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Published in:
Clinical Infectious Diseases

DOI:
10.1093/cid/ciy851

Publication date:
2019

Clinical Infectious Diseases

MAJOR ARTICLE

Failure After 2-Stage Exchange Arthroplasty for Treatment of Periprosthetic Joint Infection: The Role of Antibiotics in the Cement Spacer

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Background. Failure after a 2-stage exchange surgery for periprosthetic joint infection (PJI) is high. Previous studies demonstrated that positive cultures at reimplantation are associated with failure afterward. The aim of this multicenter study was to define the role of antibiotics in the cement spacer in relation to reimplantation cultures and subsequent failure.

Methods. We retrospectively evaluated 2-stage exchange procedures between 2000 and 2015. Culture-negative PJIs, cases in which no cultures were obtained during reimplantation, and cases without data on cement spacers were excluded.

Results. Three hundred forty-four cases were included. The rate of positive cultures during reimplantation was 9.5% for cement spacers containing a glycopeptide (27/284) (with or without an aminoglycoside) vs 21.7% for those containing monotherapy with an aminoglycoside (13/60) ($P = .008$), and was mostly attributed by a reduction in coagulase-negative staphylococci (CoNS) (17% vs 2%, $P < .001$). The failure rate was >2-fold higher at 40.0% (16/40) in cases with positive cultures at reimplantation compared to 15.8% (48/304) for those with negative cultures ($P < .001$). Overall, a glycopeptide in the cement spacer was not associated with a lower failure rate (18% vs 23%, $P = .3$), but was associated with lower failure due to CoNS (2.5% vs 13.3%, $P < .001$).

Conclusions. In a 2-stage exchange procedure for PJI, adding a glycopeptide to the cement spacer reduces the rate of positive cultures during reimplantation and is associated with a lower failure rate due to CoNS afterward.

Keywords. 2-stage exchange; prosthetic joint infection; reimplantation; antibiotic cement spacer.

A 2-stage exchange of a periprosthetic joint infection (PJI) is considered the gold standard surgical treatment in chronic PJIs and is for this reason recommended as the first-line surgical approach [1]. During a 2-stage procedure, the infected prosthesis is extracted, bone and soft tissue are extensively debrided, a temporal cement spacer is inserted, and antibiotics are administered for several weeks. When the infection is considered to be eradicated, the new prosthesis can be reimplanted. Although one expects that this should result in long-term implant survival, infection rates during follow-up are extremely high (approximately 10%–20% [2, 3]). This may partly be explained by host-related factors, as a 2-stage procedure is often chosen in patients who already underwent previous orthopedic surgeries, resulting in poor bone stock and soft tissue integrity [4]. However, recent studies also demonstrated that positive cultures during reimplantation frequently occur and are associated with subsequent failure as well [5–8]. These positive cultures are partly due to persistent infection, but the majority of them are caused by reinfections with another microorganism, probably acquired during prosthesis extraction and/or spacer insertion [9]. At the moment, antibiotics added to the cement spacer are often tailored against the microorganism causing the PJI. However, applying a broader spectrum of antibiotics to the cement spacer might be a way to reduce the rate of positive cultures at reimplantation. We therefore aimed to determine the role of antibiotics in the cement spacer in relation to positive cultures at reimplantation and subsequent failure during follow-up.

MATERIALS AND METHODS

Inclusion and Exclusion Criteria

We retrospectively evaluated all 2-stage exchange procedures performed at 2 academic centers between 2000 and 2015. Cases were considered eligible for inclusion if the 2-stage exchange was applied as the first surgical treatment for the infection, or if applied as salvage therapy after a failed surgical irrigation and debridement for an acute PJI. Primary culture–negative PJIs, cases in which no intraoperative cultures were obtained during reimplantation, and cases without available data on the type of antibiotic that was used in the cement spacer were excluded

Received 3 July 2018; editorial decision 25 September 2018; accepted 28 September 2018; published online October 3, 2018.

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Clinical Infectious Diseases® 2019;68(12):2087–93

DOI: 10.1093/cid/ciy851

from the analysis. Cultures obtained during the first stage, during reimplantation, and in cases of subsequent failure after reimplantation were evaluated. The definitive diagnosis of PJI was based on the diagnostic criteria defined by the International Consensus Meeting for PJI [10].

Definitions

Reimplantation cultures were considered positive when (1) at least 1 of the following virulent microorganisms was isolated: *Staphylococcus aureus*, gram-negative rods, *Enterococcus* species, *Streptococcus* species, and *Candida* species, or (2) if at least 2 of the following low-virulence microorganisms with the same antibiogram were isolated: coagulase-negative staphylococci (CoNS), *Corynebacterium* species, *Cutibacterium acnes*, or other. Failure after reimplantation was defined as the need for additional surgical intervention and/or the need for antibiotic suppressive antibiotic therapy due to persistent clinical signs of infection.

Microbiological Analysis and Antibiotic Treatment

Neither institution applied preoperative antibiotic prophylaxis during the first stage of the procedure, but started broad-spectrum antibiotics after obtaining multiple intraoperative tissue biopsies for culture. After prosthesis extraction and spacer implantation, all patients were subsequently treated with antibiotics for at least 6 weeks prior to reimplantation. In 1 center, prefabricated spacers were used. In general, these spacers contain 2 g of gentamicin with or without 2 g of vancomycin. Until 2008, monotherapy with an aminoglycoside was routinely applied, and after that, duotherapy with the addition of a glycopeptide. In the other center, the nonprefabricated spacers were loaded with 2 g of vancomycin with or without 2.4 g of tobramycin per 40 g of cement. In this institution, the antibiotic was targeted toward the infecting microorganisms, if known prior to surgery; otherwise, duotherapy was applied. The timing of reimplantation was decided based on trending serum inflammatory parameters and availability of the operating theater. In 1 center, reimplantation was performed under ceftazidime and teicoplanin prophylaxis, which was continued after reimplantation until intraoperative culture results were negative. In the other center, cefazolin was routinely administered as antibiotic prophylaxis and vancomycin was added to this regimen in case the patient had risk factors for—or was known to have—methicillin-resistant *S. aureus* (MRSA) colonization. All patients who had positive cultures at reimplantation were subsequently treated with antibiotics for an additional 6–12 weeks according to the local protocol, and patients were routinely followed at the outpatient clinic afterward.

Statistical Analysis

The χ^2 test (or Fisher exact test when appropriate) was used to analyze differences between groups for categorical variables, and Student *t* test (or Mann-Whitney *U* test) was used when data were not normally distributed) for continuous variables. A logistic regression analysis was performed to identify risk factors for having positive cultures at reimplantation and to identify risk factors for failure during the follow-up period after reimplantation. Variables that demonstrated a difference with a *P* value <.1 in the univariate analysis were included in the multivariate analysis. Data were presented as mean ± standard deviation when data were normally distributed or median ± interquartile range (IQR) when data were not normally distributed. A *P* value <.05 was considered to be statistically significant. Statistical analysis was performed using SPSS, version 20.0 (SPSS Inc, Chicago, Illinois).

RESULTS

Cohort Characteristics

Medical records of 539 cases were evaluated. Fifty-six cases were excluded because of culture-negative PJIs (negative cultures during the first stage of the exchange), 59 cases were excluded because no cultures were obtained during reimplantation, and 80 cases were excluded due to the lack of data on the antibiotic(s) used in the cement spacer. Finally, a total number of 344 cases remained for the final analysis, including 138 hips (40.1%) and 206 knees (59.9%). In 277 cases (80.5%), the 2-stage exchange procedure was the first surgical approach to treat the primary infection. All of these comprised chronic PJIs. In the remaining 67 cases (19.5%), the 2-stage exchange was applied as salvage strategy after a failed surgical debridement for an acute PJI. Fifty-three (15.4%) of the primary PJIs were polymicrobial. *S. aureus* was isolated in 127 cases (36.9%) (including 31 cases with MRSA), CoNS in 119 (34.6%), gram-negative rods in 54 (15.7%), *Streptococcus* species in 41 (11.9%), and *Enterococcus* species in 18 (5.2%) cases. Concerning the antibiotic used in the cement spacer, an aminoglycoside was applied in 60 (17.4%), a glycopeptide in 45 (13.1%), and both in 239 cases (69.5%). Table 1 shows the microbiological characteristics of cases in which a glycopeptide was administered in the cement spacer compared to those in which it was withheld. PJI caused by methicillin-susceptible *S. aureus* was more prevalent and PJI caused by CoNS was less prevalent in the glycopeptide group compared to monotherapy with an aminoglycoside (Table 1).

Positive Cultures at Reimplantation

Forty cases had positive cultures at reimplantation (11.6%). Positive cultures were most often CoNS (35%), followed by gram-negative rods (25.0%) and *S. aureus* (17.5%). Supplementary Table 1 provides a detailed overview of the microorganisms isolated, their correlation to the initial infection (isolated during the first stage of the exchange), and failure after reimplantation. In 25 of the 40 cases with positive cultures during reimplantation (62.5%), the isolated microorganism

Table 1. Microbiological Characteristics of Cases With or Without a Glycopeptide in the Cement Spacer

Microorganism Isolated in First Stage[a]	Glycopeptide in Cement Spacer (n = 284)	No Glycopeptide in Cement Spacer (n = 60)	*P* Value
Staphylococcus aureus	41.2%	16.7%	<.001
Methicillin-resistant *S. aureus*	9.5%	6.7%	.49
Coagulase-negative staphylococci	30.6%	53.3%	.001
Gram-negative rods	14.4%	21.7%	.16
Streptococcus spp	13.4%	5.0%	.07
Enterococcus spp	5.3%	5.0%	.93

[a]Including polymicrobial cases.

was different from that isolated during the first stage of the exchange, and comprised gram-negative rods in 29.2%, CoNS in 20.8%, *S. aureus* in 12.5%, *Streptococcus* species in 12.5%, and *Enterococcus* species in 12.5% of cases.

Figure 1A shows the percentage rate of positive cultures during reimplantation according to the cement spacer, which was 9.5% for cement spacers containing a glycopeptide (27/284) vs 21.7% for those containing monotherapy with an aminoglycoside (13/60) ($P = .008$). In 18 of the 27 glycopeptide cases with positive cultures during reimplantation (66.7%), the microorganism was different than the one isolated in the first stage of the exchange. According to the univariate analysis, hip joints, a longer duration of the first stage of the exchange, polymicrobial infections, and not adding a glycopeptide to the cement spacer were associated with a higher rate of positive cultures during reimplantation (Table 2). As the additional multivariate analysis did not demonstrate any independent predictive factors for positive cultures, we evaluated for interacting variables. We found that the use of a glycopeptide in the cement spacer was less often applied in hips (72.5% for hips and 89.3% for knees, $P < .001$). In addition, the lower rate of positive cultures in glycopeptide cement spacers was only observed if the duration of surgery was <150 minutes (Figure 2). By performing an additional multivariate analysis, only for surgeries with a duration of <150 minutes, American Society of Anesthesiologists (ASA) classification of III or higher (odds ratio [OR], 5.2 [95% confidence interval {CI}, 1.38–20.2], $P = .02$) was an independent predictor for positive cultures during reimplantation, while the addition of a glycopeptide to the cement spacer had an independent protective effect (OR, 0.26 [95% CI, .78–.91], $P = .03$).

The lower rate of positive cultures during reimplantation in the glycopeptide group was mostly attributed to a decrease of spacer infections with CoNS (17% vs 2%, $P < .001$) (Figure 3A). In the aminoglycoside group, a CoNS was cultured during reimplantation in 10 cases: 6 was the same microorganism as the one isolated during the first stage (failure rate, 17% [1/6]) during follow-up, and in 4 cases this was another microorganism (failure rate, 50% [2/4] during follow-up).

Failure After Reimplantation

The median follow-up after reimplantation was 35 months (IQR, 18–62 months), and was not significantly different between patients who had positive cultures during reimplantation compared to those who did not (35 months [IQR, 23–80] vs 34 months [IQR, 17–62], $P = .26$). The overall failure rate during follow-up was 18.6% (64/344). Fifty-two of the 64 failures (81.3%) needed additional surgical intervention due to infection (culture positive), 7 (10.9%) patients needed antibiotic suppressive therapy due persistent clinical signs of infection, and in 5 (7.8%) the implant needed to be removed, but intraoperative cultures during removal were negative.

Failures were most often caused by *S. aureus* in 28.1% of cases (18/64) (including 1 failure due to MRSA), followed by gram-negative rods in 23.4% (15/64) and CoNS in 23.4% (15/64) of cases. In 37 of 64 cases (57.8%), another microorganism than the one isolated during the first stage of the exchange was isolated during failure.

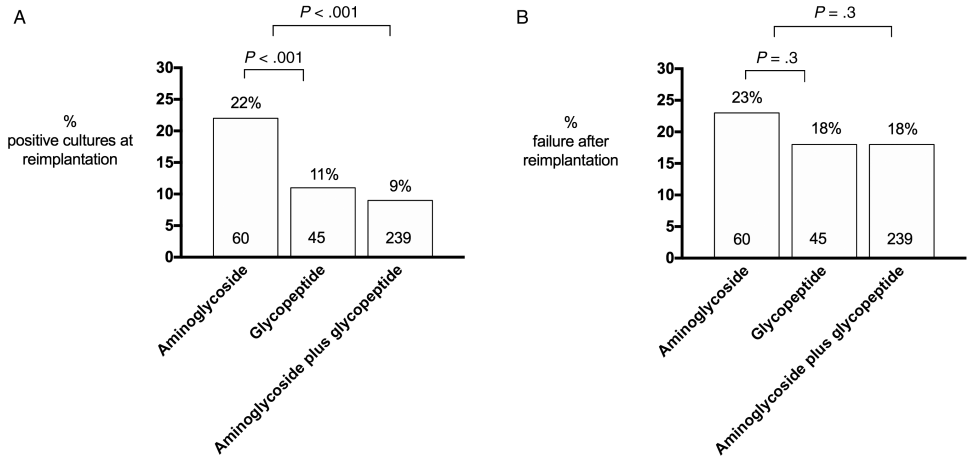

Figure 1. Positive cultures at reimplantation (*A*) and failure rate after reimplantation (*B*).

Table 2. Risk Factors for Positive Cultures at Reimplantation

Variable	Negative Cultures at Reimplantation	Positive Cultures at Reimplantation	Unadjusted OR (95% CI)	*P* Value	Adjusted OR (95% CI)	*P* Value
Patient characteristics						
Male sex	54.9% (187/304)	57.5% (23/40)	1.11 (.57–2.17)	.76		
Age >80 y	11.2% (38/340)	15.0% (6/40)	1.40 (.55–3.59)	.48		
BMI >30 kg/m^2	45.1% (83/184)	55.5% (10/18)	1.52 (.57–4.03)	.40		
ASA classification ≥III	48.8%(118/242)	55.6% (20/36)	1.31 (.65–2.66)	.45		
Charlson comorbidity index ≥3	6.8% (10/148)	6.7% (1/15)	0.99 (.12–8.28)	.99		
Joint						
Hip	37.5% (114/304)	60% (24/40)	2.50 (1.27–4.90)	.006	1.60 (.73–3.53)	.25
Revision prosthesis	20.3% (60/295)	12.5% (5/40)	0.56 (.21–1.49)	.24		
Sinus tract	34.0% (48/141)	20.0% (5/25)	0.48 (.17–1.37)	.17		
Surgical characteristics						
Duration of first-stage exchange >120 min	46.0% (132/287)	52.8% (19/36)	1.31 (.66–2.63)	.44		
Duration of first-stage exchange >150 min	25.4% (73/287)	41.7% (15/36)	2.09 (1.03–4.28)	.04	1.53 (.68–3.44)	.30
Glycopeptide in cement spacer[a]	84.5% (257/304)	67.5% (27/40)	0.38 (.18–.79)	.008	0.62 (.26–1.47)	.28
Antibiotic holiday >2 wk	66.7% (166/249)	73.5% (25/34)	1.39 (.62–3.11)	.42		
>3 cultures obtained at reimplantation	83.7%% (252/301)	90.0% (36/40)	1.90 (.85–4.28)	.30		
2-stage exchange applied as salvage therapy	19.7% (60/304)	17.5% (7/40)	0.86 (.36–2.05)	.74		
Microorganism isolated in first stage						
Polymicrobial	13.5% (41/304)	27.5% (11/40)	2.43 (1.13–5.25)	.06	1.19 (.77–1.85)	.44
Staphylococcus aureus	37.8% (115/304)	30.0% (12/40)	0.70 (.35–1.44)	.34		
CoNS	33.6% (102/304)	47.5% (17/40)	1.46 (.75–2.86)	.26		
Gram-negative rods	15.8% (48/304)	15.0% (6/40)	0.94 (.38–2.36)	.90		
Streptococcus spp	11.5% (35/304)	15.0% (6/40)	1.36 (.53–3.46)	.52		
Enterococcus spp	4.9% (15/304)	7.5% (3/40)	1.56 (.43–5.65)	.49		

P values <.1 were included in the multivariate analysis.

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; CoNS, coagulase-negative staphylococci; OR, odds ratio.

[a]With or without an aminoglycoside.

Failure was significantly higher in those patients who had positive cultures during reimplantation (40.0% [16/40] vs 15.8% [48/304] with negative cultures, $P < .001$), despite the fact that all positive cultures during reimplantation were treated with antibiotics. When the need of antibiotic suppressive therapy was not considered as failure, failure rates remained higher in the culture-positive vs the culture-negative group (37.5% [15/40] vs 13.8% [42/304], $P < .001$). No difference in failure was observed between centers, and no difference was observed in cases with positive cultures during reimplantation with the same microorganism as the one isolated during the first stage compared to positive cultures during reimplantation

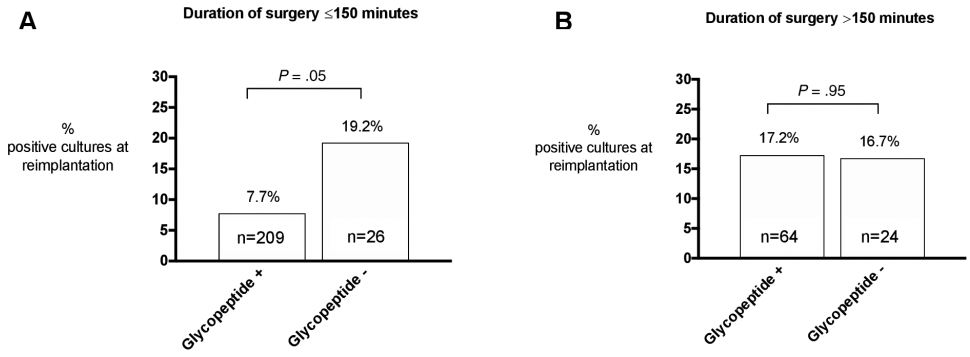

Figure 2. Positive cultures at reimplantation, by duration of surgery ≤150 minutes (*A*) and >150 minutes (*B*).

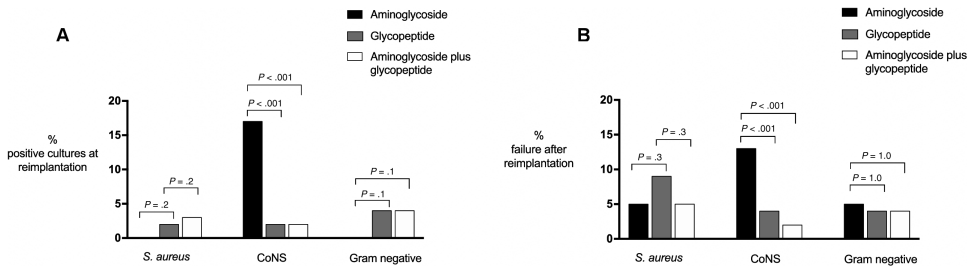

Figure 3. Positive cultures at reimplantation (*A*) and failure rate after reimplantation (*B*). Abbreviations: CoNS, coagulase-negative staphylococci; *S. aureus*, *Staphylococcus aureus*.

with another microorganism (data not shown). Positive cultures that did not meet the definition of "positive culture during reimplantation" as described in the Materials and Methods, and were thus considered as a contaminant at reimplantation, did not show a higher failure rate during follow-up compared to the group with negative cultures at reimplantation (21.1% [8/38] vs 15.0% [40/226], respectively, $P = .34$).

Table 3 shows the variables associated with failure after reimplantation in the univariate and multivariate analyses. Positive cultures at reimplantation and a 2-stage revision applied as salvage therapy to treat the infection were the only independent predictors for failure after reimplantation. Overall, the use of a glycopeptide in the cement spacer was not associated with a lower failure rate after reimplantation (Figure 1B). However, cases in which a glycopeptide was added to the antibiotic cement spacer did had a lower failure rate due to CoNS compared to those without a glycopeptide (2.5% vs 13.3%, respectively, $P < .001$; Figure 3B). To correct for the microorganism cultured at the first stage of the exchange, we performed a subanalysis on non-CoNS PJIs. The lower failure rate due to CoNS during

Table 3. Risk Factors for Failure After Reimplantation

Variable	Nonfailure	Failure	Unadjusted OR (95% CI)	*P* Value	Adjusted OR (95% CI)	*P* Value
Patient characteristics						
Male sex	55.5% (155/280)	54.1% (35/64)	0.95 (.54–1.65)	.85		
Age >80 y	11.7% (33/280)	11.5% (7/64)	0.98 (.41–2.34)	.96		
BMI >30 kg/m^2	49.4% (82/166)	30.6% (11/36)	0.45 (.21–.98)	.04[a]		
ASA classification ≥III	48.7% (111/228)	54.0% (27/50)	1.24 (.67–2.29)	.50		
Charlson comorbidity index ≥3	6.4% (9/140)	8.7% (2/23)	1.39 (.28–6.87)	.69		
Joint						
Hip	40.4% (113/280)	39.1% (25/64)	0.95 (.54–1.65)	.85		
Revision prosthesis	29.5% (38/129)	40.5% (15/37)	1.63 (.77–3.48)	.2		
Sinus tract	20.8% (57/274)	13.1% (8/61)	0.58 (.26–1.28)	.17		
Surgical characteristics						
Duration of second-stage exchange >120 min	61.8% (141/228)	55.6% (30/54)	0.77 (.42–1.41)	.40		
Duration of second-stage exchange >150 min	27.6% (63/228)	38.9% (21/54)	1.67 (.90–3.10)	.10	0.91 (.47–1.74)	.76
Glycopeptide in cement spacer[b]	83.6% (234/280)	78.1% (50/64)	0.70 (.36–1.37)	.30		
Antibiotic holiday >2 wk	67.1% (151/225)	69.0% (40/58)	1.10 (.59–2.03)	.79		
Positive cultures at reimplantation	19.3% (54/280)	37.5% (24/64)	2.51 (1.40–4.52)	.002	4.45 (2.11–9.49)	<.001
2-stage exchange applied as salvage therapy	16.8% (47/280)	31.3% (20/64)	2.25 (1.22–4.17)	.008	2.09 (1.10–4.05)	.03
Microorganism isolated in first stage						
Polymicrobial	13.9% (39/280)	20.3% (13/64)	1.58 (.79–3.16)	.20		
Staphylococcus aureus	37.5% (105/280)	34.4% (22/64)	0.87 (.49–1.54)	.64		
CoNS	32.5% (91/280)	43.8% (28/64)	1.62 (.93–2.81)	.09	1.50 (.83–2.71)	.18
Gram-negative rods	15.4% (43/280)	17.2% (11/64)	1.14 (.55–2.37)	.72		
Streptococcus spp	12.9% (36/280)	7.8% (5/64)	0.57 (.22–1.53)	.26		
Enterococcus spp	5.7% (16/280)	3.1% (2/64)	0.53 (.12–2.38)	.40		

P values <.1 were included in the multivariate analysis.

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; CI, confidence interval; CoNS, coagulase-negative staphylococci; OR, odds ratio.

[a]As data on BMI were only available in 59% of the cohort, BMI was not included in the multivariate analysis.

[b]With or without an aminoglycoside.

follow-up for the glycopeptide group remained (1.0% vs 10.9%, $P = .001$).

DISCUSSION

A 2-stage exchange procedure is still considered the most effective surgical strategy for PJI, but the high infection rates during reimplantation and afterward stress the importance of improving treatment strategies within this patient category [2, 3]. In a large cohort of 344 two-stage exchange procedures, we observed a high rate of positive cultures during reimplantation (11.6%) mostly caused by another microorganism than the one isolated during the first stage of the exchange (62.5%), which is similar to previous findings [5–9]. These findings indicate that spacers become secondarily infected during spacer implantation. Our data demonstrate that adding a glycopeptide to the cement spacer reduces the rate of positive cultures during reimplantation from 21.7% to 9.5%, and was even reduced to 2% for CoNS. Although we did not have detailed data on the susceptibility patterns in our cohort, Corona et al demonstrated in 133 chronic PJIs that resistance of gram-positive organisms to aminoglycosides is high [11]. This high rate of resistance was particularly evident for CoNS, with reported resistance percentages to gentamicin and tobramycin of 41.2% and 47.7%, respectively, which was even higher with prior aminoglycoside use. These numbers clearly explain why monotherapy with an aminoglycoside in the cement spacer is not sufficient to prevent spacer infections with CoNS. Therefore, it should be recommended to routinely add a glycopeptide to the cement spacer, independent of the microorganism(s) causing the initial PJI.

The high infection rate of spacers compared to primary arthroplasty can partly be attributed to a longer surgical procedure, increasing the risk for bacterial colonization of the wound [12, 13]. In line with this, we also observed that a longer duration of the first stage of the exchange (>150 minutes) was associated with a higher rate of positive cultures during the second stage. In these cases, the protective effect of the glycopeptide completely disappeared and adding a glycopeptide to the antibiotic prophylaxis regimen might be a potential solution for this high-risk group to reduce the reinfection rate [14, 15]. In addition, the increased risk of positive cultures during reimplantation appears to be most prominent for hips, in particular for obese patients, probably due to a higher rate of bacterial colonization in the groin [16–18].

Regarding the outcome after reimplantation, an important finding in our study was the association between positive cultures during reimplantation and subsequent failure during follow-up. The association between positive cultures during reimplantation and worse outcome has been described by others [7, 8]. As all positive cultures in our study were treated with antibiotics, our findings suggest that positive cultures serve as a surrogate parameter for comorbidity and/or the complexity of surgery. However, we did not find any association with ASA classification, Charlson comorbidity index, type of infected prosthesis (revision or primary), the presence of a sinus tract, nor duration of surgery, which is consistent with previous findings [8]. Unfortunately, we did not have detailed data on prior orthopedic surgeries, quality of bone stock, etc, which could be contributing factors. Nevertheless, our findings do clearly identify a high-risk population that should be monitored carefully after reimplantation. Although the addition of a glycopeptide significantly reduced the rate of positive cultures at reimplantation, and positive cultures were associated with a higher failure rate, the addition of a glycopeptide per se did not lower the overall failure rate during follow-up. However, we did observe a lower failure rate due to CoNS in cases in which a glycopeptide was administered. We cannot fully explain this finding. The higher failure rates due to CoNS in the aminoglycoside monotherapy group could be due to selection bias considering the possibility that aminoglycosides have been administered in a different population compared to the glycopeptide group. Indeed our results demonstrated that a glycopeptide was less often applied when a CoNS was cultured during the first stage of the exchange; however, the difference in CoNS failure remained when solely analyzing non-CoNS PJIs. Randomized controlled trials should ideally be conducted to conclude about the exact benefit of adding a glycopeptide to the cement spacer on the long term.

The present study has the following limitations. As previously pointed out, there is a risk of selection bias due to its retrospective study design, which complicates its interpretation, especially in relation to outcome. Unfortunately, we did not collect detailed information on previous surgeries, quality of bone stock, antibiotic treatment, etc, which all may have contributed to and served as additional risk factors for a poor outcome, and those variables we did collect were not always complete for the total cohort. Also, due to differences between both centers and small changes over time concerning culturing techniques and prophylactic regimens, we were not able to evaluate its exact influence on positive cultures during reimplantation. In addition, complete data on antibiotic susceptibility patterns were not available in most cases and the aminoglycoside group was relatively small compared to the glycopeptide group. Another potential limitation could be that spacers were not sonicated in our cohort. However, false-positive results have also been described and sonication still fails to predict infection during follow-up in around 10% of cases [19–25].

In conclusion, 2-stage exchange procedures have high infection rates, during both reimplantation and follow-up, and improved treatment strategies are urgently required in these patients. A reduction of positive cultures during reimplantation can be achieved by routinely adding a glycopeptide to the cement spacer, which may also reduce the rate of failure due to CoNS afterward.

Supplementary Data

Supplementary materials are available at *Clinical Infectious Diseases* online. Consisting of data provided by the authors to benefit the reader, the posted materials are not copyedited and are the sole responsibility of the authors, so questions or comments should be addressed to the corresponding author.

Note

Potential conflicts of interest. All authors: No reported conflicts. All authors have submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest. Conflicts that the editors consider relevant to the content of the manuscript have been disclosed.

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