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Local bio-absorbable antibiotic delivery in calcium sulfate beads in hip and knee arthroplasty

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ABSTRACT

Antibiotic-impregnated calcium sulfate (AICS) beads have been used for prevention and treatment of periprosthetic joint infections. We evaluated post-operative complications following the use of AICS beads. 56 patients undergoing complex primary or revision hip or knee arthroplasty received antibiotic calcium sulfate beads. Primary outcomes were wound complication rates. Secondary outcomes included reoperation and reinfection rates. One case (1.7%) of persistent wound drainage occurred requiring surgical irrigation and a polyexchange. No post-operative infections were seen. Use of 100% pure calcium sulfate AICS beads may help reduce post-operative wound complications. AICS appears to be a safe adjunct tool in local antibiotic delivery.

1. Introduction

With the increasing prevalence of infections in total joint arthroplasty, improving materials and techniques are paramount in treatment.[1] Combat of periprosthetic joint infection can be categorized into prevention, detection and treatment. Treatment options include systemic and local antibiotic delivery.[1–3,7,11]

Recently, antibiotic impregnated calcium sulfate (AICS) beads have been used for prevention and treatment of periprosthetic joint infections.[2] The role of AICS beads as an antibiotic delivery vehicle for primary prevention of infection or the treatment of infection in the setting of total hip and knee arthroplasty has not been fully studied.

Recent studies have reported increased wound complication and drainage with AICS use.[13] Some authors attribute this increased drainage rates to the impurity of the calcium sulfate.[3] The purpose of this study is to review the occurrence of post-operative infection and wound complications following the use of high purity calcium sulfate beads as a local antibiotic delivery system.

2. Methods

From February 2011 to May 2012, 56 patients underwent total joint arthroplasty and received 100% pure calcium sulfate beads (STIMULAN, Biocomposites, Wilmington, NC) mixed with tobramycin, vancomycin, and cefazolin for primary prevention of infection in high risk patients and/or eradication of established infection in patients undergoing either primary or revision knee and hip arthroplasty.

Patients were selected upon risk factors for infection such as morbid obesity (BMI > 40), end-stage renal disease or transplant patient, end-stage liver disease, complex primary arthroplasty with stemmed or revision components, or revision total joint arthroplasty.

For primary and revision total knees, a medial parapatellar approach was utilized. Revision knees were performed with gutter resection and scar resection. A posterolateral approach to the hip was used exclusively for primary and revision hips. In the beginning of the case, calcium sulfate beads were created by mixing powdered calcium sulfate with 1gram vancomycin powder, 1.2 g tobramycin powder and 1gram cefazolin powder. 10mL of saline was added into the mixture in a sterile bowl, stirred for 1 min and then spread into a sterile bead molding tray and allowed to dry and harden. The antibiotic calcium sulfate beads were then placed into the wound during final closure.

Patients were start on anticoagulation for venothromboembolic disease. Patients received either aspirin 325 mg once a day for 4 weeks or enoxaparin 40 mg subcutaneously injected if high risk for clotting for 2 weeks then aspirin for 4 weeks. Similar perioperative protocols were utilized including a multimodal pain medication regimen, rapid recovery physical therapy protocol and neuraxial anesthesia with regional block anesthesia and periarticular injections. Patients discharged to either a rehab facility or home with office followup at 2 weeks, 6 weeks, 12 weeks and annually thereafter. Patients who had a concern for wound drainage were followed more closely.

Primary outcomes included evaluation of wound complications such as persistent wound drainage, purulent exudate, local tissue irritation, systemic toxicity, heterotrophic ossification, and need for further surgery. Secondary outcomes included reoperation and reinfection rates. Approval was obtained from our Institutional Review Board.

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3. Results

56 patients met inclusion criteria for this study; 26 knee arthroplasty and 30 hip arthroplasty patients. Of the knee arthroplasty patients, 6 were primary TKA, 12 were clean revisions, and 8 infected revisions. Of the hip arthroplasty patients, 5 were primary, 19 were clean revisions, and 6 were infected revisions.

Radiographic evidence of bead placement was confirmed on the post-operative xray for all patients. Complete resorption was radiographically confirmed in all patients by 6 weeks. One patient (1.7%) who underwent a clean revision TKA for instability to a rotating hinge platform showed radiographic signs of intra-articular ossification which correlated clinically with her persistent knee pain at the 6 week and 3 month followup. She required surgical irrigation and debridement and a poly exchange.

One case (1.7%) of persistent wound drainage occurred in a patient with type 2 diabetes mellitus and smoker whom revision TKA was performed. No post-operative infections were seen in any of the patients and no cases of heterotrophic ossification were found.

4. Discussion

Our cohort had only one patient (1.7%) with prolonged serous wound drainage with use of 100% pure antibiotic impregnated calcium sulfate beads in total joint arthroplasty. This resolved without any additional surgical intervention. Additionally, this patient was a type II diabetic undergoing revision knee arthroplasty. The other observed complication was painful intra-articular calcifications in a woman who underwent revision knee arthroplasty after traumatic dislocation of original knee arthroplasty. Surgical removal of the calcifications was performed which resolved the symptoms.

In vitro studies evaluating elution characteristics of AICS beads report positive results.[8–10] McConoughey et al compared antibiotic elution characteristics between PMMA and AICS beads in vitro.[8] They reported higher elution of vancomycin and improved subsequent inhibition of bacterial growth in AICS beads compared with PMMA. Roberts et al compared antibiotic elution characteristics of AICS beads with size and type of antibiotic.[10] They found smaller sized beads eluted faster, while combining vancomycin and tobramycin allowed longer elution times up to 40 days.

Other authors have reported promising clinical results with antibiotic impregnated calcium sulfate beads as an antibiotic delivery tool. McKee et al investigated the effectiveness of Osteoset (Wright Medical, Arlington, TN, USA) AICS beads compared with polymethylmethacrylate (PMMA) beads in the setting of osteomyelitis with surgical debridement.[5] They randomized 30 patients to either group. Success was equivalent at 86% in both groups, however patients in the PMMA group required more reoperations than the AICS group (15 vs 7, $p = 0.04$). 3 patients in the AICS group had prolonged wound drainage that resolved without any intervention.

Kallala and Haddad reported their results of 15 patients undergoing revision arthroplasty for periprosthetic joint infection with addition of STIMULAN AICS beads.[6] They reported no wound drainage. One patient had some asymptomatic heterotopic ossification, three patients had transient hypercalcemia for which one patient required additional treatment. All but one patient had normal inflammatory markers at final followup. Wahl et al[12] evaluated local and system antibiotic levels in vancomycin impregnated calcium sulfate beads in 87 patients. They reported local antibiotic concentrations higher than PMMA, yet lower than cytotoxic levels, and maintaining common minimally inhibitory concentrations for Staphylococcus up to 3 months postoperatively. AICS beads may have a role in local antibiotic delivery to combat localized infection.

Enthusiasm for AICS beads, some studies have reported increased wound complication and drainage with AICS use.[13,14] Authors attribute this increased drainage rates to the impurity of the calcium sulfate.[3] STIMULAN beads are made with higher purity, less reactive materials that may result in lower drainage rates. McPherson et al reported their experience with use of STIMULAN AICS beads in 250 cases of septic and aseptic revision total hip and total knee arthroplast.[3] They reported a 3.2% (8/250) wound drainage rate associated with higher bead volumes, 1.2% heterotopic bone formation. 9/250 required revision of implants, 6 of the 9 revisions were due to infection.

Flierl et al examined the success high purity STIMULAN AICS beads in the setting of acute (< 6 weeks) and hematogenous periprosthetic joint infections treated with debridement and prosthesis retention.[4] They reported 16/33 (48%) patients had failed eradication of infection, 9/33 underwent chronic antibiotic suppression and 7/33 underwent two-stage exchange for infection. Although they had included AICS beads in their debridement, their success rate was similar to previous reports without the AICS beads. They did not report any drainage in their study.

The strength of this paper is the relatively large sample size compared to other case series. We are a tertiary center with a relatively high patient complexity, thus many patients are higher risk for infection or surrogates such as wound drainage. Also, we utilized AICS beads for a myriad of arthroplasty cases with few complications regarding drainage and re-infection.

The limitations of this paper are it's retrospective native and the inherent patient selection bias generated by this. Unfortunately we have a heterogenous patient mixture including complex primary arthroplasties and revision arthroplasties which have varying infection and drainage rates. Lastly, we did not include patient comorbidities nor risk stratification for infection or drainage.

5. Conclusion

As the number of arthroplasty surgery increasing in the United States, the number of PJI will increase. Management strategies for PJI include preoperative, intraoperative and postoperative interventions. AICS appears to be a safe adjunct tool in the application of local antibiotic delivery. Use of 100% pure calcium sulfate AICS beads may help reduce post-operative wound complications.

Conflict of interest

None.

Contributions

Zachary C. Lum DO – manuscript writer, data analysis.
Gavin C. Pereira MD – supervisor, writing, data analysis.

Disclosures

One author has received in the past, travel funding and speakers fees for Biocomposites, Inc. (Staffordshire, UK). No other disclosures relevant to this topic of research work. No additional funding was provided for this area of research.

All research herein was conducted in accordance with ethical standards in compliance with privacy guidelines and in accordance with our institution and independent institutional review board. All material herein is new and the original work of the authors listed. This manuscript has not been previously published and is not submitted for publication elsewhere.

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