



# Intraoperative intra-articular injection of gentamicin: will it decrease the risk of infection in total shoulder arthroplasty?

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**Background:** Deep infection is a debilitating complication after shoulder arthroplasty. Intra-articular injection of antibiotic can give a higher concentration compared with intravenous administration. We hypothesized that a group of patients given an intra-articular, intraoperative injection of gentamicin would report a lower infection rate than a group without local antibiotics.

**Methods:** Between 2005 and 2011, the senior author performed 507 shoulder arthroplasties. We retrospectively reviewed all of those cases. All patients were administered systemic prophylactic antibiotics. Beginning in June 2007, patients were also injected with 160 mg of gentamicin in the glenohumeral joint at the end of their surgery. Patient records were examined for preexisting medical conditions, type of surgery, and presence of infection. Patients receiving surgery before 2007 were compared with those after to determine the effect of prophylactic gentamicin administration in preventing deep infection associated with surgery. All patients were observed for a minimum of 1 year.

**Results:** Of the 507 surgeries, 164 were performed before 2007 (without intra-articular injection of gentamicin; group A) and 343 were performed with addition of gentamicin (group B). In group A, 5 patients presented with infection (3.0%) compared with 1 in group B (0.29%). The gender, mean age, mean body mass index, and prevalence of comorbidities were similar between the groups.

**Conclusions:** The data from this study support the conclusion that intra-articular intraoperative gentamicin administration may reduce postoperative infection.

This study was approved by the Marymount University IRB (study #11-25).

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The axillary fossa includes numerous sebaceous glands and hair follicles that permit the rich growth of bacterial flora.<sup>13</sup> The proximity of the axilla to surgical sites may predispose the wound to bacterial contamination. A devastating complication after primary or revision total shoulder arthroplasty is a deep infection. The reported incidence of infection after shoulder arthroplasty ranges between 0.4% and 4%.

This area challenges shoulder arthroplasty surgeons and places an enormous financial and psychological burden on patients and society. Inexorably, scientists endeavor to discover efficient ways to fight infection in 3 battlefields; prevention, diagnosis, and treatment. A great challenge is to find newer techniques that could be more effective in reducing the risk of this dreaded complication.

In a study published in 2007, Yarboro et al<sup>18</sup> demonstrated that locally applied antibiotic is the most effective method to kill bacteria present in a wound, more so than systemic administration. Direct intra-articular infusion of antibiotics delivers higher local concentrations compared with intravenous administration. This method has been used in veterinary practice for treatment of pyarthrosis.<sup>5,7,15</sup> There are reports in the literature of the use of this method for treatment of infected total knee and hip arthroplasties and, most recently, in cervical spine surgery.<sup>4,11,14,16</sup>

The purpose of this study was to determine whether the administration of intra-articular antibiotics during surgery is effective to prevent deep postoperative infections. Gentamicin was selected as the antibiotic of choice on the basis of the work of Yarboro.<sup>18</sup> A recent study by Pahys et al<sup>11</sup> described the use of vancomycin powder in wounds after cervical spine surgery. In this study, they reported a greatly diminished infection rate after the application of vancomycin during surgery.<sup>11</sup> Our study focused on a different method of antibiotic administration, intraoperative intra-articular injection of gentamicin, and evaluated whether this method reduces the risk of infection after total shoulder arthroplasty. Our hypothesis was that the addition of gentamicin will reduce the number of infections after total shoulder arthroplasty.

## Materials and methods

We retrospectively reviewed our prospectively collected database of all shoulder arthroplasties that the senior author (J.L.) performed between 2005 and 2011. We analyzed the data of 507 consecutive shoulder arthroplasties in 504 patients including 433

(86%) primary arthroplasties and 71 (14%) revisions. These cases were reviewed for the presence of deep postoperative infection that manifested within 180 days of surgery. Infection was defined as increasing pain, elevated erythrocyte sedimentation rate and C-reactive protein level, clinical appearance of infection at the time of surgery, possible positive culture, and more than 10 white blood cells per high-power field.<sup>8</sup>

The system used in both standard and reverse arthroplasties was DePuy (DePuy Orthopaedics Inc, Warsaw, IN, USA). Indications for primary shoulder arthroplasties were osteoarthritis in 281 cases, rotator cuff tear arthropathy in 78 cases, rheumatoid arthritis in 13 cases, post-traumatic arthritis in 49 cases, and avascular necrosis in 12 cases.

The most common indications for revision arthroplasty were loosening of glenoid or humeral components, periprosthetic fracture, component malposition, failed hemiarthroplasty, and rotator cuff tears. All revisions considered for the study were aseptic in nature. There were 292 standard total shoulder arthroplasties, 76 hemiarthroplasties, 4 CAP hemiarthroplasties, 64 reverse arthroplasties, and 71 revision arthroplasties. Fixation of the glenoid component was cemented in total shoulder replacement and cementless in reverse total shoulder arthroplasty. Fixation of the humeral components was cemented in 77 cases and cementless in the remaining cases. DePuy bone cement was used in primary arthroplasties, and gentamicin-impregnated cement was used in revision surgeries. Our inclusion criteria included any patient who underwent an arthroplasty from 2005 to 2011. We excluded patients who had a history of infection in the shoulder being operated on before arthroplasty. After excluding 4 previously infected arthroplasties, we entered 507 of them in the study. Of the cohort, 177 (34.9%) had a history of previous surgery on the shoulder being operated on, including fracture fixation, arthroscopy, rotator cuff repair, acromioplasty, and biceps tenotomy or tenodesis.

The senior author performed all surgeries in a standard surgical theater not equipped with a laminar airflow system. All procedures were performed under general anesthesia in a beach chair position through a deltopectoral approach. Within 1 hour before skin incision, prophylactic intravenous antibiotics (cefazolin) were administered to all patients. Clindamycin or vancomycin was administered in patients with an allergy to cephalosporin. Intravenous antibiotics were subsequently continued for 24 hours postoperatively. The same sterile preparation and drape technique was used for all patients. We routinely used iodine-impregnated incision drapes (Ioban; 3M, St. Paul, MN, USA) to cover the surgical site unless the patient had an allergy to iodine, for whom we used non-iodine drapes. Drains were not used, and the surgical team did not wear body-exhaust suits.

In group B, at the end of the procedure and when all the final components were in place and before closure of the incision, we inserted a spinal needle into the joint through the lateral skin. After closure of the deltopectoral interval, subcutaneous tissue,



**Figure 1** Spinal needle inserted into joint before closure.

and skin, we injected 160 mg of gentamicin in 20 mL of saline into the joint through the spinal needle (Fig. 1). The incision site was then covered with a standard sterile dressing.

The postoperative rehabilitation protocol was the same for all patients, and all were observed clinically and radiographically for 1 year. All deep periprosthetic infections were identified according to the aforementioned symptoms.

During the course of the study, there was only one significant change to the surgeon's technique. Beginning in July 2009, all reverse shoulder arthroplasties were performed with press-fit components and without bone cement. All prior reverse arthroplasties were implanted with cement.

For the evaluation of the injection of gentamicin, we divided the cases into the following groups: group A consisted of 164 patients who underwent surgery before June 2007 and did not receive intra-articular injection of gentamicin; group B consisted of 343 patients for whom intra-articular gentamicin was administered after June 2007. Of 164 patients, 70 men (42%) and 94 women (58%) with an average age of 74 years (range, 33-94 years) were in group A. Of those, 131 were primary arthroplasties and 33 were revision total shoulder arthroplasties. In group B, there were 145 (42%) men and 198 (58%) women with an average age of 70 years (range, 20-95 years). Of those, 284 were primary arthroplasties and 59 were revision total shoulder arthroplasties.

For statistical analysis, Fisher exact test, Wilcoxon ranked sum, and Bonferroni confidence intervals were performed to reveal differences between groups A and B. A  $P$  value  $<.05$  was considered significant.

## Results

Of the 507 surgeries, 164 were performed before June 2007 (group A), and 343 were performed beginning in June 2007 with intra-articular injection of gentamicin (group B). In group A, deep infection developed in 5 of 164 patients (3.0%) compared with 1 of 343 cases (0.29%) in group B. This difference is considered statistically significant ( $P < .01$ ). Of the cases diagnosed with periprosthetic infection, the type of surgery and microorganism were varied, as summarized in Table I. Retrospective hospital records review comparing the demographic and surgical characteristics between these groups showed that they were comparable in the characteristics presented in Table II. There was no difference in the gender, mean age, or mean body mass index. The number of comorbidities was similar between the groups. In group A, 18 (13.4%) had diabetes. In group B, 39 (12.3%) had diabetes.

There is a list of local or systemic side effects of gentamicin administration including nephrotoxicity and ototoxicity. Some side effects are dose dependent, and some are not. We did not observe any complications related to the injection of gentamicin. The cost of 160 mg of gentamicin is \$60.

## Discussion

The rate of deep infection is reported to be 0% to 3.9% after primary unconstrained shoulder arthroplasty and 3.3% to 4.0% after reverse shoulder arthroplasty.<sup>1,9</sup> Similarly, in a previous 23-year study, 1.1% of primary shoulder arthroplasties (25 of 2279) and 3.6% of revision cases (7 of 194) were diagnosed with deep periprosthetic infections.

*Staphylococcus aureus*, *Staphylococcus epidermidis*, *Propionibacterium acnes*, and *Corynebacterium* species are the most commonly isolated organisms found in infected shoulder arthroplasties. Obesity, malnutrition, systemic administration of steroids, malignant disease, chemotherapy, diabetes mellitus, asynchronous infection, postoperative hematoma formation, and revision surgery all specifically influence the potential for infection after shoulder arthroplasty.<sup>1,17</sup> In addition, the risk of a periprosthetic shoulder infection increases when the operation is performed for fracture, cuff tear arthropathy, or radiation-induced osteonecrosis.<sup>3</sup>

Orthopaedic surgeons try to reduce the risk of infection. Several well-established methods to reduce infection exist, including aseptic technique, skin preparation, saline solution pulse lavage, antibiotic prophylaxis, and decreasing surgical duration. Preoperative intravenous prophylactic antibiotics have strong scientific evidence, whereas some infection prevention methods are not clinically proven.<sup>15</sup> Preoperative antibiotics are commonly used in surgeries, but some methods, such as adding antibiotic to the bone cement, are basically applied to joint replacements.<sup>10</sup>

**Table I** Characteristics of the infected cases

Antibiotic	Age (years) and gender	Type of TSA	Primary or revision TSA	Microorganism
No	72, M	Hemi	Primary	<i>Staphylococcus aureus</i>
No	84, M	Reverse	Primary	No bacteria identified
No	58, F	Hemi	Primary	MRSA
No	79, M	Reverse	Revision	No bacteria identified
No	80, M	Reverse	Primary	No bacteria identified
Yes	81, F	Reverse	Revision	<i>Staphylococcus epidermidis</i>

MRSA, methicillin-resistant *Staphylococcus aureus*; TSA, total shoulder arthroplasty.

**Table II** Distribution of comorbidities

Group	HTN	CAD	DM	HLD	COPD	Osteoporosis
No. of cases, total	253	53	62	130	18	35
Gentamicin + (group B)	68%	60.4%	71%	60%	55.6%	65.7%
Gentamicin – (group A)	32%	39.6%	29%	40%	44.4%	34.3%

HTN, hypertension; CAD, coronary artery disease; DM, diabetes mellitus; HLD, hyperlipidemia; COPD, chronic obstructive pulmonary disease. None of these comorbidities had a significant association with infection rate, as determined by the Fisher exact test.

Surgeons try to find new and, if possible, easy and inexpensive methods to decrease infection. For instance, Brown et al<sup>2</sup> evaluated the efficacy of a dilute povidone-iodine (Betadine) lavage before wound closure in preventing early deep postoperative infection after total hip and knee arthroplasty. They used the protocol of dilute Betadine lavage for 3 minutes in 688 consecutive cases (274 total hip and 414 total knee arthroplasties) and compared the occurrence of periprosthetic infections within the first 90 days after surgery with a total of 1862 consecutive cases (630 total hip and 1232 total knee arthroplasties) that were done with this lavage method. Eighteen early postoperative infections were identified before the use of dilute Betadine lavage and 1 since (0.97% and 0.15%, respectively;  $P = .04$ ). They concluded that Betadine lavage might be an inexpensive, effective means of reducing acute postoperative infection.

There are methods to increase antibiotic concentration at the surgical site specifically in total joint arthroplasties. One method is use of antibiotic-impregnated cement. However, bone cement is not always used for component fixation. In addition, commercially available antibiotic-loaded cement is more expensive than cement without antibiotics, and there are concerns that routine use may lead to antibiotic resistance. Another method is insertion of materials such as antibiotic beads, which are being used for the treatment of infection rather than for prevention. Scientists are also developing newer and more advanced methods, such as self-protective “smart” devices, which are still in the investigational phase.<sup>12</sup>

In the veterinary field, continuous intra-articular infusion of gentamicin achieves higher drug concentrations in joint tissues of normal tarsocrural joints of horses compared with intravenous administration.<sup>6</sup> Although this technique has

not previously been described in total joint arthroplasty, it has been studied in other surgical fields.

There are several limitations to our study, predominantly related to its retrospective design. Although the numbers of both cases and controls are high, and the analysis shows that these 2 groups are identical in terms of the possible risk factors, it does not have the rigor of a prospective randomized clinical trial or a case-control matched study.

A prospective, randomized trial would eliminate these potentially confounding factors; however, time and expense may limit such studies. The main objective of the current study was to see whether the intra-articular injection of gentamicin, which we consider a simple and inexpensive method, was effective in reducing infection after shoulder arthroplasties. Our results showed that intra-articular intraoperative gentamicin administration was associated with a significant reduction in the infection rate after shoulder arthroplasty (3% vs 0.29%;  $P < .05$ ). For the time being, we have no clear answer to how this local gentamicin works. It needs further investigation to see whether it lowers the number of the bacteria at the surgical site or has an effect on the formation of the biofilm or some other mechanism.

This study raises a few questions about the local injection of antibiotics. The length of time for which the injected medication stays in the joint space is unknown and requires further study to be determined. In addition, the application of drains after arthroplasty is a matter of controversy. Drains were not used in our study, and it remains unclear to us how they would affect the antibiotic's placement or efficacy. Finally, the results of this study raise the question of whether injection of other antibiotics or a combination of them could have the same or better results in terms of preventing infection.

## Conclusions

The data from this study support that intra-articular intraoperative gentamicin administration is highly effective in decreasing the rate of infection after shoulder arthroplasty. Given the low cost and safety of the intervention combined with the statistical significance of our findings, we conclude that intra-articular intraoperative gentamicin injection may represent a reasonable means of reducing acute postoperative deep infection in total shoulder arthroplasty.

## Disclaimer

The authors, their immediate families, and any research foundation with which they are affiliated did not receive any financial payments or other benefits from any commercial entity related to the subject of this article.

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