



Treatment approaches to prosthetic joint infections: results of an Emerging Infections Network survey[☆]

Birgir Johannsson^{a,*}, James Taylor^a, Charles R. Clark^b, Hala Shamsuddin^c,
Susan E. Beekmann^a, Philip Polgreen^{a,d}

on behalf of the Infectious Diseases Society of America Emerging Infections Network

^aDepartment of Internal Medicine, Carver College of Medicine, University of Iowa, Iowa City, IA 52242, USA

^bDepartment of Orthopedics and Rehabilitation, University of Iowa, Iowa City, IA 52242, USA

^cDepartment of Health and Human Services, United States Food and Drug Administration, Silver Spring, MD 20993, USA

^dCollege Public Health, University of Iowa, Iowa City, IA 52242, USA

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Abstract

We report the results of an Emerging Infections Network survey of 994 infectious disease consultants (IDCs) regarding their participation in the medical management of prosthetic joint infections and observations of adverse effects associated with antibiotic-impregnated materials (response rate, 54.8%). There was general agreement about when a prosthesis can be retained, but substantial variability in the duration of suppressive antibiotics was recommended, with 36% supporting life-long suppression. For 2-stage procedures, 95% recommended a minimum of 4 weeks of systemic antibiotics after the first stage. However, there was little agreement regarding the duration of an antibiotic-free period before reimplantation. Eleven percent of IDCs reported adverse events related to antibiotic-impregnated materials, ranging from skin reactions to renal failure. Further studies to address the substantial variability in the duration of antibiotic suppressive therapy for retained joints and for the duration of antibiotic-free period before reimplantation are needed.

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1. Introduction

Infections of prosthetic joints represent a major cause of morbidity from both the loss of mobility (Kilgus et al., 2002; McPherson et al., 2002; Segawa et al., 1999) and from notable pain and discomfort (Husted and Toftgaard Jensen, 2002; Wang et al., 2002). The infection rate of prosthetic joints has decreased over the last 3 decades from around 10% to less than 1% for both knee and hip replacements (Kurtz et al., 2008; Phillips et al., 2006). However, the number of primary total hip and knee joint replacements has increased steadily and is projected to increase further by 2030

(by 174% for hips and 673% for knees) (Kurtz et al., 2007). In addition, the demand for hip revision procedures is projected to double by the year 2026, whereas the demand for knee revisions is expected to double by 2015 (Kurtz et al., 2005). Thus, the burden of prosthetic joint infections (PJIs) will likely increase because both the number of primary joint replacements and revisions increase.

Despite the clinical importance of PJIs, to date, no formal guidelines from surgical or medical societies for the diagnosis and management of PJIs have been published. The Infectious Disease Society of America plans to release guidelines on the subject in the fall of 2009 (Infectious Diseases Society of America, 2009). No single diagnostic test can reliably confirm the presence of PJI, but using a combination of tests may improve the diagnostic value of each individual test (Ghanem et al., 2008; Muller et al., 2008). Diagnostic approaches may also vary depending on availability of tests and the experience of the physicians involved. For example,

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* Corresponding author. University of Iowa Hospitals and Clinics, Iowa City, IA 52242, USA. Tel.: +1-319-384-6186.

E-mail address: birgir-johannsson@uiowa.edu (B. Johannsson).

newer diagnostic tests, such as sonication of removed prosthetic material (Trampuz et al., 2006), may improve the diagnostic yield of cultures, but the availability and degree of usage of these diagnostic methods is unknown.

Surgical treatment options for PJIs include prosthesis retention, single-stage resection/reimplantation, 2-stage resection/reimplantation, and resection without reimplantation. Medical treatment options frequently include prolonged parenteral antibiotics, oral antibiotics, suppressive therapy, and local antibiotics in the form of antibiotic-impregnated materials (beads or spacers). There is no current consensus or data from randomized clinical trials to guide the duration or route of systemic antibiotics, duration of suppressive therapy, or optimal duration of an antibiotic-free period before reimplantation. In addition, the use of antibiotic-impregnated materials in the treatment of PJI has become almost universal, but these materials often require hand mixing of cement and antibiotics at the time of implantation. The drug(s) and dosages chosen may vary by institution and surgeon. Although generally considered a safe practice (Springer et al., 2004), there are anecdotal reports of toxicity from these materials (Curtis et al., 2005; Dovas et al., 2008; Patrick et al., 2006; van Raaij et al., 2002). How often these adverse effects occur is unclear. Thus, with increasing numbers of prosthetic joint replacements, complications from use of antibiotic-impregnated materials may also increase.

The goals of this study were to 1) report current diagnostic, surgical, and medical treatment approaches to PJIs; 2) help guide future studies regarding the management of PJIs; and 3) gather information regarding potential toxicities related to use of orthopedic antibiotic-impregnated materials used to treat PJIs.

2. Materials and methods

In July 2008, staff at the Infectious Diseases Society of America Emerging Infections Network (EIN) coordinating center distributed a survey via e-mail or facsimile to 994 infectious disease consultants who see primarily adult patients in the United States. EIN members who did not respond to the first survey received a reminder notice 2 weeks after the first was distributed, followed by a third after 4 weeks. The survey included a 1-page introduction to the topic and a 2-page questionnaire. EIN members were specifically asked about the following: 1) how commonly different surgical approaches (retention of prosthesis, single or 2-stage revision arthroplasty) were used at their institution, 2) under what circumstances the infectious disease consultant (IDC) would support antibiotic treatment without prosthesis removal and what criteria, if any, had to be fulfilled to stop oral suppressive therapy, 3) if a 2-stage approach was selected, what duration of antibiotic therapy was appropriate after prosthesis removal but before reimplantation of prosthesis and how long of an antibiotic-free period before reimplantation was recommended, 4)

which of the available diagnostic tests the IDC would recommend and/or felt to be of use in monitoring the progress of therapy, 5) when during the treatment course of a PJI the IDC was involved, and 6) whether input from the IDC is sought in antibiotic selection or antibiotic dose when antibiotic-impregnated material is used to treat PJI and if they had observed toxicity related to the use of these materials. In the survey, a 4- or 5-point Likert scale was used for the first 2 questionnaire items with the remainder in a multiple-choice format with answer options for individual questions as yes–no, most appropriate, or select all that apply (Appendix A).

3. Results

Five hundred forty-five (54.8%) of 994 EIN members responded to the survey. Of those, 48% are in private practice, 44% work at a university/medical school, and 8% work at other institutions. Response rates were not significantly different ($P = 0.212$) for EIN members in private practice (55%) versus those at a university/medical school (52%). Not all respondents answered all the questions, so the total for individual questions varies. Four hundred fifty-three EIN members (83%) had treated a PJI in the previous year. Of those who specified the number of patients treated (432), most (79%) had treated 25 or fewer patients, with 14%, 5%, and 2% having treated 26 to 50, 51 to 99, and more than 100 patients, respectively. Single-stage revision arthroplasty was the least common procedure, with 247 (58%) respondents reporting that it was “never” (81, 19%) or “rarely” (166, 39%) performed at their institution. Two-stage revision arthroplasty was the most common approach, with 377 (83%) respondents noting that this was “always” (29, 6%) or “often” (348, 77%) the procedure of choice at their institution.

Responses for retention of prosthesis was more variable, and these procedures were “rarely” performed at 127 (19%) institutions, “often” at 100 (23%) and “occasionally” at another 213 (48%). Few IDCs (11, 2%) indicated that they would “under no circumstance” support antibiotic treatment with prosthesis retention. The circumstances when most IDCs support retention of prosthesis and suppressive antibiotic therapy can be broadly categorized into patient- and organism-related factors. Of the patient-related factors, perceived poor surgical risk (417 or 76%), patient refusal for surgery (7, 1.3%), advanced age or short life expectancy (11, 2.1%), and early presentation after surgery (275, 50%) were noted. Of organism-related factors, highly susceptible organisms or organisms of perceived low virulence (such as coagulase-negative staphylococci) were noted as acceptable reasons by 210 (37.9%) respondents.

The duration of suppressive antibiotic therapy recommended for a retained prosthesis was variable (Fig. 1). One hundred sixty-two (36%) of 444 respondents considered the duration of oral suppressive therapy to be life long. The

remaining 282 (64%) respondents would consider stopping therapy if certain criteria were met. Most considered stopping suppressive therapy after a minimum length of therapy had been completed, either as the sole criterion (72 or 26%) or in combination with normalization of inflammation markers (69 or 24%). Another 32 (11%) used inflammation markers alone to guide when suppressive therapy could be stopped.

All most all IDCs would use prolonged antibiotic therapy after prosthesis resection in a 2-stage revision arthroplasty and would recommend an antibiotic-free period (latency period) before joint reimplantation. However, the duration of this latency period was variable for the respondents. Four hundred thirty-four (95%) agreed that at least 4 weeks of therapy is needed after prosthesis removal. One hundred fifty respondents (33%) thought that more than 6 weeks of therapy was needed. A majority of respondents (378, 84%) agreed that monitoring of inflammation markers (C-reactive protein and/or erythrocyte sedimentation rate) was useful to monitor progress of antibiotic therapy after prosthesis removal. Sixty-eight respondents (15%) thought that a new prosthesis could be implanted as soon as antibiotic therapy was stopped (i.e., no latency period). Three hundred fifty-six (78%) thought that a latency period of at least 7 days off antimicrobial therapy was needed before reimplantation, but there was no agreement concerning the time off antibiotics beyond 7 days (Table 1).

The diagnostic test IDCs recommended most frequently when evaluating for PJI were joint aspiration for analysis and culture (76%) and tissue biopsy (frozen section) at the time of reimplantation (54%). These were also the tests most commonly available to the infectious disease physician (Table 2). Sonication of the removed prosthesis was infrequently recommended (11%) and not available to 65% of IDCs. Although available to 53% of respondents, only 16

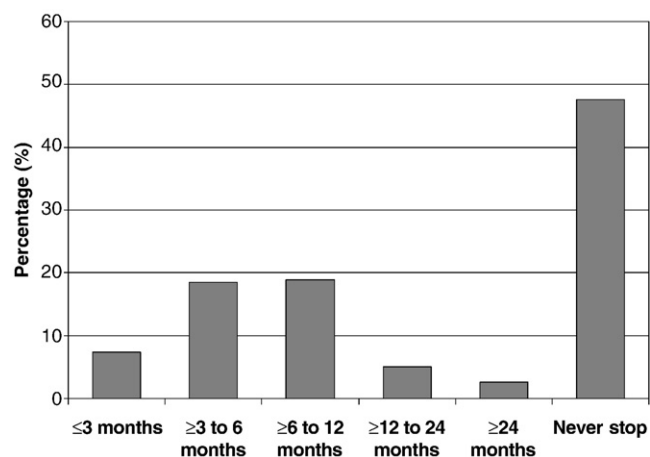


Fig. 1. Distribution of the perceived optimal duration of oral suppressive antibiotic therapy based on responses of 340 of 444 EIN members who considered time (including the 162 respondents who would never stop therapy) as an important criterion for determining the duration of suppressive therapy when prosthetic material is retained.

Table 1

The perceived optimal latency period (time off antibiotics) before reimplantation of prosthetic material when a 2-stage resection/reimplantation approach is used

Length of latency period	No. of responses (%)
None	68 (15)
<7 days	32 (7)
7–14 days	130 (29)
15–28 days	121 (27)
>28 days	105 (23)

(6%) would recommend culturing ground-up cement from a removed prosthesis.

The most common time points where IDCs were usually asked to be involved in the care of patients with PJI were at the time of diagnosis (259, 59%) or around the time of surgery (114, 27%). However, the majority of respondents (360, 79%) stated they were never or rarely asked for input regarding use of antibiotic-impregnated material. The antibiotics most commonly used are aminoglycosides (115, 25%) or vancomycin (64, 14%) alone, but more commonly, these are used in combination (268, 60%). Adverse reactions due to use of antibiotic-impregnated materials were reported by 49 IDCs (11%). Of the 27 respondents who specified the type of reaction, nephrotoxicity related to aminoglycoside use was reported by 15 (56%) IDCs. The level of certainty for kidney injury ranged from a presented case report to possible association because other nephrotoxic agents or comorbid conditions were present at the time the injury occurred. Skin reactions were reported by 9 (33%) IDCs and were believed to be related mostly to vancomycin or cephalosporin use. Skin reactions included toxic epidermal necrolysis (2 IDCs, 7%; 1 related to vancomycin in cement and 1 related to tobramycin in cement), rash (2, 7%), and rash related to vancomycin allergy (5, 19%). Other reported adverse effects were vancomycin-induced thrombocytopenia, ototoxicity from aminoglycoside use, and erosion through the surgical site by vancomycin beads (1 each, 4%). In addition, 3 of 49 (6%) IDCs who reported adverse reactions mentioned

Table 2

The availability of diagnostic tests and which tests infectious disease physicians recommend for the diagnosis of PJI

Test	Not available (%)	Recommended (%)	Not recommended (%)
Sonication of removed prosthesis	288 (65)	24 (11)	193 (89)
Grinding up of removed cement	207 (47)	16 (6)	256 (94)
Tissue biopsy (frozen section) at the time of reimplantation	44 (10)	221 (54)	189 (46)
Joint aspirate for analysis and culture	8 (2)	337 (76)	104 (24)

measurable aminoglycoside blood levels for sustained periods (i.e., weeks) without definitive toxicity.

4. Discussion

PJIs occur at a rate of around 1% for both hip and knee arthroplasties in the United States (Kurtz et al., 2008), and they are an important cause of morbidity. They cause both transient pain and loss of function but, in some cases, can cause chronic pain (Husted and Toftgaard Jensen, 2002; Wang et al., 2002) and permanent loss of mobility (Kilgus et al., 2002; McPherson et al., 2002; Segawa et al., 1999). The economic impact of PJIs is also substantial. In a study using the Healthcare Cost and Utilization Project's Nationwide Inpatient Sample database, the length of hospital stay for infected arthroplasties was significantly longer for both hip and knee replacements, and the average total hospital charges for infected hips and knee arthroplasties exceeds an estimated \$70 000 and \$55 000 dollars, respectively (Kurtz et al., 2008).

PJI treatment most often includes surgical resection with subsequent joint reimplantation (in 1 or 2 stages), systemic antibiotics of variable duration, and local implantation of antibiotic-impregnated material. In some cases, joint salvage is attempted with suppressive antibiotic therapy. The lack of data from randomized clinical trials makes therapeutic decisions difficult.

We found a general degree of consensus for some diagnostic and therapeutic modalities but considerable variability for others. Most IDCs recommend joint aspiration for cell count and culture (available to 98%, recommended by 76%). Our results agree with the published literature as to the utility of this diagnostic method, especially when combined with inflammatory markers (Ghanem et al., 2008), and also may reflect wide availability and ease of use. In contrast, tissue biopsy (frozen sections for histopathology) was commonly available (90%) but only recommended by around half of respondents (221 or 54%). Sonication of the removed prosthesis was not widely available but also not widely recommended despite evidence that it increases the yield of microbiologic diagnosis (Trampuz et al., 2006).

As for surgical therapy, 2-stage resection arthroplasty/reimplantation was the most commonly used and recommended surgical modality of treatment. The preference for 2-stage resection arthroplasty may reflect the North American geographic location of most EIN members because this approach is more common in the United States compared with other areas (for example, Europe). In the 2-stage approach, the patient typically receives systemic antibiotic therapy after joint resection in addition to locally placed antibiotic-impregnated material, followed by an antibiotic-free period (latency period), then reimplantation of the joint. Substantial variability was noted in the duration of systemic antibiotic therapy, as well as the length of the latency period. Most EIN members agreed that at least 4 weeks of systemic antibiotic administration were needed, and most favored 6

weeks. This is in agreement with some reports in the literature, which recommend 6-week course of systemic antibiotic therapy (Betsch et al., 2008). However, others have reported successful outcomes with a shortened 5-day postoperative course of systemic antibiotics, antibiotic-impregnated cement spacer, and reimplantation when the erythrocyte sedimentation rate fell below 20 mm/h (McKenna et al., 2009). There was also no agreement about the optimal length of the latency period. Almost equal numbers of EIN members reported that an appropriate latency period would be 7 to 14 days (130, 28%), 15 to 28 days (121, 26%), and >28 days (105, 23%), and 68 (15%) felt that no latency period was needed. Thus, the optimal duration of latency period remains undefined and highly variable, indicating the need for prospective randomized studies.

There was considerable agreement among EIN members as to when retention of the prosthesis was deemed possible: certain patient-related risk factor (poor surgical candidate, refusal to undergo surgery, advanced age), short duration of symptoms at presentation, and the presence of a lower virulence or a highly susceptible organism. These results are consistent with findings from retrospective studies indicating that successful retention of prosthesis is associated with a shorter duration of symptoms (Marculescu et al., 2006; Tattevin et al., 1999) and the presence of lower virulence (coagulase-negative versus coagulase-positive staphylococci) (Deirmengian et al., 2003) or more susceptible organisms (methicillin-susceptible versus methicillin-resistant *Staphylococcus aureus*) (Kilgus et al., 2002). The ability to cure PJI due to methicillin-susceptible *S. aureus* with prosthesis retention and prolonged treatment with a combination of fluoroquinolone and rifampin was demonstrated in randomized controlled trial (Zimmerli et al., 1998). In this trial, the most important determinants for success were a stable implant, initial debridement, and a short duration of infection (mean, 5 days). However, incorporating these findings into clinical practice in an era of increasing methicillin resistance among *S. aureus* isolates (Diekema et al., 2001) may be difficult. This issue was addressed in a more recent retrospective cohort study where patients with early PJI due to *S. aureus* resistant to both methicillin and fluoroquinolone were treated with fusidic acid and rifampin with good results (Aboltins et al., 2007). However, this approach may not be feasible for many practitioners in the United States because fusidic acid is not licensed in the United States. A recent study found that PJIs with an early manifestation, a duration of clinical symptoms less than 3 weeks, a susceptible microorganism as well as stable implant and intact soft tissues at presentation might achieve a favorable outcome with retention of the prosthesis (Kosters et al., 2008).

In contrast, there was little agreement among respondents regarding the duration of suppressive antibiotic therapy, with durations ranging from as short as 3 months to life long. This lack of agreement likely reflects the many factors that can affect the outcome of suppressive antibiotic therapy and identifies a need for more data to guide PJI therapy.

Randomized clinical trials would be ideal but also expensive to design and conduct because such a study would likely require a large patient population and be conducted at multiple centers. In the absence of such studies, a patient registry to collect clinical data and outcomes might help inform clinical decision making.

The use of antibiotic-impregnated materials is common practice in the treatment of PJIs and can take the form of a nonarticulating spacer (Haleem et al., 2004), articulating spacer (either custom made or prosthesis of antibiotic-loaded spacer or PROSTALAC) (Hofmann et al., 2005; Hsieh et al., 2004b; Scharfenberger et al., 2007), or cement beads (Hsieh et al., 2004a). The clinical utility of these impregnated materials is uncertain because similar outcomes have been noted with or without their use (Disch et al., 2007). However, a recent metaanalysis noted that the use of antibiotic-impregnated cement has lowered the infection rates in primary hip arthroplasty as well as significantly reduced the need for revision hip arthroplasty (Parvizi et al., 2008).

Despite widespread use, respondents were rarely asked for input regarding the choice and use of antibiotic-impregnated material. This may be due to several factors: the perception in orthopedics practice that the use of these materials is standard of care and the limited number of antibiotics that fulfill criteria for use in cement (thermal stability, low risk of allergy, limited effects on the mechanical properties of cement, low protein binding) (Anagnostakos et al., 2006). The use of antibiotic-impregnated material is generally considered safe (Springer et al., 2004); however, there are no studies that specifically address the long-term safety in patients with impaired renal function. Antibiotics are hand mixed into the bone cement at time of surgery, because these antibiotic-impregnated materials are not commercially available in the United States in a ready-to-use form; the dose is not standardized and may vary with each procedure. In addition, the elution of drug from cement is variable and depends on many factors. For example, generic tobramycin appears to elute more than twice as fast from cement than proprietary tobramycin (McLaren et al., 2008), and bone cements produced by different manufacturers may elute different amounts of drug (Bridgens et al., 2008). In addition, the elution of antibiotics may be affected by combining 2 (or more) antibiotics in cement, thus, increasing the elution of each antibiotic (Penner et al., 1996). Finally, the presence of inflammation at the site of implantation may increase systemic dissemination of antibiotics from impregnated materials. The degree of risk for adverse effects remains unknown but might be nontrivial in the population of patients who typically undergo prosthetic joint replacement (for example, older are patients much more likely to have diminished renal function before implantation). In such patients, even very small amounts of aminoglycosides may accumulate, causing renal toxicity if the exposure is long enough. In this survey, the number of EIN members reporting an adverse effect due to antibiotic-impregnated materials was not insignificant (11%). However, because we did not ask

how many cases each ID physician had seen, the true incidence of adverse effects due to these implanted materials is difficult to ascertain and may be more infrequent than the number above indicates. Although a portion of the adverse effects noted would not be considered life threatening, our results provide information on the spectrum of adverse effects and raise concern about the potential for nephrotoxicity. Large prosthetic joint registries have been in place in Sweden (from 1976), Finland (from 1980), and Norway (from 1987) (Havelin et al., 2000; Knutson et al., 1994; Puolakka et al., 2001) with no published reports on adverse effects related to antibiotic-impregnated materials. These findings appear to contradict the findings of our survey. However, this discrepancy may in part be due to how these registries are set up; collecting information on the implant, the procedure and patient demographics at the time of surgery and the fact that the adverse effects related to antibiotic-impregnated materials are more of a medical than surgical nature. Further investigation, in the form of case series or patient registries, into which patient groups are at the greatest risk of developing the more serious adverse effects related to antibiotic-impregnated materials is warranted.

The nature of our survey limited us in describing the complete clinical context of PJIs. For example, many factors affect the selection of therapeutic modalities used in the management of PJIs. Consequently, our inability to differentiate between initial and repeat infections is a potential limitation of the survey. Our results are also subject to limitations in recall by the respondents and, finally, may be biased in favor of more severe cases (reporting bias).

In summary, 2-stage revision arthroplasty was the most common procedure performed at the institutions of the ID physicians surveyed. An extended course of systemic antibiotics for at least 4 weeks was favored after removal of the infected prosthesis. There was little agreement on how long the latency period off antimicrobials should be. IDCs agree with retention of prosthesis given certain circumstances, and most support life-long oral suppressive therapy if retention is attempted. A substantial number of EIN members reported having personally seen adverse effects related to antibiotic-impregnated materials, ranging from skin reaction to renal failure. Our study highlights the need for prospective trials to help guide treatment of PJIs and also the need to investigate further the possible adverse effects due to antibiotic-impregnated materials.

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Appendix A. Copy of the Infectious Diseases Society of America Emerging Infections Network query on the treatment of prosthetic joint infections

This EIN survey is primarily designed to better understand the actual treatment practices for prosthetic joint infections. We also are interested in whether members have observed renal toxicity related to use of aminoglycoside impregnated materials.

With more patients requiring joint replacement, prosthetic joint infections, though relatively rare, will likely increase. Treatment approaches vary. In certain cases (e.g., early presentation, clear hematogenous spread), retention of the prosthesis may be attempted with debridement/joint washout and perhaps polyethylene liner exchange (“poly exchange”). When joints are removed, a two stage exchange with or without the placement of a spacer or an extension device is common in the United States, but in some European countries, a single stage procedure with removal and reimplantation at same operative procedure is commonly performed.

The extent of infectious diseases physicians’ involvement in the management of patients with prosthetic joint infections is commonly performed. joint infections is unclear. The goal of this survey is to estimate how frequently infectious diseases consultants provide input and their experience with management strategies. Also, relatively new approaches to increase the diagnostic yield from explanted prostheses (e.g., sonication of the removed joint¹) have been recommended, and tissue biopsies for evaluation of inflammation (frozen sections) prior to reimplantation² may be used, but the degree of dissemination of these practices is unknown.

Finally, although use of antibiotic impregnated materials during surgical therapy is generally perceived as a safe practice, there have been reports of toxicity from these materials³. Antibiotic impregnated bone cement is used in virtually all reimplantation arthroplasties. Polymethylmethacrylate (PMMA) bead impregnated with antibiotics may also be used during surgical therapy. High-dose (>1 g antibiotic per batch of cement) antibiotic impregnated bone cement is not commercially available and requires hand mixing of cement and antibiotics in the operating room. Use of hand-mixed antibiotic impregnated materials is not standardized, and the drug(s) and dosages chosen are likely to vary. With increasing numbers of prosthetic joint placements, complications from use of antibiotic-impregnated materials also may increase. Thus, the final questions ask about any observed toxicities associated with use of these materials.

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EMERGING INFECTIONS NETWORK QUERY Treatment of Prosthetic Joint Infections

Name: _____

1. Have you treated any patients with prosthetic joint infections in the past year?

No, proceed to question 10.

Yes, circle number: 1-5 6-25 26-50 51-100 >100

2. How common are the following approaches to prosthetic joint infections in your institution(s)?

<input type="checkbox"/> Do not know	Never	Rarely	Occasionally	Often	Always
Retention of prosthesis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Singlestage procedure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Two stage procedure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

3. Please indicate when you are consulted during treatment of prosthetic joint infections:

	Never	Rarely	Occasionally	Usually
At diagnosis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Perioperatively	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Following surgery	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Following discharge (outpatient basis)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Retention of Infected Prosthesis

4. Under what circumstances would you support antibiotic treatment with prosthesis retention?

None; skip to question 6.

[Check any that apply]

Availability of a safe oral antibiotic

Highly susceptible organism

Poor surgical risk

Early presentation postoperatively

Other, specify: _____

5. Under what circumstances would you consider stopping oral suppressive therapy in a patient who has resolution of joint symptoms? *[Check any that apply]*

Never (lifelong suppression)

After a minimum period of time, *specify*: _____

Normalization of inflammatory parameters

Other, *specify*: _____

Two Stage Procedure for Replacing Infected Prosthetic Joints

6. How long do you recommend treating after infected prosthesis removal and before implanting a new prosthesis? *[Circle]*

<2 weeks

2-4 weeks

>4-6 weeks

>6 weeks

7. Have you found it useful to follow CRP or ESR to evaluate progress in treating an infected prosthetic joint?

No

Yes

8. What minimum length of time off of antibiotics do you recommend prior to joint reimplantation? *[Circle]*

None

<7 days

7-14 days

15-28 days

>28 days

9. Do you recommend any of the following at your institution? *[Check all that apply]*

	Yes	No	Not routinely available
Sonication of removed prosthesis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Grind up cement from removed prosthesis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tissue biopsy (frozen section) before reimplantation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Joint aspirate for culture before reimplantation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Use of Antibiotic Impregnated Beads/Cement for Spacers/Joint Reimplantation

Check here if your institution never uses antibiotic-impregnated materials during surgical treatment of prosthetic joint infections. Check here if you do not know. Thank you for completing this survey.

10. Is ID input requested on antibiotic selection/dosage before use of these materials?

Never

Rarely

Occasionally

Often

Always

11. Most commonly, which antibiotics are used in joint/spacer cement?

Aminoglycoside

Vancomycin

Other, *specify*: _____

12. Have you personally seen toxicity attributable to antibiotics from impregnated materials?

No

Yes, *specify toxicity, antibiotic & type of impregnated material (e.g., PMMA beads, cement)*:

13. Do you have comments about prosthetic joint infections or this survey?

Thank you for completing this survey!

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