dr. Bhandari reports paid consultant for AgNovos Healthcare, research support for Canadian Institutes of Health Research (CIHR), board or committee member for International Society of Orthopaedic Surgery and Traumatology (SICOT), research support for National Institutes of Health (NIAMS & NICHD), research support for Physicians' Services Incorporated, paid consultant for Sanofi-Aventis, paid consultant for Smith & Nephew, research support for U.S. Department of Defense, all outside the submitted work. Dr. Slobogean reports editorial or governing board for Journal of Orthopaedic Trauma, board or committee member for Orthopaedic Trauma Association, paid consultant for Smith & Nephew, paid consultant for Zimmer, all outside the submitted work. All other authors have nothing to report.

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eligibility criteria, received definitive fracture treatment with a surgical implant, and provided informed consent. Patients were excluded if they had a medical contraindication to the antiseptic solution, received previous surgical intervention or debridement at a nonparticipating hospital, had a chronic or acute infection at the fracture site, had burns at the fracture site, were incarcerated, had expected survival less than 90 days, or were unable to provide informed consent.

All patients were included in the PREP-IT trials only after written informed consent was obtained. All potential participants for the study received the current antiseptic solution being used at the cluster. Local administration of vancomycin was performed at the discretion of treating surgeons and prospectively recorded as per the trial protocols.

2.3. Data Collection

Research personnel at each of the 28 participating clinical sites documented each participant's fracture and surgical details in the PREP-IT electronic data capture system. Data relevant to the current analysis included fracture type (open vs closed), Gustilo classification,[22] Tscherne classification,[23] fracture location, surgical date, operating surgeon, and whether or not vancomycin powder was placed in the surgical wound at the time of fracture management surgery.

2.4. Vancomycin Use Patient Population

All participants included in PREP-IT as of March 2020 with complete baseline, fracture, and surgical data were included in the current analysis. If patients had multiple fractures, only one fracture was included in the analysis based on the first fracture treated.

2.5. Statistical Analysis

Participant demographics and fracture characteristics were described using descriptive statistics. Means with standard deviations were reported for continuous data with normal distributions, whereas counts (n) and percentages (%) were presented for categorical data.

We reported vancomycin powder use at the surgical site by the type of fracture (open vs closed fractures), fracture severity (Gustilo Grade and Tscherne Grade), and fracture location. To account for perceived variability of infectious risk based on injury pattern, tibia fracture was subcategorized into high-risk (periarticular plafond and plateau fractures) and low-risk (diaphyseal fractures) injuries. The local administration of vancomycin powder was also stratified by clinical site, participation in the previous VANCO Trial, and individual surgeon. Descriptive statistics were used to report vancomycin powder use as counts (n) and percentages (%). Chi-square tests were used to determine whether there were differences in the local administration of vancomycin powder in the following: (1) open fractures versus closed fractures, (2) in high-risk vs low-risk tibial fracture patterns, and (3) in cases from sites that participated in the VANCO Trial versus those from sites not participating in the VANCO Trial. All tests were two-tailed with alpha = 0.05. Logistic regression models were used to determine differences in the local administration of vancomycin powder and Gustilo Grade, Tscherne Grade, and clinical sites. Odds ratios, 95% CIs, and associated *P*-values were reported. We did not adjust the alpha for multiple testing given the exploratory nature of the study objectives. All analyses were performed using R (version 3.6.1, R Foundation for Statistical Computing, Vienna, Austria).

2.6. Sources of Funding

The PREPARE trial is funded by the Patient-Centered Outcomes Research Institute (PCS-1609-36512) and the Canadian Institutes of Health Research (Foundation Grant); the PREP-IT trial is funded by the US Department of Defense (W81XWH-17-1-070) and the Canadian Institutes of Health Research (Foundation Grant). Canadian Institues of Health Research funded start-up activities at the Methods Center, and Physicians' Services Incorporated provided funding to the Methods Center and PREPARE for the PREP-IT trial.

3. Results

Prospective data were collected from 4941 fracture patients across 28 trauma centers from 448 different surgeons. Of the included patients, 3040 sustained closed fractures and 1901 had open fractures. Patient characteristics are summarized in Table 1.

Vancomycin powder was placed in 31.3% of surgical wounds (1547/4941). It was used more frequently in open fracture cases (738/1901, 38.8%) compared with closed fractures (809/3,040, 26.6%) ($P < 0.001$).

Increasing Gustilo grade did not seem to be associated with an increase in the rate of local administration of vancomycin powder at the fracture site ($P = 0.11$). The use of vancomycin powder in Gustilo Type I/II, IIIa, IIIb, and IIIc was 399/1046 (38.1%), 283/685 (41.3%), 36/111 (32.4%), and 17/33 (51.5%), respectively (Table 2). Conversely, a higher Tscherne grade (2 and 3) for closed fractures was associated with an increased odds of vancomycin powder use (odds ratio 1.70, 95% CI 1.16–2.49; $P = 0.01$).

The local administration of vancomycin powder also differed between high-risk and low-risk tibial fracture patterns (Table 3). It was used in 46.6% (157/337) of open tibial periarticular injuries (plateau/plafond) compared with 34.3% (186/542) of open tibial shaft fractures ($P < 0.001$). Similarly, in closed periarticular fractures of the tibia, it was used in 30.9% (161/521) of fractures compared with 25.6% (139/542) in closed tibial shaft fractures ($P = 0.057$).

There were a total of 2230 fractures that involved the tibia and fibula included in the analysis and seen in Supplemental Digital Content 1 (http://links.lww.com/OTAI/A59). There was a difference in the rate of antibiotic usage for open and closed fractures. Antibiotic powder was placed in 38.2% (362/948) of open fractures and 27.4% (351/1282) of closed fractures in this location.

In both open and closed fractures, the pelvis was the most likely fracture location to receive antibiotic powder with open injuries receiving antibiotics 88.9% (8/9) of the time and closed injuries 39.7% (123/310) (Supplemental Digital Content 1, http://links.lww.com/OTAI/A59).

There was significant variation in the frequency of local administration of vancomycin powder between hospitals. For example, within the two highest enrolling centers, one site used vancomycin powder in 79.2% of cases while the second site used it in 1.2% of cases ($P < 0.001$) (Supplemental Digital Content 2, http://links.lww.com/OTAI/A60). There was also a difference in vancomycin powder use among hospitals that did and did not participate in the VANCO Trial (Table 4). For those sites that

TABLE 1

Participant Demographics and Fracture Characteristics

Characteristic	Open Fractures (N = 1901)	Closed Fractures (N = 3040)	Overall (N = 4941)
Age, mean (standard deviation)	46 (18)	55 (22)	52 (20)
Sex, n (%)			
Female	726 (38.2)	1585 (52.1)	2311 (46.8)
Male	1173 (61.7)	1447 (47.6)	2620 (53)
Prefer not to say	1 (0.1)	1 (0.0)	2 (0.0)
Ethnicity, n (%)			
White/Caucasian	1421 (74.8)	2348 (77.2)	3769 (76.3)
Black/African American/Caribbean	371 (19.5)	479 (15.8)	850 (17.2)
Asian/Middle Eastern/South Asian/East Asian	38 (2.0)	107 (3.5)	145 (2.9)
American Indian or Alaska Native	17 (0.9)	17 (0.6)	34 (0.7)
Native/Aboriginal/Native Hawaiian/Other Pacific Islander	4 (0.2)	16 (0.5)	20 (0.4)
Other	36 (1.9)	48 (1.6)	84 (1.7)
Prefer not to say	13 (0.7)	17 (0.6)	30 (0.6)
ASA classification, n (%)			
Class I	176 (9.3)	295 (9.7)	471 (9.5)
Class II	802 (42.2)	1244 (40.9)	2046 (41.4)
Class III	717 (37.7)	1252 (41.2)	1969 (39.9)
Class IV	174 (9.2)	216 (7.1)	390 (7.9)
Class V	18 (0.9)	4 (0.1)	22 (0.4)
Mechanism of injury, n (%)			
MVA	1047 (55.1)	891 (29.3)	1938 (39.2)
Fall	504 (26.5)	1864 (61.3)	2368 (47.9)
Other	348 (18.3)	282 (9.3)	630 (12.8)
Primary fracture location, n (%)			
Shoulder	22 (1.2)	NA	22 (0.4)
Arm	127 (6.7)	NA	127 (2.6)
Elbow	79 (4.2)	NA	79 (1.6)
Forearm and wrist, n (%)	260 (13.7)	NA	260 (5.3)
Hand	21 (1.1)	NA	21 (0.4)
Pelvis	9 (0.5)	310 (10.2)	319 (6.5)
Hip	4 (0.2)	735 (24.2)	739 (15)
Femur	257 (13.5)	495 (16.3)	752 (15.2)
Knee	38 (2)	74 (2.4)	112 (2.3)
Tibia and fibula	948 (49.9)	1282 (42.2)	2230 (45.1)
Hind and mid foot	69 (3.6)	107 (3.5)	176 (3.6)
Fore foot	56 (2.9)	32 (1.1)	88 (1.8)
Other lower extremity	9 (0.5)	1 (0)	10 (0.2)
Missing	2 (0.1)	4 (0.1)	6 (0.0)
Method of definitive fixation, n (%)	**N = 1889**	**N = 3040**	**N = 4929**
Internal fixation	1747 (92.5)	2759 (90.8)	4506 (91.4)
Hemi arthroplasty	2 (0.1)	171 (5.6)	173 (3.5)
Total joint replacement	2 (0.1)	55 (1.8)	57 (1.2)
External fixation	42 (2.2)	11 (0.4)	53 (1.1)
Joint fusion	6 (0.3)	2 (0.1)	8 (0.2)
External fixation and Internal fixation	64 (3.4)	15 (0.5)	79 (1.6)
Joint fusion and Internal fixation	3 (0.2)	3 (0.1)	6 (0.1)
Hemi arthroplasty and Internal fixation	0 (0.0)	4 (0.1)	4 (0.1)
Total joint replacement and Internal fixation	0 (0.0)	3 (0.1)	3 (0.1)
Joint fusion and external fixation	1 (0.1)	0 (0.0)	1 (0.0)
Number of irrigation and debridements			
None	48 (2.5)	NA	48 (2.5)
One	1440 (75.7)	NA	1440 (75.7)
Two	277 (14.6)	NA	277 (14.6)
Three	69 (3.6)	NA	69 (3.6)
Four or more	67 (3.5)	NA	67 (3.5)

participated in the VANCO Trial, vancomycin powder was placed in the surgical wound in 38.0% of cases (994/2613) compared with 23.8% (553/2328) of cases performed at sites which did not participate in the VANCO Trial ($P < 0.001$).

Most of the surgeons use vancomycin antibiotic powder in less than one-quarter of their cases in both open and closed fractures (Table 5). Conversely, only 21.2% and 8.8% of surgeons used vancomycin powder in 75% or more of their closed and open fractures cases, respectively.

4. Discussion

The burden of extremity fractures requiring surgical intervention is significant and continues to grow.[24] Unfortunately, these

TABLE 2

Local Administration of Vancomycin Powder by Fracture Severity

Classification	Use of Vancomycin Powder N (%)	Odds Ratio (95% CI)	P
Gustilo classification			
I/II	399/1046 (38.1)	Ref	0.11
IIIa	283/685 (41.3)	1.14 (0.94–1.39)	
IIIb	36/111 (32.4)	0.78 (0.51–1.18)	
IIIc	17/33 (51.5)	1.72 (0.86–3.45)	
Tscherne classification			
Tscherne 0/1	761/2891 (26.3)	Ref	0.01
Tscherne 2/3	45/119 (37.8)	1.70 (1.16–2.49)	

surgical procedures are associated with an infection rate much higher than that of many elective orthopaedic procedures.[1,2,22] Preventing SSI is an important goal of surgical intervention in extremity fractures, and opportunities for improvement in this area remain. The high infection rates have encouraged the growth of adjuvant treatments, such as topical antibiotic powder, to reduce the occurrence of SSI and the sequelae that results from both catastrophic and indolent infections.

Current evidence regarding the local administration of vancomycin powder in spine surgery has been mixed, while the most recent data of its use in high-risk extremity fractures is encouraging.[7–10,12–19] Data from the VANCO trial suggest a 50% decrease in gram-positive SSI when vancomycin powder was placed in the surgical wounds during the operative management of tibial plateau and plafond fractures.[20] Our current results demonstrate significant variability in the placement of antibiotic powder in surgical wounds, suggesting variable interpretation of these results.

There may be several reasons for this observation. The VANCO trial only reported the efficacy of powder placed into surgical wounds for tibial plateau and plafond fractures, and additional research in the orthopaedic trauma literature has not convincingly demonstrated a benefit to vancomycin powder use.[23] This study demonstrates that vancomycin powder was used more frequently in these high-risk fracture patterns as compared with others; however even in these injuries, vancomycin powder was used just over 30% of the time. Furthermore, outside of periarticular tibia fractures and open injuries, it does not seem as though surgeons have expanded vancomycin powder's application. The reluctance to place antibiotic powder in the surgical wounds of other injuries may stem from the lack of available evidence. Most of the surgeons seem to be very discerning and selective in regard to which cases they use vancomycin powder. This is likely the result of a responsibility toward antibiotic stewardship that many surgeons may feel.

TABLE 3

Local Administration of Vancomycin Powder by High-Risk and Low-Risk Tibia Fractures

Fracture Location	Periarticular Tibia (OTA 41-A/B/C or 43-A/B/C), N (%)	Other (OTA 42 or 44), N (%)	P
Use of vancomycin powder in open fractures	157/337 (46.6)	186/542 (34.3)	0.001
Use of vancomycin powder in closed fractures	161/521 (30.9)	139/542 (25.6)	0.057
Use of vancomycin powder in open and closed fractures	318/858 (37.1)	325/1084 (30)	0.001

TABLE 4

Local Administration of Vancomycin Powder by Participation in the VANCO Trial

Location of Vancomycin Powder Use	Patients From Sites Who Participated in the VANCO Trial, N (%)	Patients From Sites Who Did Not Participate in the VANCO Trial, N (%)	P
Use of vancomycin powder in open fractures	422/1041 (40.5)	316/860 (36.7)	0.09
Use of vancomycin powder in closed fractures	572/1572 (36.4)	237/1468 (16.1)	<0.001
Use of vancomycin powder in open and closed fractures	994/2613 (38.0)	553/2328 (23.8)	<0.001

Previous work has also demonstrated an increased risk of gram-negative and polymicrobial infections when vancomycin powder is used.[25] This concern may be another reason surgeons are reticent to place antibiotic powder in their surgical wounds. In the VANCO trial, a strong protective effect of vancomycin against gram-positive infections was reported as a secondary analysis. This is not surprising because vancomycin is only active against gram-positive organisms and therefore should not be expected to reduce SSI from other pathogens. Importantly, no reciprocal increase in the infection rate among gram-negative or polymicrobial organisms was seen in this trial, but this concern may still dissuade some surgeons from its use.

The decision to apply local antibiotics at the surgical site is further complicated by recommendations from the Centers for Disease Control and Prevention (CDC) and consensus guidelines from orthopaedic infection specialists. The CDC has recommended against local antibiotic use at the surgical incision, while at the 2018 International Consensus Meeting on Musculoskeletal Infections, the conclusion was drawn that there is "moderate" evidence to support the use of local antibiotics in contaminated wounds.[26] These recommendations were based on prior best available evidence and may have had a significant impact on the decision to use these adjuncts.

The current variability in the adoption of local antibiotic application may also be related to concerns surrounding the potential to develop antibiotic-resistant organisms or nephrotoxicity. While these are important considerations, several studies suggest these problems are unlikely to occur and should have limited impact on the decision to use intrawound local antibiotics.[27–29] To date, no clinical data have shown an increase in vancomycin-resistant organisms when local antibiotic powder is applied during surgery.

TABLE 5

Local Administration of Vancomycin Powder in Open and Closed Fractures by Surgeon

Proportion of Fracture Surgeries	Number of Surgeons Using Vancomycin Powder in Closed Fracture Surgery*	Number of Surgeons Using Vancomycin Powder in Open Fracture Surgery*
75%–100%	14/66 (21.2)	6/68 (8.8)
50%–74%	12/66 (18.2)	10/68 (14.7)
25%–49%	11/66 (16.7)	7/68 (10.3)
1%–24%	15/66 (22.7)	26/68 (38.2)
0%	14/66 (21.2)	19/68 (27.9)

* A minimum of 10 cases per surgeon were required to be included in this analysis.

Additional explanations for the findings of this study may relate to the hesitancy of surgeons to adapt practice based on available data. There is a clear deficit in translating research results into clinical practice, the reasons for which are multifactorial but important to consider in the context of the present article.[30] Lack of familiarity with research in this arena and an adverse reaction to adopting new practice may be at play.

Perhaps the most interesting finding from this study is the high discordance between vancomycin use at the two highest enrolling centers. This result underscores the current state of vancomycin use which is undoubtedly influenced by the mixed literature, personal opinion, and recommendations from governing bodies. This practice variability presents a clear opportunity to standardize care.

Although the data for the current analysis were collected prospectively, the trend of vancomycin powder use was investigated in a retrospective manner, and thus, the conclusion of this study should be interpreted with this limitation. Because the primary aim of the parent trials does not evaluate the efficacy or usage rates of vancomycin, this study is subject to issues of missing data or misclassification. In addition, the data presented herein provide usage rates over a relatively short period of 18 months. Finally, we do not report on the use of other antibiotic powder types or where the powder was specifically applied because these data were not available.

The results of the current analysis are strengthened by the large number of fractures, surgeons, and trauma centers included. While having data over a longer period of time may provide further insight, these data do provide the best available evidence describing current practice and ongoing hesitation for the widespread use of local administration of vancomycin powder for fracture management surgery.

Vancomycin powder has many properties that make it an excellent local delivery device. It is safe, cost-effective, does not take up substantial space, is widely available, easy to use, and has not been associated with significant wound drainage.[11–18] Vancomycin is effective against common infectious agents in orthopaedic trauma including *Staphylococcus aureus* and other gram-positive bacteria.[31–33] There is also minimal concern regarding local cytotoxicity leading to healing issues or other systemic toxicity side effects.[18,34] Additional investigations regarding other types of antibiotic powder and the application of these adjuvants in all types of skeletal trauma may further clarify the role these treatments play in improving care and help in efforts to create consensus regarding their use.

5. Conclusion

Prophylactic intrawound vancomycin powder use remains controversial with varied support throughout the literature. This study demonstrates wide variability in its use across institutions, fracture types, and surgeons. This study highlights the lack of definitive data in this arena and represents an opportunity for practice standardization as more decisive research is published.

Appendix 1. The PREP-IT Investigators

Executive Committee: Gerard P. Slobogean (Principal Investigator, University of Maryland School of Medicine, Baltimore, MD); Sheila Sprague (Principal Investigator, McMaster University, Hamilton, ON); Jeffrey Wells (Patient Representative, Trauma Survivors Network, Falls Church, VA); Mohit Bhandari (Principal Investigator, McMaster University, Hamilton, ON)

Steering Committee: Gerard P. Slobogean (Co-Chair, University of Maryland School of Medicine, Baltimore, MD); Mohit Bhandari (Co-Chair, McMaster University, Hamilton, ON); Sheila Sprague (Principal Investigator, McMaster University, Hamilton, ON); Jean-Claude D'Alleyrand (Walter Reed National Military Medical Center, Bethesda, MD); Anthony D. Harris (University of Maryland School of Medicine, Baltimore, MD); Daniel C. Mullins (University of Maryland, Baltimore, MD); Lehana Thabane (McMaster University, Hamilton, ON); Jeffrey Wells (Trauma Survivors Network, Falls Church, VA); Amber Wood (Association of periOperative Registered Nurses, Denver, CO)

Adjudication Committee: Gregory J. Della Rocca (Chair, University of Missouri, Columbia, MO); Anthony D. Harris (University of Maryland School of Medicine, Baltimore, MD); Joan Hebden (University of Maryland School of Medicine, Baltimore, MD); Kyle J. Jeray (Greenville Health System, Greenville, SC); Lucas Marchand (University of Maryland, Baltimore, MD); Lyndsay M. O'Hara (University of Maryland School of Medicine, Baltimore, MD); Robert Zura (LSU Health, New Orleans, LA)

Data and Safety Monitoring Committee: Michael J. Gardner (Chair, Stanford University School of Medicine, Palo Alto, CA); Jenna Blasman (Patient Representative, Kitchener, ON); Jonah Davies (University of Washington, Seattle, WA); Stephen Liang (Washington University, St. Louis, MO); Monica Taljaard (Ottawa Hospital Research Institute, Ottawa, ON)

Research Methodology Core: PJ Devereaux (McMaster University, Hamilton, ON); Gordon H. Guyatt (McMaster University, Hamilton, ON); Lehana Thabane (McMaster University, Hamilton, ON); Diane Heels-Ansdell (McMaster University, Hamilton, ON)

Patient Centred Outcomes Core: Debra Marvel (Patient Representative, Baltimore, MD); Jana Palmer (Patient Representative, Baltimore, MD); Jeffrey Wells (Patient, Trauma Survivors Network, Falls Church, VA); Jeff Friedrich (Editor, Slate Magazine, Washington DC); Daniel C. Mullins (University of Maryland, Baltimore, MD); Nathan N. O'Hara (University of Maryland School of Medicine, Baltimore, MD); Ms. Frances Grissom (Trauma Survivor Network, Baltimore, MD)

Orthopaedic Surgery Core: Gregory J. Della Rocca (University of Missouri, Columbia, MO); I. Leah Gitajn (Dartmouth University, Hanover, NH); Kyle J. Jeray (Greenville Health System, Greenville, SC); Saam Morshed (San Francisco General Hospital, San Francisco, CA); Robert V. O'Toole (University of Maryland School of Medicine, Baltimore, MD); Bradley A. Petrisor (Hamilton Health Sciences, Hamilton, ON)

Operating Room Core: Megan Camara (R Adams Cowley Shock Trauma Center, Baltimore, MD); Franca Mossuto (Hamilton Health Sciences, Hamilton, ON)

Infectious Disease Core: Anthony D. Harris (University of Maryland School of Medicine, Baltimore, MD); Manjari G. Joshi (University of Maryland School of Medicine, Baltimore, MD)

Military Core: Jean-Claude D'Alleyrand (Walter Reed National Military Medical Center, Bethesda, MD); Justin Fowler (United States Army, USA); Jessica Rivera (San Antonio Military Medical Center, San Antonio, TX); Max Talbot (Canadian Armed Forces, Montreal, QC)

McMaster University Methods Center (Hamilton, ON): Sheila Sprague (Principal Investigator); Mohit Bhandari (Principal Investigator); Shannon Dodds (Research Coordinator); Alisha Garibaldi (Research Coordinator); Silvia Li (Research Coordinator); Uyen Nguyen (Research Coordinator); David Pogorzelski (Research Coordinator); Alejandra Rojas (Research

Coordinator); Taryn Scott (Research Coordinator); Gina Del Fabbro (Research Assistant); Olivia Paige Szasz (Research Assistant); Diane Heels-Ansdell (Statistician); Paula McKay (Manager)

University of Maryland School of Medicine Administrative Center (Baltimore, MD): Gerard P. Slobogean (Principal Investigator); Nathan N. O'Hara (Manager); Andrea Howe (Project Manager); Joshua Rudnicki (Project Manager)*; Haley Demyanovich (Project Manager); Kelly Little (Financial Manager); Adam Boissonneault (Co-Investigator)

University of Maryland School of Pharmacy, The PATIENTS Program (Baltimore, MD): C. Daniel Mullins (Executive Director); Michelle Medeiros (Director of Research); Genevieve Polk (Assistant Director, Dissemination and Research); Eric Kettering (Senior Instructional Technology and Dissemination Specialist); Diamond Hale (Project Manager)*, Nirmen Mahal (Program Specialist)

PREP-IT Clinical Sites:

Lead Clinical Site (Aqueous-PREP and PREPARE):

University of Maryland School of Medicine, R Adams Cowley Shock Trauma Center, Baltimore, MD: Robert V. O'Toole, Jean-Claude D'Alleyrand, Andrew Eglseder, Aaron Johnson, Christopher Langhammer, Christopher Lebrun, Theodore Manson*, Jason Nascone, Ebrahim Paryavi*, Raymond Pensy, Andrew Pollak, Marcus Sciadini, Gerard P. Slobogean, Yasmin Degani, Haley K. Demyanovich, Andrea Howe, Nathan N. O'Hara, Katherine Joseph*, Joshua Rudnicki, Megan Camara, Lucas Marchand*, Heather Phipps, Eric Hempen

Aqueous-PREP and PREPARE:

Hamilton Health Sciences—General Site, Hamilton, ON: Brad A. Petrisor, Herman Johal, Bill Ristevski, Dale Williams, Matthew Denkers, Krishan Rajaratnam, Jamal Al-Asiri, Jordan Leonard*, Francesc A. Marcano-Fernández*, Jodi Gallant, Federico Persico*, Marko Gjorgjievski*, Annie George*, Sarah M. McGaugh*, Kaitlyn Pusztai, Sarah Piekarski, Mavis Lyons, Julia Gennaccaro

IU Health Methodist Hospital, Indianapolis, IN: Roman M. Natoli, Greg E. Gaski*, Todd O. McKinley, Walter W. Virkus, Anthony T. Sorkin, Jan P. Szatkowski, Joseph R. Baele*, Brian H. Mullis, Yohan Jang, Luke A. Lopas, Lauren C. Hill, Andrea Hudgins*, Courteney L. Fentz, Maricela M. Diaz, Katelyn M. Garst, Emma W. Denari

San Antonio Military Medical Center, San Antonio, TX: Patrick Osborn, Justin Fowler, Sarah Pierrie, Eric Martinez*, Joseph Kimmel*, Maria Herrera

Prisma Health - Upstate, Greenville, SC: Kyle J. Jeray, John D. Adams, Michael L. Beckish, Christopher C. Bray, Timothy R. Brown, Andrew W. Cross, Timothy Dew, Gregory K. Faucher, Richard W. Gurich Jr, David E. Lazarus, S. John Millon, M. Jason Palmer, Scott E. Porter, Thomas M. Schaller, Michael S. Sridhar, John L. Sanders, L. Edwin Rudisill, Jr, Michael J. Garitty*, Andrew S. Poole*, Michael L. Sims*, Robert M. Carlisle II*, Erin Adams Hofer*, Brandon S. Huggins*, Michael D. Hunter*, William A. Marshall*, Shea Bielby Ray*, Cory D. Smith*, Kyle M. Altman*, Julia C. Bedard, Markus F. Loeffler, Erin R. Pichiotino, Austin A. Cole, Ethan J Maltz, Wesley Parker, T. Bennett Ramsey, Alex Burnikel, Michael Colello, Russell Stewart, Jeremy Wise, M. Christian Moody, Matthew Anderson, Joshua Eskew, Benjamin Judkins, James M. Miller, Stephanie L. Tanner, Rebecca G. Snider, Christine E. Townsend*, Kayla H. Pham, Abigail Martin*, Emily Robertson*, John Wilson Sykes

University of California, San Francisco, San Francisco, CA: Saam Morshed, Theodore Miclau, Utku Kandemir, Meir Marmor, Amir Matityahu, R. Trigg McClellan, Eric Meinberg, David Shearer, Paul Toogood, Anthony Ding, Erin Donohoe, Jothi Murali, Ashraf El Naga, Jennifer Tangtiphaiboontana, Tigist Belaye, Eleni Berhaneselase, Alexandra Paul*, Kartik Garg*, Dmitry Pokhvashchev

Aqueous-PREP:

McGovern Medical School at UTHealth Houston, Houston, TX: Joshua L. Gary*, Stephen J Warner, John W. Munz, Andrew M. Choo, Timothy S. Achor, Milton L. "Chip" Routt, Mayank Rao*, Guillermo Pechero*, Adam Miller*, Michael Kutzler, Sterling Boutte, Ryan J. Warth

University of Florida, Gainesville, FL: Jennifer E. Hagen, Matthew Patrick, Richard Vlasak, Thomas Krupko, Kalia Sadasivan*, Michael Talerico, Marybeth Horodyski, Chris Koenig, Daniel Bailey*, Daniel Wentworth*, Chi Van*, Justin Schwartz*, Marissa Pazik, Elizabeth Lossada-Soto

The CORE Institute, Phoenix, AZ: Niloofar Dehghan, Clifford B Jones*, J Tracy Watson*, Michael McKee, Ammar Karim*, Michael Talerico*, Debra L Sietsema, Alyse Williams, Tayler Dykes

Vanderbilt Medical Center, Nashville, TN: William T Obremskey, Amir Alex Jahangir, Manish Sethi, Robert Boyce, Daniel J. Stinner, Phillip Mitchell, Karen Trochez, Andres Rodriguez*, Vamshi Gajari*, Elsa Rodriguez, Charles Pritchett, Natalie Hogan, A. Fidel Moreno

Banner University Medical Center—Tucson, Tucson, AZ: Christina Boulton, Jason Lowe, Jason Wild*, John T. Ruth, Michel Taylor*, Brad Askam, Andrea Seach, Sabina Saeed*, Hunter Culbert*, Alejandro Cruz, Thomas Knapp*, Colin Hurkett*, Maya Lowney*, Breanna Featherston, Robin Carlson, Iliana Romero, Isaac Zarif

Wright State University, Dayton, OH: Michael Prayson, Indresh Venkatarayappa, Brandon Horne, Jennifer Jerele, Linda Clark

Hospital Universitari Parc Tauli, Barcelona, Spain: Francesc Marcano-Fernández, Montsant Jornet-Gibert*, Laia Martínez-Carreres, David Martí-Garín, Jorge Serrano-Sanz, Joel Sánchez-Fernández, Matsuyama Sanz-Molero, Alejandro Carballo, Xavier Pelfort, Francesc Acerboni-Flores, Anna Alavedra-Massana, Neus Anglada-Torres, Alexandre Berenguer, Jaume Cámara-Cabrera, Ariadna Caparros-García, Ferran Fillat-Gomà, Ruben Fuentes-López, Ramona Garcia-Rodriguez, Nuria Gimeno-Calavia, Guillem Graells-Alonso*, Marta Martínez-Álvarez, Patricia Martínez-Grau, Raúl Pellejero-García, Ona Ràfols-Perramon, Juan Manuel Peñalver, Mònica Salomó Domènech, Albert Soler-Cano, Aldo Velasco-Barrera, Christian Yela-Verdú, Mercedes Bueno-Ruiz, Estrella Sánchez-Palomino, Vito Andriola, Matilde Molina-Corbacho, Yeray Maldonado-Sotoca, Alfons Gasset-Teixidor, Jorge Blasco-Moreu, Núria Fernández-Poch, Josep Rodoreda-Puigdemasa, Arnau Verdaguer-Figuerola, Heber Enrique Cueva-Sevieri, Santiago Garcia-Gimenez

Vall d'Hebron University Hospital, Barcelona, Spain: Ernesto Guerra-Farfan, Jordi Tomas-Hernandez, Jordi Teixidor-Serra, Vicente Molero-Garcia, Jordi Selga-Marsa, Juan Antonio Porcel-Vazquez, Jose Vicente Andres-Peiro, Joan Minguell-Monyart,

Jorge Nuñez-Camarena, Maria del Mar Villar-Casares, Jaume Mestre-Torres, Pilar Lalueza-Broto, Felipe Moreira-Borim, Yaiza Garcia-Sanchez

PREPARE:

MetroHealth Medical Center, Cleveland, OH: Nicholas M. Romeo, Heather A Vallier, Mary A Breslin*, Joanne Fraifogl, Eleanor S Wilson*, Leanne K Wadenpfuhl*, Paul G. Halliday*, Isabella Heimke*

FRASER HEALTH AUTHORITY/Royal Columbian Hospital, New Westminster, BC: Darius G. Viskontas, Kelly L. Apostle, Dory S. Boyer, Farhad O. Moola, Bertrand H. Perey, Trevor B. Stone, H. Michael Lemke, Mauri Zomar*, Ella Spicer, Chen "Brenda" Fan*, Kyrsten Payne

Carolinas Medical Center, Atrium Health Musculoskeletal Institute, Charlotte, NC: Kevin Phelps, Michael Bosse, Madhav Karunakar, Laurence Kempton, Stephen Sims, Joseph Hsu, Rachel Seymour, Christine Churchill, Claire Bartel*, Robert Miles Mayberry*, Maggie Brownrigg*, Cara Girardi*, Ada Mayfield, Juliette Sweeney, Hannah Pollock*

Inova Fairfax Medical Campus, Falls Church, VA: Robert A. Hymes, Cary C. Schwartzbach, Jeff E. Schulman, A. Stephen Malekzadeh, Michael A. Holzman, Greg E. Gaski, Jonathan Wills, Lolita Ramsey, James S. Ahn, Farhanaz Panjshiri*, Sharmistha Das, Antoinisha D. English, Sharon M. Haaser*, Jaslynn A. N. Cuff

Wake Forest Baptist Health, Winston-Salem, NC: Holly Pilson, Eben A. Carroll, Jason J. Halvorson, Sharon Babcock, J. Brett Goodman, Martha B. Holden, Debra Bullard*, Wendy Williams, Taylor Hill, Ariel Brotherton

University of Utah, Salt Lake City, Utah: Thomas F. Higgins, Justin M. Haller, David L. Rothberg, Lucas S. Marchand, Ashley Neese, Mark Russell*, Zachary M. Olsen, Abby V. McGowan, Sophia Hill

Dartmouth-Hitchcock Medical Center, Lebanon, NH: I. Leah Gitajn, Marcus Coe, Kevin Dwyer, Devin S. Mullin, Clifford A. Reilly*, Peter DePalo, Amy E. Hall, Rebecca E. Dabrowski*, Theresa A. Chockbengboun

Massachusetts General Hospital, Boston, MA: Marilyn Heng, Mitchel B. Harris, R. Malcolm Smith*, David W. Lhowe, John G. Esposito, Mira Bansal*, Michael McTague*, Ahmad Alnasser

University of Mississippi Medical Center, Jackson, MS: Patrick F. Bergin, George V. Russell, Matthew L. Graves, John Morellato, Heather K. Champion*, Leslie N. Johnson*, Sheketha L. McGee, Eldrin L. Bhanat, Josny Thimothee, Jackie Serrano

University of Pennsylvania, Philadelphia, PA: Samir Mehta, Derek Donegan, Jaimo Ahn*, Annamarie Horan, Mary Dooley, Ashley Kuczinski*, Ashley Iwu

Sanford Health, Sioux Falls, SD: David Potter, Robert VanDemark III, Branden Pfaff*, Troy Hollinsworth*, Kristi Atkins

Brigham Women's Hospital, Boston, MA: Michael J. Weaver, Arvind G. von Keudell, Elizabeth M. Allen*, Abigail E. Sagona

University of Maryland, Capital Region Health: Largo, MD: Todd Jaeblon, Robert Beer, Haley K. Demyanovich, Brent Bauer, Sean Meredith, Autumn Stone

Duke University Hospital, Durham, NC: Mark J. Gage, Rachel M. Reilly, Cindy Sparrow*, Ariana Paniagua

University of Wisconsin Madison, Madison, WI: Christopher M. Domes, Kristina P Johnson

Bryan Medical Center, Lincoln, Nebraska: Steven F. Shannon, Alesha N. Scott, Bobbi Clinch

Cedars-Sinai Medical Center, Los Angeles, CA: Carol A. Lin, Mark S. Vrahas, Charles N. Moon, Charles N. Moon, Geoffrey S. Marecek, Denice Dubuclet

University of California, Irvine, Orange, CA: John A. Scolaro, James R. Learned, Philip K. Lim, Susan Demas

University of Cincinnati, Cincinnati, OH: Michael J. Beltran, Michael T. Archdeacon, Henry Claude Sagi, John D. Wyrick, Theodore Toan Le, Richard T. Laughlin, Cameron G. Thomson

*Individual is no longer actively working on the Aqueous-PREP and/or PREPARE trial

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