The Journal of Arthroplasty 29 (2014) 877–882

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Periprosthetic Joint Infections Treated with Two-Stage Revision over 14 Years: An Evolving Microbiology Profile

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ARTICLE INFO

Article history:
Received 2 August 2013
Accepted 28 September 2013

Keywords:
infected total hip arthroplasty
total knee arthroplasty infection
total hip arthroplasty infection
complications
revision total knee arthroplasty
revision total hip arthroplasty
infectious

ABSTRACT

Late periprosthetic joint infection (PJI) occurs in 0.3%–1.7% of total hip arthroplasties (THAs) and 0.8%–1.9% of total knee arthroplasties (TKAs). Surgical debridement, explant, and appropriate antibiotics are imperative for successful treatment. We analyzed organisms from PJIs at one institution for temporal trends over 14 years. Poisson regression model demonstrated a linear increase in infection rate for the following bacteria as the primary organism: MRSA (incidence rate ratio [IRR] = 1.11, $P = 0.019$), *Streptococcus viridans* (IRR = 1.18, $P = 0.002$), and *Propionibacterium acnes* (IRR = 1.21, $P = 0.024$). The increase in proportion of these organisms may warrant further discussion on pre-surgical MRSA screening and empiric therapy to include MRSA coverage, increased incubation time to detect *P. acnes*, and dental prophylaxis against *S. viridans*.

In 2012 alone, over 900,000 total hip arthroplasties (THAs) or total knee arthroplasties (TKA) were performed in United States [1]. Periprosthetic joint infection (PJI) is a potentially devastating complication that occurs in approximately 0.3%–1.7% of all THAs and 0.8%–1.9% of all TKAs [2,3], and is one of the leading causes of revision surgery. As the number of total joint arthroplasties performed in the United States each year continues to rise [4], the cases complicated by deep postoperative infection will likely increase and carry with it a significant socio-economic cost [5].

In 2012, over 8800 arthroplasties were performed at our institution. Our overall incidence of surgical site infection (SSI) for hip procedures is 0.3% statistically below the state average after a risk-adjusted analysis [2]. However, as a high volume tertiary referral center, our hospital assumes the care of many complex arthroplasty cases, including PJIs. A so-called two-stage reimplantation with surgical debridement and possible explantation of components with placement of an antibiotic spacer followed by timely and appropriate antibiotic administration has led to the highest rates of successful eradication of PJI [6], and is currently the treatment of choice for our institution. Often the infectious organism is not identified, either due to inability to culture it from aspirated joint fluid and tissue samples or secondary to prior antibiotic treatment. In these cases, epidemiologic data of PJIs may be used to guide the orthopedic surgeon and infectious disease specialist in determining the best empiric coverage for the most likely infectious organisms. The purpose of this study is to characterize the organisms responsible for deep infection following total hip and knee arthroplasty at our institution over the last 14 years and to evaluate temporal trends in pathogen type and virulence.

Materials and Methods

This study was conducted at a high-volume teaching orthopedic specialty hospital in an urban setting. After institutional review board approval, an electronic search of all hospital records was conducted over a 14 year period (January 1, 1998 to June 30, 2011) to identify all revisions and explantations of THAs and TKAs. A 2-stage reimplantation has been the standard of care for our institution [7], therefore most cases received an antibiotic cement spacer at the time of explantation. Patients were included if all arthroplasty components were removed and culture data were available in the form of intraoperative cultures and/or pre-explantation joint aspiration.

Guidelines from The Workgroup Convened by the Musculoskeletal Infection Society [8] were used to evaluate for PJI. Hard copy charts

Disclosure: None of the authors received payments or services, either directly or indirectly (i.e., via his or her institution), from a third party in support of any aspect of this work. None of the authors, or their institution(s), have had any financial relationship, in the thirty-six months prior to submission of this work, with any entity in the biomedical arena that could be perceived to influence or have the potential to influence what is written in this work. Also, no author has had any other relationships, or has engaged in any other activities, that could be perceived to influence or have the potential to influence what is written in this work.

Source of Funding: No outside funding was used to conduct this study.

The Conflict of Interest statement associated with this article can be found at http://dx.doi.org/10.1016/j.arth.2013.09.053.

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0883-5403/2905-0004$36.00/0 – see front matter
http://dx.doi.org/10.1016/j.arth.2013.09.053

Table 1
Culture Data Over 14-Year Period by Organism.

	'98	'99	'00	'01	'02	'03	'04	'05	'06	'07	'08	'09	'10	'11*	Total THAs	Total TKAs	Total by Species
Negative Cultures	20	18	12	11	12	6	5	9	7	15	12	10	23	7	80	87	**167**
Gram Positive																	
Diphtheroids	0	1	0	1	0	0	0	0	0	1	0	0	2	3	5	3	**8**
MSSA	8	15	10	6	5	10	13	8	13	14	10	12	11	10	82	63	**145**
MRSA	1	4	2	0	0	1	1	5	0	1	3	2	10	4	20	14	**34**
Other staph	2	1	4	8	2	5	8	3	6	9	7	2	7	5	23	46	**69**
MRSE	3	2	1	5	1	2	3	1	0	4	3	4	8	4	21	20	**41**
MSSE	5	7	12	11	12	9	6	11	7	12	5	9	4	2	56	56	**112**
Enterococcus	4	2	5	1	5	1	4	6	1	5	2	2	2	1	27	14	**41**
Clostridium	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2	0	**2**
S. viridans	0	1	1	2	0	2	0	1	3	3	4	1	5	6	15	14	**29**
Other strep	4	4	6	1	3	6	4	7	2	5	3	7	4	1	20	37	**57**
P. acnes	0	0	1	0	0	2	0	0	2	0	2	0	3	3	3	10	**13**
Listeria	0	0	1	0	0	1	0	0	0	0	1	0	0	0	2	1	**3**
Arcanobacterium	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	**1**
Unspecified	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2	0	**2**
Total	**27**	**38**	**44**	**36**	**28**	**39**	**39**	**42**	**34**	**54**	**40**	**40**	**56**	**40**	**278**	**279**	**557**
Gram Negative																	
E. cloacae	0	0	2	0	0	1	1	0	1	0	0	1	1	0	2	5	**7**
P. aeruginosa	0	3	0	1	1	1	1	3	0	1	2	1	0	1	9	6	**15**
E. coli	0	1	0	1	0	1	1	2	1	0	1	1	1	1	7	4	**11**
Proteus	0	0	1	0	0	1	1	0	0	1	0	1	0	0	2	3	**5**
Serratia	0	1	1	0	0	1	0	0	0	0	0	0	0	1	2	2	**4**
Klebsiella	0	0	1	0	0	0	0	0	0	2	1	0	1	0	2	3	**5**
Other	0	0	2	1	2	0	0	0	0	1	1	1	1	0	3	6	**9**
Total	**0**	**5**	**7**	**3**	**3**	**5**	**4**	**5**	**2**	**5**	**5**	**5**	**4**	**3**	**27**	**29**	**56**
Fungal																	
Candida	**0**	0	0	1	0	1	0	0	0	1	2	0	0	0	3	2	**5**
Total by Year	**47**	**61**	**63**	**51**	**43**	**51**	**48**	**56**	**43**	**75**	**59**	**55**	**83**	**50**	**395**	**390**	**785**

* Data from 2011 represent a 6-month collection period.

were reviewed until 2006; radiographs and electronic medical records (Eclipsys, AllScripts; Chicago, IL) were reviewed for all cases presenting after 2006. Patients were considered eligible if basic demographic data (height, weight, and age), operative reports, and culture data were available. Cases with negative cultures were considered for inclusion based on clinical documentation. That is, if a clear concern for peri-prosthetic infection was expressed in the patient's medical chart, the patient was included. Patients treated with an extended course (greater than two weeks) of post-operative antibiotics before a second stage were included for analysis. Several patients were initially treated with an antibiotic spacer and replanted after cultures were negative (always less than two weeks after initial explant); these patients were not considered to have a peri-prosthetic infection for this study.

Culture data, including aerobic, anaerobic, and fungal species, were recorded for the first three organisms listed in the culture reporting. In the case of polymicrobial infection, the primary offending organism was defined as the organism represented most frequently in the aspirate and/or intra-operative cultures. If all organisms were present in all cultures, then the primary organism was defined as the organism with the greatest abundance of growth (in descriptive terms from our microbiology laboratory). In the rare instance where these criteria were equivocal, an infectious disease specialist determined the primary organism. When a species was encountered in a minority of cultures (e.g., in one out of six intra-operative cultures) and was also a member of commensal skin flora (e.g. *Staphylococcus epidermidis*), the case was reviewed by an infectious disease specialist to determine if the species was a contaminant or actual pathogen.

The difference in proportion of THA and TKA infected with each organism was compared using Chi-square tests corrected via False Discovery Rate estimation. The annual rate (%) of PJI for each organism for each study year was calculated then analyzed via a Poisson regression model. Basic patient demographics for THA and TKA were collected and compared by Fisher exact test. A two-tailed z-test was used to calculate differences in proportions of medical co-morbidities in the populations. Statistical significance was calculated with $\alpha = 0.05$ and $\beta = 0.20$.

Results

Over the 14 year study period, there were 395 THAs and 390 TKAs explanted for infection. All data are available for review in Table 1. Demographics for the groups were similar for age and length of hospital stay. Body Mass Index (BMI) was significantly higher for the TKA group, consistent with prior cross-sectional studies [9] and our own data for primary hip and knee arthroplasty. Basic medical co-morbidity data were gathered for all patients, as shown in Table 2. TKA patients were noted to have a statistically higher proportion of rheumatoid arthritis and hypertension, whereas THA patients had a higher proportion of renal disease, although the overall incidence was quite low. There were no differences in overall proportion of patients with diabetes or history of myocardial infarction.

The distribution of organism type can be seen in Fig. 1: 72.6% of primary pathogens were Gram-positive, 7.1% Gram-negative, and 0.6% fungal. In 21.3% of patients, no organism was identified. 12.1% of

Table 2
Comparison of Groups by Arthroplasty Type.

	THA	TKA	*P*
N	395	390	
Men	235	203	0.21
Women	160	195	
Age	65.3 ± 14.0	65.6 ± 12.0	0.75
LOS	20.9 ± 18.9	18.8 ± 21.7	0.15
BMI	28.1 ± 6.7	30.7 ± 7.2	0.0001
Medical History:			
Diabetes	13.7	17.9	0.11
Rheumatoid	7.5	12.6	0.017
Hypertension	46.1	56.5	0.0036
Renal Disease	2.8	1	0.0016
Myocardial Infarction	7.5	6.6	0.62