International Journal of Infectious Diseases 85 (2019) 175–181

Contents lists available at ScienceDirect

International Journal of Infectious Diseases

journal homepage: www.elsevier.com/locate/ijid

The prognosis of streptococcal prosthetic bone and joint infections depends on surgical management—A multicenter retrospective study

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ARTICLE INFO

Article history:
Received 18 May 2019
Received in revised form 11 June 2019
Accepted 12 June 2019
Corresponding Editor: Eskild Petersen, Aarhus, Denmark

Keywords:
Streptococcal
Prosthetic bone and joint infection
Debridement
Antibiotic

ABSTRACT

Background: The optimal treatment of streptococcal prosthetic joint infections (PJIs) is unclear.
Methods: A cohort of streptococcal PJIs was reviewed retrospectively in seven reference centers for the management of complex bone and joint infections, covering the period January 1, 2010 to December 31, 2012.
Results: Seventy patients with monomicrobial infections were included: 47 had infections of total hip arthroplasty and 23 had infections of total knee arthroplasty. The median age was 77 years (interquartile range (IQR) 69–83 years), the median Charlson comorbidity score was 4 (IQR 3–6), and 15.6% ($n = 11$) had diabetes. The most commonly identified streptococcal species were *Streptococcus agalactiae* and *Streptococcus dysgalactiae* (38.6% ($n = 27$) and 17.1% ($n = 12$), respectively). Debridement, antibiotics and implant retention (DAIR) was performed after a median time of 7 days (IQR 3–8 days), with polyethylene exchange (PE) in 21% of cases. After a minimum follow-up of 2 years, 27% of patients had relapsed, corresponding to 51.4% of DAIR treatment cases and 0% of one-stage ($n = 15$) or two-stage ($n = 17$) exchange strategy cases. Rifampicin or levofloxacin in combination therapy was not associated with a better outcome (adjusted $p = 0.99$). *S. agalactiae* species and DAIR treatment were associated with a higher risk of failure. On multivariate analysis, only DAIR treatment and *S. agalactiae* were independent factors of relapse. Compared to DAIR without PE, DAIR with PE was only associated with a trend towards a benefit (odds ratio 0.33, 95% confidence interval 0.06–1.96; adjusted $p = 0.44$).
Conclusions: Streptococcal PJIs managed with DAIR have a poor prognosis and *S. agalactiae* seems to be an independent factor of treatment failure.

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https://doi.org/10.1016/j.ijid.2019.06.012

Introduction

Prosthetic joint infections (PJIs) complicate 1–2% of total knee arthroplasties (TKA) and total hip arthroplasties (THA) (Gwam et al., 2017; Katz et al., 2012; Zimmerli et al., 2004). With an estimated increase of 673% for primary procedures for TKA and 174% for THA in the USA by 2030, the burden of PJIs will be one of the major challenges for the health care system in the future (Kurtz et al., 2007). A similar situation is expected in other developed countries such as England and Wales (Patel et al., 2015), due to the growing incidence of obesity worldwide (Cooper et al., 2000; Felson et al., 1988).

PJIs are of particular interest due to their high medical cost, their impact on functional capacity, and their need for multidisciplinary management. Indeed, PJIs are considered to be difficult to treat infections requiring complex surgical procedures and prolonged antimicrobial therapy (Zimmerli et al., 2004). *Streptococcus spp* are responsible for 10–20% of PJIs and are the second most common bacteria after staphylococcal species (Zimmerli et al., 2004; Bémer et al., 2014; Kaandorp et al., 1997). The reported outcomes of PJIs due to *Streptococcus spp* have varied widely across studies, with cure rates ranging from 35% to 100% (Odum et al., 2011; Sendi et al., 2011; Zeller et al., 2009; Meehan et al., 2003; Marculescu et al., 2006; Betz et al., 2015). A poorer outcome has been associated with comorbidities (American Society of Anesthesiologists (ASA) score above 2), *Streptococcus agalactiae* as the infecting organism, the surgical management, and antibiotic therapy without rifampicin (Zeller et al., 2009; Fiaux et al., 2016; Lora-Tamayo et al., 2017). While current guidelines still recommend 4- to 6-week therapy with penicillin G or ceftriaxone for β-hemolytic streptococcal PJIs, most patients are treated orally with highly bioavailable antimicrobial treatments such as rifampicin, levofloxacin, and amoxicillin (Fiaux et al., 2016; Osmon et al., 2013). Outcomes of streptococcal PJIs may have changed with these new therapeutic approaches. Consequently, this multicenter retrospective study was conducted in French reference centers for complex PJIs to identify prognostic factors associated with relapse following surgery in streptococcal PJIs.

Methods

Study design

This study was conducted in seven reference centers for the management of complex bone and joint infections in France (Angers, Brest, Le Mans, Nantes, Poitiers, Rennes, and Tours, which constitute the Centres de Référence des Infections Ostéo-articulaires du Grand Ouest (CRIOGO)). All adult patients with a PJI due to *Streptococcus spp* and treated in one of these centers between January 1, 2010 and December 31, 2012, were included retrospectively. This study was approved by the local ethics committee of Angers University Hospital (No. 2015-50). Data were recorded according to national procedures (Commission Nationale de l'Informatique et des Libertés, No. 1879591).

Definition of cases and microbiology

Streptococcal PJIs were defined according to Infectious Diseases Society of America (IDSA) guidelines and patients were identified using the medical records and microbiology databases (Osmon et al., 2013). Only infections of a TKA or a THA were studied and polymicrobial infections were excluded. Only the first episode of infection was included. All patients with a minimum follow-up of 24 months after the end of treatment were included.

Management of patients in reference centers

Overall, patient management was performed in accordance with IDSA guidelines and previous studies (Zimmerli et al., 2004; Osmon et al., 2013). For all cases, surgical treatment and antibiotic therapy were discussed by the multidisciplinary team, comprising at least a microbiologist, an infectious diseases consultant, and an orthopedic surgeon. Briefly, debridement, antibiotics and implant retention (DAIR) with polyethylene exchange (PE) was only proposed for early postoperative or acute hematogenous infections. According to the results of previous studies, 3–4 weeks between the onset of the infection and surgery was the cut-off decided within the CRIOGO network for DAIR treatment (Crockarell et al., 1998; Buller et al., 2012). Luxation of the prosthesis and PE was preferred for DAIR treatment, and arthroscopic synovectomy was not used due to a higher risk of relapse (Choi et al., 2011; Byren et al., 2009; Waldman et al., 2000). Failures following a conservative approach or late-onset infection were managed with one- or two-stage replacement. One-stage exchange was considered according to the local experience at each center, provided no bone reconstruction was necessary, the soft tissue envelope was not degraded, and the microorganism had been isolated from preoperative joint aspirate or blood culture. Two-stage exchange remained the gold standard for all other situations, with the preferred approach involving spacer implantation for 12 weeks.

Follow-up

Routine monitoring was first ensured by the infectious diseases consultant together with the orthopedic surgeon until the end of antimicrobial therapy, and then by the referring surgeon. Data were collected from local databases and medical records. Remission was defined as the disappearance of local signs of infection, improvement in functional activity, and normalization of C-reactive protein. A new sample from which the same *Streptococcus spp* was isolated as was identified in the previous infected joint prosthesis was defined as relapse of the infection. Isolation of another microorganism was considered as reinfection. Missing data on the outcome prior to 2 years post-treatment was an exclusion criterion.

Statistical analysis

All statistical analyses were conducted using R software (version 3.5.0). Continuous variables were expressed as the median (interquartile range (IQR)). Categorical variables were reported as numbers and percentages (%). All parameters were tested for risk of relapse. The Student *t*-test or the Mann–Whitney test was used for continuous data, as appropriate. The Chi-square test or Fisher's exact test was used for categorical variables, as appropriate. An automatic model selection based on the Akaike Information Criterion (AIC), with the stepwise backward–forward method, was computed using R software and the step function. All variables with a p-value of <0.3 in the univariate analysis were included in the initial model. The Kaplan–Meier method was used to evaluate the cumulative probability of failure. A log-rank test was performed to compare survival curves. All tests were two-sided. A p-value of <0.05 was

used as the cut-off for statistical significance. The false discovery rate method was used to take into account the multiple comparisons, using R software and the 'p.adjust' function. Adjusted *p*-values were calculated and presented in the final multivariate analysis results.

Results

Study population

Seventy patients were included. The number of patients included per center ranged from 5 to 17. The baseline characteristics and clinical presentation of the patients are provided in Table 1. Two thirds of patients ($n = 49$) were hospitalized in orthopedic wards, 29% ($n = 20$) in infectious disease departments, and one patient in the rheumatology department. The median length of stay in hospital was 22 days (IQR 14–30 days), with a range of 7–125 days.

Microbiology

Preoperative joint aspirates were performed in 68.6% of cases ($n = 48$), with a positive rate of 89.6% (43/48). Culture of intraoperative specimens was positive for 59/70 (84%) patients. For patients with negative intraoperative culture results, the bacteriological diagnosis had been made previously from preoperative joint aspiration or blood culture, and antibiotic treatment had been started before surgery. Seventy-one percent ($n = 50$) of patients had at least one set of blood culture drawn; these were positive in 38% of cases (19/50).

Table 1
Clinical characteristics and laboratory results of streptococcal prosthetic joint infections.

Parameter	Value
Age, years	77 (69–83)
Male sex	38 (54%)
Comorbidities	
Body mass index	29 (23–34)
ASA score[a]	3 (2–3)
Charlson Comorbidity Index	4 (3–6)
Chronic arterial hypertension	44 (62.9%)
Chronic heart failure	22 (31.4%)
Diabetes	11 (15.6%)
Chronic obstructive pulmonary disease	7 (10%)
Alcohol abuse	6 (8.6%)
Rheumatoid arthritis	5 (7.1%)
Chronic renal failure	4 (5.7%)
Peripheral arterial disease	4 (5.7%)
Active cancer	4 (5.7%)
Cirrhosis	1 (1.4%)
Time from onset of symptoms to clinical diagnosis (days)	7 (2–56)
Clinical and radiographic findings	
Temperature upon hospital admission	38.2 (37.4–38.8)
Painful prosthesis	63 (90%)
Abscess	24 (34.3%)
Sinus tract	17 (24.3%)
Implant loosening	15 (21.4%)
Portal of entry	
Unidentified	27 (38.6%)
Skin	20 (28.6%)
Surgical site infection	8 (11.4%)
Gastrointestinal tract	6 (8.6%)
Oral cavity	5 (7.1%)
Upper respiratory tract	3 (4.3%)
Lung	1 (1.4%)
Laboratory results	
C-reactive protein (mg/l)	186 (87–273)
White blood cell count (10^9/l)	11.7 (9–14)

Data are expressed as the median (interquartile range), or number (%).
[a] ASA score: American Society of Anesthesiologists.

Fourteen different species of *Streptococcus* were identified. The most common microorganism was *S. agalactiae* (group B *Streptococcus*), which accounted for 38.6% of cases ($n = 27$), followed by *S. dysgalactiae* (17.1%, $n = 12$), *S. pneumoniae* (10%, $n = 7$), milleri group *Streptococcus* (7.1%, $n = 5$), *S. mitis/oralis* (7.1%, $n = 5$), *S. gallolyticus* (5.7%, $n = 4$), *S. pyogenes* (4.3%,$n = 3$), *S. sanguinis* (2.9%, $n = 2$), *S. canis* (2.9%, $n = 2$), *Streptococcus spp* (1.4%, $n = 1$), *S. salivarius* (1.4%, $n = 1$), and *S. gordonii* (1.4%, $n = 1$).

Twenty-one percent ($n = 15$) of patients had concomitant extra-articular infections (skin and soft tissue infection surrounding the prosthesis in nine patients, dental abscess in two patients, meningitis in two patients, and sigmoid diverticulitis in two patients). None of the patients had infective endocarditis (ruled out with an echocardiogram, notably for *S. agalactiae* species).

Management of streptococcal PJIs

Antimicrobial therapy and surgical treatment are presented in Table 2. For patients with a confirmed allergy to amoxicillin, a cephalosporin was used for the intravenous period of treatment. Only one early postoperative infection was managed with exchange arthroplasty and no infection with a sinus tract was managed with DAIR treatment. DAIR treatment was performed after a median time of 7 days (IQR 3–8 days), with a range of 1–56 days. Nine DAIR treatment failures (eight DAIR and one DAIR + PE) were managed with a one-stage ($n = 4$) or two-stage ($n = 5$) exchange arthroplasty, with a cure rate of 100%. Of the remaining 10 patients with failure, two died from their infection, three underwent suppressive antimicrobial therapy, and one had a chronic sinus tract; no data were available for the final four. Empirical therapy was appropriate in all cases. No significant difference in intravenous antibiotic duration was observed between patients managed with DAIR and those treated with one- or two-stage exchange arthroplasty. Ten serious adverse events occurred: four skin rashes due to β-lactams, switched to other β-lactams ($n = 2$) or clindamycin ($n = 2$); two cases of amoxicillin-induced encephalopathy caused by severe renal insufficiency, switched to ceftriaxone; one severe thrombocytopenia related to rifampicin, switched to levofloxacin; one torsade de pointes under amoxicillin–levofloxacin combination therapy, switched to amoxicillin monotherapy; one severe diarrhea due to rifampicin, switched to co-trimoxazole; one rifampicin-induced hepatitis, switched to ceftriaxone. The oral route was used for definitive therapy in 88.6% ($n = 62$) of patients.

Outcome

Twenty-seven percent ($n = 19$) of patients experienced a relapse, with a median time to relapse of 3.7 months (range 0.2–20 months, IQR 2–5.5 months). The median follow-up of patients without relapse was 32 months (IQR 25–43 months). No association between comorbidities and the choice of DAIR treatment or exchange arthroplasty was observed (data not shown). Fifty percent of patients treated with DAIR experienced relapse, whereas all patients treated with prosthesis exchange were cured (adjusted $p < 0.001$). There was a trend towards improved outcomes in patients treated with the PE strategy, with 29% of relapses compared to 55% with DAIR alone (odds ratio (OR) 0.33, 95% confidence interval (CI) 0.06–1.96; adjusted $p = 0.44$). The one-stage exchange strategy ($n = 15$) showed similar performance to the two-stage exchange strategy ($n = 17$), with no treatment failure. The failure rate ranged from 13% to 60% (18% and 33% in centers that recruited more than 10 patients), with no significant between-center difference ($p = 0.2$). None of the patient comorbidities was associated with the outcome. Of note, patients with a

Table 2
Antimicrobial and surgical treatments. Univariate analysis of outcome predictors in streptococcal prosthetic joint infections

Parameter	Remission ($n = 51$)	Relapse ($n = 19$)	Univariate		Multivariate	
			p-Value	Adjusted *p*-value	*p*-Value	Adjusted *p*-value
Use of IV antibiotic therapy	46 (90%)	15 (79%)	0.21	0.56	>0.05	
IV antibiotic therapy, duration (days)	14 (7–39)	11.5 (6–14)	0.15	0.49	>0.05	
Combination antimicrobial therapy	31 (61%)	10 (59%)	0.89	0.99	NA[b]	
Amoxicillin therapy (alone or in combination therapy)	27 (53%)	12 (63%)	0.44	0.71		
Total duration of treatment						
≤6 weeks	8 (16%)	5 (26%)	0.31	0.63		
>6 weeks	43 (84%)	14 (74%)				
Serious adverse event	7 (14%)	3 (16%)	0.99	0.99		
Use of levofloxacin	18 (35%)	6 (32%)	0.77	0.99		
Combination therapy	15 (29%)	5 (26%)	0.80	0.99		
Rifampicin[a]	23 (45%)	8 (42%)	0.82	0.99		
Joint						
Infection of THA	36 (71%)	11 (58%)	0.31	0.63		
Infection of TKA	15 (29%)	8 (42%)				
Type of surgery						
DAIR (with or without PE exchange)	19 (37.3%)	19 (100%)	<0.001	<0.001	<0.001	<0.001
DAIR without PE exchange	14 (27%)	17 (89%)	<0.001	<0.001	<0.001	<0.001
DAIR with PE exchange	5 (10%)	2 (11%)	0.99	0.99	NA[b]	
One-stage exchange	15 (29%)	0 (0%)	0.007	0.04	<0.001	<0.001
Two-stage exchange	17 (33%)	0 (0%)	0.004	0.03	<0.001	<0.001
Time from symptoms to surgery (days)	23 (7–102)	7 (4–21)	0.12		>0.05	
Time from symptoms to DAIR (days)	7 (4–8)	7 (4–21)	0.71		NA[b]	

Data are expressed as the median (interquartile range), or number (%). DAIR, debridement, antibiotics and implant retention; IV, intravenous; PE, polyethylene exchange; THA, total hip arthroplasty; TKA, total knee arthroplasty.
[a] Rifampicin was always used in combination therapy.
[b] NA: not applicable (only variables with a *p*-value <0.3 in the univariate analysis were included in the model).

higher ASA score (≥3) had similar outcomes as compared with the other patients. *S. agalactiae* PJIs were associated with a higher rate of relapse than other species (44% vs. 16%; OR 4.1, 95% CI 1.4–12.5; $p = 0.01$). On multivariate analysis, the identification of *S. agalactiae* as the infecting organism (OR 7.09, 95% CI 1.58–31.8; adjusted $p = 0.0334$) and DAIR treatment without PE exchange (OR 32.36, 95% CI 5.48–191.13; adjusted $p < 0.001$) were independent predictors of relapse. Grouping DAIR with and without PE was also an independent predictor of relapse (adjusted $p < 0.001$). The cumulative probabilities of remission of *S. agalactiae* and other streptococcal species are presented in Figure 1.

Discussion

Main results

This study performed in reference centers for complex PJIs found a high rate of relapse with DAIR treatment and the *S. agalactiae* species. These two elements were found to be independent predictive factors of treatment failure.

Prognostic significance of streptococcal species

It was found that *S. agalactiae* accounted for more than a third of streptococcal PJIs, which is consistent with previous studies relating an incidence of between 17% and 44% in PJIs (Sendi et al., 2011; Zeller et al., 2009; Meehan et al., 2003; Fiaux et al., 2016;

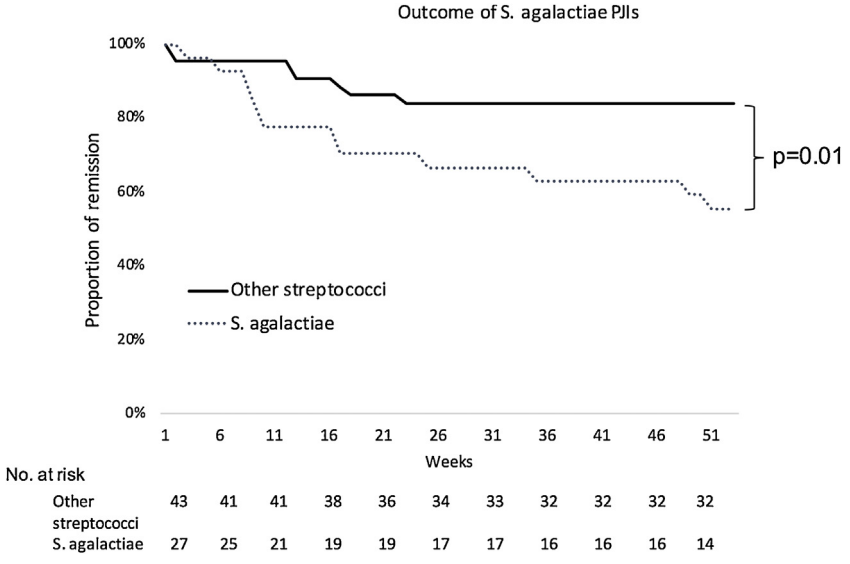

Figure 1. Cumulative probability of remission for patients infected with *Streptococcus agalactiae* or other streptococcal species.

Lora-Tamayo et al., 2017; Everts et al., 2004; Sendi et al., 2008; Skoff et al., 2009). Indeed, a growing incidence of *S. agalactiae* infections in non-pregnant women including PJIs has been observed, probably related to an increase in comorbidities in adults, especially diabetes (Sendi et al., 2008; Skoff et al., 2009). Twenty-six percent of patients with an *S. agalactiae* PJI in this study had diabetes, compared with 9% for other streptococcal PJIs (non-significant difference).

S. agalactiae was independently associated with a higher rate of relapse as compared to other streptococcal species. This finding is difficult to interpret, with conflicting results amongst studies. Zeller et al. reported an independent association, whereas two very recent large cohorts did not (Zeller et al., 2009; Fiaux et al., 2016; Lora-Tamayo et al., 2017). A protective effect of rifampicin has been suggested as one explanation, however rifampicin-based antibiotic combinations were used at a similar frequency in different studies, which makes this hypothesis unlikely (Fiaux et al., 2016; Lora-Tamayo et al., 2017). The interaction between *S. agalactiae* and host factors should be studied further.

Impact of surgical strategies on infection outcome

The overall outcome of these patients with streptococcal PJIs was mixed, with a treatment failure rate of 27%. Fifty percent of patients treated by DAIR experienced a relapse of their infection, whereas all patients treated with prosthesis exchange were cured, which is close to previous data. Fiaux et al. reported 55 streptococcal PJIs managed by DAIR with a failure rate of 58.2% (Fiaux et al., 2016). The very recent study of Lora-Tamayo et al., which included a large international cohort of streptococcal PJIs, noted relapse in 42.1% of cases (Lora-Tamayo et al., 2017). Betz et al. reported discordant results, with a remission rate of 100% (Betz et al., 2015); however the small size of their cohort ($n = 14$) and the lack of information about streptococcal species involved may explain some of these differences. These results are consistent with staphylococcal PJIs managed with DAIR treatment, with a relapse rate between 45% and 56% (Lora-Tamayo et al., 2013; Zürcher-Pfund et al., 2013).

This high failure rate of DAIR treatment may be related to certain variations in DAIR protocol. The time from onset of symptoms to debridement and performing a PE are probably major confounding factors. However, the study results are borne out by respect of the a priori exclusion criteria (no patient with fistula was treated with DAIR) and a median time before surgery of 1 week in this population with 18% of PE, which is quite similar to Meehan et al. (4 days, 26% of PE), Lora-Tamayo et al. (5 days, 53% of PE), and Sendi et al. (6 days, no information on PE), but differs from Fiaux et al., with 62% of DAIR treatment performed between 30 and 90 days after the implantation with 100% PE (Fiaux et al., 2016). This delay for debridement has been associated with a worse outcome for staphylococcal PJIs and streptococcal PJIs, with a cut-off ranging between 8 and 21 days (Marculescu et al., 2006; Buller et al., 2012), as well as the absence of PE (Lora-Tamayo et al., 2013; Zhang et al., 2017). Finally, in the recent study of Lora-Tamayo et al. (Lora-Tamayo et al., 2017), the outcome may have been impacted by the inclusion of polymicrobial infection, as described previously (Lora-Tamayo et al., 2013).

No failure occurred in patients treated with an exchange arthroplasty. A previous study by Sendi et al. found the same results in *S. agalactiae* PJIs with a one-stage ($n = 3$) or two-stage exchange strategy ($n = 12$) (Sendi et al., 2011). Interestingly, five of these episodes were initially treated with DAIR, as in the case of nine patients in our series (five managed with a one-stage exchange and four with a two-stage exchange strategy after failure with DAIR treatment). In streptococcal PJIs, despite the high failure rate of DAIR, salvage therapy (second-line surgery) with one- or two-stage exchange could be safe with an excellent prognosis. Of note, in the study by Fiaux et al., the cure rates observed after one-stage and two-stage arthroplasty were 76.9% ($n = 10/13$) and 94.7% ($n = 18/19$), respectively (Fiaux et al., 2016). When considering the results of a high failure rate with DAIR and the excellent prognosis with exchange arthroplasty, patients with streptococcal PJIs, especially those due to *S. agalactiae*, should always be considered for replacement of the prosthesis (in one or two stages, depending on the patient and the episode).

Role of antimicrobial therapy

Most of the patients in this study received combination therapy including a β-lactam (mainly amoxicillin) with rifampicin or levofloxacin. This approach is based on the benefit provided for staphylococcal and gram-negative-related PJIs, respectively, and to favor oral switch (Lora-Tamayo et al., 2013; Senneville et al., 2011; Tornero et al., 2016; Martínez-Pastor et al., 2009; Zimmerli et al., 1998). No antimicrobial therapy, alone or in combination, was associated with a better outcome. In particular, the use of rifampicin and levofloxacin had no impact on the relapse rate. A trend towards a better prognosis in rifampicin–levofloxacin combinations was suggested recently; however the effect did not persist in the multivariate analysis of the study (Fiaux et al., 2016). The largest study on streptococcal PJIs also failed to show a benefit of rifampicin therapy (Lora-Tamayo et al., 2017). More precisely, rifampicin did not improve the prognosis of patients who received β-lactams, whereas patients treated without β-lactams benefited from this antibiotic (e.g., glycopeptides) (Lora-Tamayo et al., 2017). Despite anti-biofilm activity and low minimum inhibitory concentrations (MICs) against streptococcal species, the benefit of adding rifampicin in the treatment of PJIs is not yet established in infections due to bacteria not belonging to the *Staphylococcus* genus. Moreover, adverse events are common with rifampicin treatment alone or in combination with fluoroquinolones (31–33% for rifampicin alone (Fiaux et al., 2016; Nguyen et al., 2015) and 33% for rifampicin–fluoroquinolone combination (Senneville et al., 2011)), leading to treatment discontinuation in 10% of cases (Fiaux et al., 2016). Reducing the dosage of rifampicin seems to be a promising approach to reduce digestive intolerance (Nguyen et al., 2015); however current data for streptococcal PJIs should raise the question of whether rifampicin should be prescribed.

Study limitations and strengths

The inferences that can be drawn from the study data may be limited by the retrospective design of the study, with no randomization of the surgical strategy and with heterogeneity between centers. Another flaw is the lack of statistical power. For instance, the low rate of PE did not allow a significant association between PE and the outcome to be identified. Only a trend towards a benefit was observed. The period of the study (2010–2012) may have influenced the type of DAIR chosen for the surgery. Since 2010, several studies have highlighted the importance of PE in acute infections. PE is now a standard of care and is systematically performed during DAIR surgery, which was not the case in 2010. The lack of beneficial effects of rifampicin or levofloxacin seems to agree with some of the literature observations, but a beta error due to an underpowered study cannot be excluded. Furthermore, none of the comorbidities were associated with the outcome, whereas a high ASA score, chronic renal failure, and rheumatoid arthritis have previously been identified as independent factors of relapse (Zeller et al.,

2009; Lora-Tamayo et al., 2017). This may be due to a lack of power of the samples in the present study. Including a longer study period could have enhanced the power of the study, but the data were not available for analysis.

Some strengths of the study should also be highlighted, such as the fact that only monomicrobial infections were included and the effort made to extend the follow-up to more than 2 years.

Conclusions

Streptococcal PJIs have a similar and high rate of failure for DAIR treatment as other PJIs, and *Streptococcus agalactiae* is an independent risk factor for relapse, perhaps through host comorbidities. Replacement of the prosthesis should be considered as a first-line strategy for streptococcal PJIs, especially those with the highest risk of failure with DAIR treatment. Disappointingly, rifampicin seems to have no or only a slight protective effect on streptococcal PJIs.

Funding

None.

Ethical approval

This study was approved by the local ethics committee of Angers University Hospital (No. 2015-50). Data were recorded according to national procedures (Commission Nationale de l'Informatique et des Libertés, No. 1879591).

Informed consent

No consent was requested by the ethics committee due to the retrospective nature of the study.

Conflict of interest

The authors declare no conflict of interest.

Acknowledgements

Thanks to Doctor Alaa Ghali for reviewing the manuscript.

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