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Original article

Do local antibiotics reduce periprosthetic joint infections? A retrospective review of 744 cases

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ABSTRACT

Periprosthetic joint infections (PJI) are uncommon but not rare and have significant morbidity and financial implications. Local antibiotics have been used successfully in other areas of orthopedics to reduce postoperative infections, but this method has not been proven in total joint arthroplasty (TJA). Beginning January 1, 2014, our primary investigators began using surgical site lavage with providone-iodine solution and administering 2 g of vancomcyin powder in the surgical wound prior to capsule closure for all primary and revision total hip and knee arthroplasties. We performed a retrospective chart review of patients two years prior to this date and two years after to compare occurrence of PJI. The groups were broken down into patients who received local antibiotics versus those who did not. The groups were further broken down by type of surgery performed; primary or revision total hip or knee arthroplasty. Administration of local antibiotics was preventative for PJI only in the primary total knee arthroplasty group (aOR = 0.28, 0.09–0.89). Administration of local antibiotics trended towards a preventative effect for PJI in the other groups but was not statistically significant. Patients receiving local antibiotics had similar blood urea nitrogen and creatinine levels postoperatively compared to the no antibiotics group indicating minimal systemic effects of local vancomycin powder. While the use of local antibiotics may prevent PJI, more data is required especially in the revision arthroplasty groups.

1. Introduction

Total joint arthroplasty (TJA) is a common procedure that will continue to grow in popularity due to the high rate of successful outcomes. By the year 2030 the demand for total hip arthroplasty (THA) is expected to grow 174% and the demand for total knee arthroplasty (TKA) is expected to grow 673%. Revision total hip (RTHA) and revision total knee arthroplasties (RTKA) are expected to grow 137% and 601% respectively by 2030.[1] Periprosthetic joint infections (PJI) are uncommon but not rare. The prevalence of PJI is 1.3% after THA, 3.2% after RTHA, 2% after TKA and 5.6% after RTKA.[2] Revision arthroplasty is a morbid and costly procedure that should be avoided if possible. One study showed a 30% increase in the cost of RTKA compared to TKA.[3]

The use of local antibiotics in TJA for infection prophylaxis is currently off label which is likely why there is scarce literature to advocate its use. Especially lacking are large multicenter prospective trials. There has been a trend towards increased usage of local antibiotics in surgical wounds in recent orthopedic literature, particularly orthopedic spine and trauma surgery. Most of these studies have been promising, showing reduced infection rates and costs savings in the local antibiotic group. One retrospective study using local vancomycin powder after posterior spinal fusion (PSF) showed not only a significant reduction in surgical site infections, but also a large savings in cost when comparing the need for a second surgery compared to the cost of vancomycin powder. In this study 0 out of 96 patients receiving local vancomycin powder required a second operation for surgical site infection versus 7 out of 207 in the control group. The cost of a single dose of vancomycin was determined to be $12, or $1152 for the entire study group. A total of $573,897 was spent on the 7 patients who had surgical site infections.[4] A retrospective study by O'Neill et al. of 110 patients undergoing PSF showed patients receiving standard systemic prophylaxis preoperatively had an infection rate of 13%, while the group that received standard prophylaxis plus local vancomycin

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had an infection rate of 0%.[5] A retrospective comparative study by Caroom et al. using prospectively collected data in patients undergoing posterior cervical fusion showed local use of vancomycin decreased infection rate from 15% to 0% in a group of 112 patients.[6]

Orthopedic trauma surgeons have advocated the use of local antibiotics in open fractures for decades. One trauma study observed 26 patients receiving vancomycin impregnated calcium sulfate after open reduction internal fixation of long bone fractures. Zero patients in this study had an infection at an average follow up on 10.5 months.[7] The use of antibiotic impregnated polymethyl methacrylate in grade II and III open fractures has been advocated by some. Ostermann et al. retrospectively reviewed 1085 patients with open fractures and found a reduction of infection in type III open fractures from 20% to 6.5% when aminoglycoside impregnated beads were added to systemic therapy alone.[8] However, antibiotic beads are not desirable for TJA because it would involve a second surgery to remove the beads and likely lead to third body wear.

Total joint surgeons have used anti-biotic impregnated cement in THA and TKA with some success. A systematic review and meta-analysis of 6381 patients undergoing TJA showed the relative risk of infection in patients receiving antibiotic impregnated cement versus plain cement was 0.47 ($p = 0.04$).[9] A more recent meta-analysis showed patients with antibiotic impregnated cement had a reduction in infection rate in THA but not TKA. This same study also showed adding antibiotics had a dose dependent reduction of compressive and tensile strength of the bone cement which was an unfavorable side effect.[10] Another trend in TJA is irrigating the surgical wound with diluted antibiotic solution prior to placement of permanent implants. A study of 1682 TJA compared infection rates between groups with and without providone-iodine lavage prior to permanent implant placement. This study showed a decrease in the 3 month deep infection rate (0.97%–0.15%, $p = 0.04$) in the providone-iodine group.[11]

The purpose of this study is to determine whether or not local antibiotics in primary and revision total hip and knee arthroplasties reduced the rate of PJI compared to systemic antibiotics alone. We also hope to show that the local use of vancomycin and providone-iodine is safe and does not create wound complications or systemic side effects. To our knowledge there are currently no studies on the usage of vancomycin powder and providone-iodine irrigation for the prevention of infection in TJA.

2. Patients and methods

After approval from the Institutional Review Board, a retrospective analysis was performed on patients from the Texas Tech University Department of Orthopedics during January 1, 2012 to December 31, 2015 undergoing TKA, RTKA, THA or RTHA. We chose this 4 year time period because our primary investigators began irrigating surgical wounds with providone-iodine (Betadine Microbicides) solution before placement of permanent implants and administering vancomycin powder in the wounds prior to closure of the joint capsule beginning January 1, 2014. This change in protocol was initiated due to recent literature from orthopedic spine and trauma studies showing reduced infection rates in patients treated with local administration of antibiotics at the surgical site. This time period allowed us to compare four years of data; two prior to the use of local antibiotics and two after.

During this time period we identified 897 procedures coded as TKA, THA, RTKA, or RTHA. Seven hundred and two patients were included in the study for a total of 744 procedures. Sixty-one patients that underwent revision hip or knee arthroplasty who had a pre-existing PJI were excluded from the study due to their high risk of re-infection. Ninety-two cases did not have a minimum of 6 months follow up and were excluded from the study. The indications for TKA or THA were patients with radiographic evidence of osteoarthritis of the hip or knee who had failed at least 3 months of non-operative treatment modalities. The indications for RTKA and RTHA were aseptic loosening, periprosthetic fracture, and polyethylene wear.

A retrospective chart review of the included patients was performed. Epidemiologic data was collected on the following patient characteristics; age at time of surgery, sex, body mass index (BMI), smoking status, hypertension, diabetes, heart disease, chronic obstructive pulmonary disease, rheumatoid arthritis, and lupus. We chose these characteristics because we considered them to be potential confounders for infection rate between groups. Age was recorded as a whole number in years. Obesity for this study was defined as BMI greater than 30 at the time of surgery. Sex, smoking status, diabetes, hypertension, chronic obstructive pulmonary disease, rheumatoid arthritis, and lupus were self-reported on patient intake forms which were scanned into the patient's chart. Heart disease was defined as a patient self-reporting coronary artery disease or history of a myocardial infarction. Blood urea nitrogen (BUN) and creatinine values were recorded on postoperative day 1 and reported as numerical values to the first decimal place to monitor for acute kidney injury postoperatively.

All TJA in both groups followed identical preoperative, periopertive, and postoperative protocols with regards to pain control, anesthesia, wound closure, and postoperative wound care. Patients undergoing primary arthroplasty received cefazolin preoperatively followed by three doses postoperatively. If patients were allergic to cefazolin they received clindamycin perioperatively in the same fashion. Patients undergoing revision arthroplasty received vancomycin preoperatively. Revision patients were kept on vancomycin until their intraoperative cultures were negative for growth at two days. If revision patients were allergic to vancomycin, they received clindamycin perioperatively. The procedures were performed by two orthopedic surgeons at our institution over a period of four years. Patients from January 1, 2012 to December 31, 2013 did not receive local antibiotics prior to surgical wound closure. Patients from January 1, 2014 to December 31, 2015 were treated with surgical wound providone-iodine lavage prior to permanent implant placement and administration of vancomycin powder in the surgical wound prior to closure of the joint capsule. The group that did not receive local antibiotics will from now on be referred to as the no-antibiotics group, and the group that received antibiotics will be referred to as the antibiotics group. For primary arthroplasty, prior to placement of final implants the antibiotics group's surgical wound was irrigated with 300 ml of providone-iodine and normal saline using a bulb syringe. The no-antibiotics group was irrigated with 300 ml of normal saline in the same fashion prior to final implant placement. For revision arthroplasty, prior to placement of final implants the antibiotics group was irrigated with 3 liters of providone-iodine and normal saline solution using a Pulsavac lavage system (Zimmer Biomet). The no-antibiotics group was irrigated with 3 liters of normal saline using a Pulsavac lavage system. The providone-iodine and saline solution was prepared using 15 ml providone-iodine per 1 l normal saline. This concentration was chosen based on a previous study that used providone-iodine to irrigate THA and TKA surgical wounds prior to implant placement. This study showed a decreased infection rate in the providone-iodine group.[11] After the permanent implants were placed and prior to capsule closure, the antibiotics group received 2 g of vancomycin powder evenly distributed throughout the surgical wound. The no-antibiotics group received no vancomycin powder prior to closure. Joint capsule, deep tissue, and skin closures were identical between groups. All wounds were dressed

with an incisional wound vacuum set at 125 mmHg of continuous suction. Prior to discharge from the hospital, the wound vacuum was removed and replaced with an Aquacell (ConvaTec) dressing. This dressing was left in place until the first postoperative visit.

Patients were observed in clinic at various intervals from 2 weeks to 6 months postoperatively. Surgical wounds were evaluated at each clinic visit. Sutures were typically removed between 2 and 3 weeks postoperatively. The postoperative clinic notes were reviewed at time points between 2 weeks and 6 months. Patients were recorded as having no infection or having a PJI. Periprosthetic joint infections were defined in accordance with the definition set forth by Parvizi et al. and the workgroup of the Musculoskeletal Infection Society as described in 2010.[12] Wound healing complications that did not meet PJI criteria were recorded at each visit.

3. Statistical analysis

Sample characteristics were summarized by local antibiotic administration and by type of surgery. Continuous variables were compared using *t*-test and one-way analysis of variance, and gender and risk factors were compared using chi-squared test, in order to assess differences in sample distribution.

Unadjusted odds ratios for PJI during 6 months after surgery were assessed considering the following sources of differences: local antibiotic use, surgery (primary vs. revision arthroplasty), body part (hip vs. knee), age, smoking, obesity, hypertension, heart disease, diabetes mellitus, chronic obstructive pulmonary disease (COPD), rheumatoid arthritis, lupus, creatinine, and blood urea nitrogen. Adjusted odds ratios were calculated using logistic regression analysis with all the aforementioned factors. Odds ratios were reported with 95% confidence intervals, and p values were also estimated for the adjusted model. Significance level was set at 0.05. Wound healing complications were assessed using chi-sqaured test. All tests were performed using SPSS Version 22 (IBM, Armonk, New York).

4. Results

Among TKA patients, we observed statistically significant differences in percentage of smokers ($p < 0.001$), hypertension ($p = 0.010$), and COPD ($p = 0.032$) between those who were treated with local antibiotics and those who were not (Table 1). No other statistically significant differences were found in sample characteristics among TKA, RTKA, THA, and RTHA (Tables 2–4). Only diabetes showed unadjusted higher odds for PJI in TKA patients (OR = 3.00, 1.16–7.85). However, after adjusting for other variables, administration of local antibiotics was the only statistically significant factor on PJI in TKA, which showed a preventive effect (aOR = 0.28, 0.09–0.89) (Table 5). Although we observed similar preventative trends in other cohorts (RTKA, aOR = 0.21, 0.02–2.18; THA, aOR =

Table 1
TKA sample characteristics by local antibiotic use.

	Local antibiotics		
	No (n = 152)	Yes (n = 191)	p-value
Gender, n (%)			0.326
Female	104 (68.4)	121 (63.4)	
Male	48 (31.6)	70 (36.6)	
Age, mean (SD)	27 (17.8)	80 (41.9)	<0.001
Smoker, n (%)	98 (64.5)	106 (55.5)	0.093
BMI > 30, n (%)	105 (69.1)	155 (81.2)	0.010
HTN, n (%)	23 (15.1)	42 (22)	0.107
Heart Disease, n (%)	40 (26.3)	50 (26.2)	0.977
DM, n (%)	2 (1.3)	11 (5.8)	0.032
COPD, n (%)	14 (9.2)	24 (12.6)	0.325
Rheumatoid, n (%)	0 (0)	5 (2.6)	0.069
Lupus, n (%)	64.1 (10.3)	63.6 (10.2)	0.972
Creatinine, mean (SD)	0.9 (0.3)	0.9 (0.4)	0.551
BUN, mean (SD)	15.5 (5.6)	15.1 (5.7)	0.574

Table 2
RTKA sample characteristics by local antibiotic use.

	Local antibiotics		
	No (n = 45)	Yes (n = 46)	p-value
Gender, n (%)			0.762
Female	25 (55.6)	27 (58.7)	
Male	20 (44.4)	19 (41.3)	
Age, mean (SD)	63.8 (10.7)	61.5 (9.7)	0.284
Smoker, n (%)	8 (17.8)	13 (28.3)	0.235
BMI > 30, n (%)	31 (68.9)	28 (60.9)	0.423
HTN, n (%)	29 (64.4)	31 (67.4)	0.767
Heart Disease, n (%)	11 (24.4)	6 (13)	0.163
DM, n (%)	16 (35.6)	13 (28.3)	0.455
COPD, n (%)	3 (6.7)	5 (10.9)	0.714
Rheumatoid, n (%)	3 (6.7)	4 (8.7)	1.000
Lupus, n (%)	0 (0)	2 (4.3)	0.495
Creatinine, mean (SD)	1 (0.3)	1.1 (1.2)	0.494
BUN, mean (SD)	16.7 (6.7)	16 (6.7)	0.647

Table 3
THA sample characteristics by local antibiotic use.

	Local antibiotics		
	No (n = 97)	Yes (n = 133)	p-value
Gender, n (%)			0.698
Female	50 (51.5)	72 (54.1)	
Male	47 (48.5)	61 (45.9)	
Age, mean (SD)	60.4 (13.8)	58.8 (13.9)	0.383
Smoker, n (%)	23 (23.7)	46 (34.6)	0.076
BMI > 30, n (%)	48 (49.5)	66 (49.6)	0.983
HTN, n (%)	49 (50.5)	79 (59.4)	0.181
Heart Disease, n (%)	13 (13.4)	22 (16.5)	0.513
DM, n (%)	14 (14.4)	24 (18)	0.466
COPD, n (%)	4 (4.1)	12 (9)	0.193
Rheumatoid, n (%)	8 (8.2)	10 (7.5)	0.839
Lupus, n (%)	1 (1)	2 (1.5)	1.000
Creatinine, mean (SD)	0.9 (0.4)	1 (1.2)	0.396
BUN, mean (SD)	15.2 (6.5)	13.9 (5.9)	0.121

Table 4
RTHA sample characteristics by local antibiotic use.

	Local antibiotics		
	No (n = 37)	Yes (n = 43)	p-value
Gender, n (%)			0.875
Female	20 (54.1)	24 (55.8)	
Male	17 (45.9)	19 (44.2)	
Age, mean (SD)	63.5 (17.7)	65 (11.9)	0.651
Smoker, n (%)	7 (18.9)	13 (30.2)	0.244
BMI > 30, n (%)	12 (32.4)	16 (37.2)	0.655
HTN, n (%)	20 (54.1)	25 (58.1)	0.713
Heart Disease, n (%)	7 (18.9)	8 (18.6)	0.971
DM, n (%)	8 (21.6)	4 (9.3)	0.208
COPD, n (%)	0 (0)	2 (4.7)	0.497
Rheumatoid, n (%)	6 (16.2)	3 (7)	0.290
Lupus, n (%)	2 (5.4)	0 (0)	0.211
Creatinine, mean (SD)	1 (0.4)	0.9 (0.2)	0.312
BUN, mean (SD)	17.3 (7.2)	15.6 (5.4)	0.227

Table 5
Unadjusted and adjusted Odds Ratio for 6-month postoperative joint prosthetic infection in TKA patients.

	Infection					
	No (n = 325)	Yes (n = 18)	OR	95%CI	aOR	95%CI
Local antibiotics, n (%)	185 (56.9)	6 (33.3)	0.38	0.14–1.03	**0.28***	**0.09–0.89**
Gender (male), n (%)	111 (34.2)	7 (38.9)	1.23	0.46–3.25	1.13	0.35–3.68
Age, mean (SD)	64 (10.2)	59.4 (9.1)	0.96	0.92–1.00	0.95	0.91–1.00
Smoker, n (%)	102 (31.4)	5 (27.8)	0.84	0.29–2.42	1.02	0.29–3.59
BMI > 30, n (%)	193 (59.4)	11 (61.1)	1.07	0.41–2.84	0.73	0.24–2.19
HTN, n (%)	246 (75.7)	14 (77.8)	1.12	0.36–3.51	0.98	0.27–3.63
Heart Disease, n (%)	60 (18.5)	5 (27.8)	1.70	0.58–4.95	2.02	0.57–7.16
DM, n (%)	81 (24.9)	9 (50)	3.01	1.16–7.85	2.62	0.87–7.93
COPD, n (%)	12 (3.7)	1 (5.6)	1.53	0.19–12.50	1.39	0.12–16.55
Rheumatoid, n (%)	36 (11.1)	2 (11.1)	1.00	0.22–4.54	0.80	0.16–3.99
Lupus, n (%)	4 (1.2)	1 (5.6)	4.72	0.50–44.56	8.62	0.52–143.45
Creatinine, mean (SD)	0.91 (0.37)	0.91 (0.31)	1.02	0.28–3.69	0.32	0.03–3.30
BUN, mean (SD)	15.1 (5.5)	17.2 (8.3)	1.06	0.98–1.13	1.09	0.98–1.20

OR = Odds Ratio; aOR = Adjusted Odds Ratio.
The bold values represent a statistically significant difference between groups.
* $p < 0.05$.

Table 6
Unadjusted and adjusted Odds Ratio for 6-month postoperative joint prosthetic infection in RTKA patients.

	Infection					
	No (n = 83)	Yes (n = 8)	OR	95%CI	aOR	95%CI
Local antibiotics, n (%)	45 (52.9)	1 (16.7)	0.18	0.02–1.59	0.21	0.02–2.18
Gender (male), n (%)	36 (42.4)	3 (50)	1.36	0.26–7.14	3.30	0.43–25.33
Age, mean (SD)	63.8 (10.7)	61.5 (9.7)	1.02	0.94–1.11	0.99	0.92–1.06
Smoker, n (%)	20 (23.5)	1 (16.7)	0.65	0.07–5.89	0.12	0.01–1.92
BMI > 30, n (%)	54 (63.5)	5 (83.3)	2.87	0.32–25.70	2.87	0.37–22.13
HTN, n (%)	56 (65.9)	4 (66.7)	1.04	0.18–5.99	0.96	0.16–5.74
Heart Disease, n (%)	15 (17.6)	2 (33.3)	2.33	0.39–13.93	1.59	0.17–14.77
DM, n (%)	27 (31.8)	2 (33.3)	1.07	0.19–6.23	0.41	0.02–7.45
COPD, n (%)	8 (9.4)	0 (0)	[a]		[a]	
Rheumatoid, n (%)	6 (7.1)	1 (16.7)	2.63	0.26–26.31	3.44	0.20–58.44
Lupus, n (%)	2 (2.4)	0 (0)	[a]		[a]	
Creatinine, mean (SD)	0.96 (0.34)	1.09 (1.21)	0.77	0.11–5.48	5.92	0.18–198.99
BUN, mean (SD)	16.7 (6.7)	16 (6.7)	1.05	0.94–1.17	0.85	0.70–1.03

OR = Odds Ratio; aOR = Adjusted Odds Ratio.
[a] Omitted because no PJI were observed among patients with the risk factor.

Table 7
Unadjusted and adjusted Odds Ratio for 6-month postoperative joint prosthetic infection in THA patients.

	Infection					
	No (n = 228)	Yes (n = 2)	OR	95%CI	aOR	95%CI
Local antibiotics, n (%)	132 (40.6)	1 (5.6)	0.73	0.04–11.77	0.33	0.01–13.61
Gender (male), n (%)	107 (32.9)	1 (5.6)	1.13	0.07–18.30	0.89	0.03–31.43
Age, mean (SD)	59.5 (13.9)	49 (7.1)	0.95	0.87–1.04	0.90	0.78–1.04
Smoker, n (%)	69 (21.2)	0 (0)	[a]		[a]	
BMI > 30, n (%)	112 (34.5)	2 (11.1)	[b]		[b]	
HTN, n (%)	127 (39.1)	1 (5.6)	0.80	0.05–12.87	2.19	0.06–76.26
Heart Disease, n (%)	35 (10.8)	0 (0)	[a]		[a]	
DM, n (%)	38 (11.7)	0 (0)	[a]		[a]	
COPD, n (%)	16 (4.9)	0 (0)	[a]		[a]	
Rheumatoid, n (%)	17 (5.2)	1 (5.6)	12.41	0.74–207.30	27.24	0.38–1,950.30
Lupus, n (%)	3 (0.9)	0 (0)	[a]		[a]	
Creatinine, mean (SD)	0.98 (0.95)	1.05 (0.21)	1.06	0.34–3.34	0.77	0.00–217.46
BUN, mean (SD)	14.4 (6.2)	17 (2.8)	1.06	0.87–1.29	1.27	0.85–1.88

OR = Odds Ratio; aOR = Adjusted Odds Ratio.
[a] Omitted because no joint prosthetic infections were observed among patients with the risk factor.
[b] Omitted because the factor predicted perfectly the outcome.

0.33, 0.01–13.61; RTHA, aOR = 0.47, 0.07–3.03), the evidence was not statistically significant (Tables 6–8). There were no differences between groups in regards to wound healing complications ($p = 0.39$).

Overall, when all groups were combined, the preventive effect of local antibiotics to reduce the odds of PJI statistically significant (aOR = 0.39, 0.18–0.84). Other factors did not show statistically significant effects.

Table 8
Unadjusted and adjusted Odds Ratio for 6-month postoperative joint prosthetic infection in RTHA patients.

	Infection					
	No (n = 72)	Yes (n = 8)	OR	95%CI	aOR	95%CI
Local antibiotics, n (%)	40 (55.6)	3 (37.5)	0.48	0.11–2.16	0.47	0.07–3.03
Gender (male), n (%)	31 (43.1)	5 (62.5)	2.20	0.49–9.93	3.30	0.43–25.33
Age, mean (SD)	64.3 (15.2)	64 (11.1)	1.00	0.95–1.05	0.99	0.92–1.06
Smoker, n (%)	19 (26.4)	1 (12.5)	0.40	0.05–3.45	0.12	0.01–1.92
BMI > 30, n (%)	25 (34.7)	3 (37.5)	1.13	0.25–5.11	2.87	0.37–22.13
HTN, n (%)	41 (56.9)	4 (50)	0.76	0.18–3.26	0.96	0.16–5.74
Heart Disease, n (%)	13 (18.1)	2 (25)	1.51	0.27–8.36	1.59	0.17–14.77
DM, n (%)	11 (15.3)	1 (12.5)	0.79	0.09–7.09	0.41	0.02–7.45
COPD, n (%)	2 (2.8)	0 (0)	[a]		[a]	
Rheumatoid, n (%)	8 (11.1)	1 (12.5)	1.14	0.12–10.53	3.44	0.20–58.44
Lupus, n (%)	2 (2.8)	0 (0)	[a]		[a]	
Creatinine, mean (SD)	0.95 (0.31)	1.04 (0.26)	2.53	0.27–23.52	5.92	0.18–198.99
BUN, mean (SD)	16.5 (6.4)	15.1 (6.2)	0.96	0.85–1.09	0.85	0.70–1.03

OR = Odds Ratio; aOR = Adjusted Odds Ratio.
[a] Omitted because no joint prosthetic infections were observed among patients with the risk factor.

5. Discussion

Our results show that local vancomycin had a statistically significant preventative effect on PJI in TKA and there was a trend towards prevention of infections in the RTKA, THA, and RTHA antibiotics groups. Our results also showed there was no difference in wound healing complications between groups. The current literature on the use of local antibiotics in TJA is limited, but studies have shown they can decrease the rate of PJI. One study out of France showed 1–2 g of vancomycin spread evenly over the articular surfaces of the implants reduced PJI within the first two months from 4.7% to 0%.[13] A retrospective review by a single surgeon over a 10-year period showed that in 2293 TJA, local vancomycin administration continuously throughout the case significantly reduced the PJI rate.[14] Another retrospective review of 507 patients undergoing shoulder arthroplasty showed that a single injection of gentamicin at the end of surgery reduced the infection rate from 3.0% to 0.29%.[15] The role for use of local antibiotics after orthopedic hardware implantation is poorly defined. More high quality studies are required to determine the efficacy of such practices.

Vancomcyin is a bactericidal antibiotic that works by inhibiting cell wall synthesis in Gram positive bacteria. It is most commonly used in the treatment of MRSA infections. The most notable and commonly reported side effects of intravenous administration are nephrotoxicity and ototoxicity.[16] Postoperatively vancomycin has been implicated in acute renal failure in elderly patients. Our study showed no elevations in postoperative BUN and creatinine levels in the antibiotics group when compared to the no-antibiotics group. There is a concern for toxicity to osteoblasts and other cell types secondary to a high concentration of the drugs with local usage. Studies have shown delayed bone healing in rat models with use of local antibiotics, especially drugs from the fluoroquinolone class.[17] Based on the available literature, vancomycin is minimally toxic to osteoblasts at the cellular level at concentrations less than 1000 mcg/ml.[18–22] We did not measure the intracapsular concentration of vancomycin in our study. This may be a source of concern when using on-growth or in-growth type implants which require osteoblast activity for stable implant fixation.

Our adjusted analysis showed that no patient risk factors appeared to increase the risk of PJI after TJA. Multiple studies have shown diabetes, obesity, smoking, nutritional status, alcoholism, chronic kidney disease, heart disease and rheumatoid arthritis to be risk factors for increased rates of PJI.[23–25] Several of these factors are widely accepted as risk factors for PJI in TJA. Patients who are at higher risk for infection may benefit from the use of local antibiotics during TJA in order to reduce their risk of PJI.

The financial cost of PJI is very high as mentioned previously.[3] Kapadia et al. found the average cost of non-infected THA was $25,659 while the infected average cost was $88,623.[26] The same group also found that the average cost of non-infected TKA was $28,249 while the infected TKA average cost was $116,383.[27] The cost of 2 g of vancomycin powder at our institution was $29.72, and the cost of one 8 ounce bottle of providone-iodine cost $7.23. The primary investigator of our study performs about 225 hip and knee arthroplasties a year. The yearly cost of local antibiotics at our institution for 225 arthroplasties is $8,313.75. If using local antibiotics in TJA prevents just one infection a year, it would save the hospital significant money. With the impending comprehensive care for joint replacement model (CJR) from Medicare, PJI could have significant financial implications for the hospital and surgeon.[28] The use of local vancomycin has had documented success in other surgical specialties, especially spine procedures involving instrumentation.[4–9]

While using local vancomycin powder may lower the rates of PJI, the question remains will usage on every arthroplasty patient lead to increased vancomycin resistant organisms? This poses a very difficult question for clinicians and surgeons alike. Vancomycin resistant enterococcus (VRE) has been a problem since 1989 when a twenty-fold increase in the number of cases was reported.[29] The Centers for Disease Control (CDC) issued recommendations for use of vancomycin in 1995 through the Hospital Infection Control Practices Advisory Committee. The CDC continues to recommend for prudent use of vancomycin, limiting its use to the following patients; infections caused by beta-lactam-resistant Gram positive microorganisms, treatment of Gram positive infections with patients allergic to beta-lactam antimicrobials, when antibiotic associated colitis fails to respond to metronidazole, prophylaxis for endocarditis in high risk patients undergoing certain procedures, and prophylaxis for major surgical procedures involving implantation of prosthetic devices at institutions with a high rate of MRSA.[30] Vasso et al. reviewed 29 TKA patients infected with resistant bacterial strains treated with a two-stage revision. Patients with MRSA had a repeat infection 10% of the time, while patients with resistant strains of Enterococcus, Acinetobacter, and Pseudomonas had repeat infections 33% of the time.[31] There are a limited number of articles discussing VRE in TKA and THA, most of these being case reports. None of the infections in the vancomycin group had a culture positive for VRE. After an extensive literature review, there was no data on the usage of local vancomycin powder in surgical wounds leading to increased numbers of vancomycin resistant organisms. However there has been some concerning reports regarding the use of antibiotic-loaded bone cement (ALBC) and the development of

bacterial resistance. A study by Josefsson et al. found that in infected patients who received gentamicin ALBC, 88% had at least one gentamicin resistant strain isolated from culture.[32] In a second study by Hansen et al. it was determined that the use of ALBC in TKA patients did not lead to an increase in antibiotic resistance.[33] This topic will likely continue to be a source of controversy between total joint surgeons and the CDC in the future as the use of powdered antibiotics in orthopedics continues to rise.

Our study has several limitations. First, PJI are a relatively rare occurrence and although there are 744 cases in this study more data may be required for a more accurate analysis. The RTKA, THA, and RTHA cohorts showed a trend towards local antibiotics preventing PJI but were not statistically significant. Second, this study encompassed a 6 month postoperative follow up period. While the majority of PJI occur within the first 6 months, a 2 year follow up may be better for this population. There were also significant differences between the TKA groups in regards to smoking, HTN, and COPD. Lastly, we had 92 patients who did not follow up. There is a possibility these patients could have had an infection and either moved or sought the care of a different surgeon. Lastly, there is a concern that application of a negative pressure incisional wound vacuum at the time of closure may drain some of the antibiotics. This is unlikely however since water tight closure is performed on the joint capsule followed by a multi-layered closure to the skin.

In conclusion, PJI continue to be a large burden on the healthcare community, both financially and emotionally. As the number of TJA cases continue to increase, a more effective means of preventing PJI is necessary to counteract costs. Further studies, preferably prospective and randomized, are required to compare the efficacy of local antibiotics versus traditional methods in the prevention of PJI.

Conflict of interest statement

No authors have any conflicts of interest to disclose regarding this manuscript.

Ethical review committee statement

This study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. An IRB approval letter has been attached as a separate file.

All of the surgeries, data collection, and statistical analysis were done at Texas Tech University Health Sciences Center in Lubbock, TX.

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