Sp68: Is there a Role for Local Antibiotic Cement Bead Application in Improving Outcomes After Debridement?

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Recommendation: Local antibiotic cement bead application, when used judiciously and in conjunction with other infection control measures including thorough debridement and systemic antibiotics, is a valuable tool for improving outcomes.

Level of Evidence: Moderate

Delegate vote:

Rationale:

Surgical site infection (SSI) is a significant complication following spine surgery, with considerable implications for patient outcomes, healthcare costs, and resource utilization. SSIs can manifest as superficial or deep infections, often presenting within 30 days of surgery or up to a year in cases involving implanted hardware.[1] Deng et al in their study of 2252 patients reported that prevalence of SSIs after spine surgery varies widely, ranging from 1% to 10%, depending on factors such as patient comorbidities, surgical technique, and instrumentation use.[2]

Risk factors for SSIs include prolonged surgical duration, blood loss, revision surgeries, diabetes, smoking, obesity, and immunosuppression. Deep infections, in particular, can lead to devastating outcomes, including hardware failure, the need for multiple revision surgeries, prolonged hospitalization and bed rest. This increases morbidity due to prolonged infection and septicemia, sometimes even leading to mortality.

Polymethyl methacrylate (PMMA) is the most commonly used cement media for antibiotic beads preparation. However, other recent advances are the use of bioabsorbable materials like calcium sulfate and calcium phosphate. Shing et al mentioned that calcium sulphate is capable of more rapid elution of antibiotics but calcium phosphate provides a stronger scaffold with more favourable mechanical properties.[3] Whether or not to universally remove the PMMA beads has been another issue of discussion. While a permanent implantation of the PMMA cement has been described, the retained PMMA beads or spacers can serve as a nidus for future growth of bacteria. Viswanathan et al in their retrospective series of 13 patients had shown that PMMA beads may continue to elute low levels of antibiotics (below the MIC) for even up to 5 years after implantation.[4] This prolonged antibiotic release can potentially lead to the development of multi-drug resistance. Hou T et al had described that hydrogels, bone grafts, fibrin gel-coated vancomycin alginate beads (FG-Vanco-AB) and ceramics are other alternatives where removal of the carrier is not required. However, the duration of elution is reduced.[5]

Madadi AK et al in a retrospective analysis of 23 cases stated that the key factors influencing release kinetics are solubility, diffusivity, porosity, tortuosity, and bead diameter.[6] Vancomycin, Teicoplanin, Daptomycin and Tobramycin have been described to have the highest elution duration. Van vugt TAG et al stated that the consideration in selection of antibiotics while using PMMA is the heat sensitivity and

thus only heat stable antibiotics can be used. However this is not a pre-condition in case of calcium sulphate and phosphate .[7]

Edelstein et al in their prospective cohort of 21 patients stated that the antibiotic-loaded cement beads along with systemic administration provide a high local concentration of antibiotics at the infection site, surpassing what can be achieved through systemic administration alone. They also mentioned that antibiotics should be used should be as per the culture sensitivity, with weight and age appropriate dose. This targeted approach minimizes systemic toxicity while effectively managing local microbial load, thus enhancing outcomes of infection treatment.[8]
Wassif R K et al in their article stated that antibiotic beads create a conducive environment for tissue healing and bone regeneration, improving overall patient outcomes.[9]
Edelstein et al in another prospective cohort study of 37 patients mentioned that the use of antibiotic beads is to be considered as an adjunct to thorough surgical debridement, systemic antibiotics, and appropriate wound care.[10] Surgical expertise in ensuring the complete removal of infected and necrotic tissue remains paramount.

Viswanathan et al again suggested in their study that using local antibiotic cement beads after debridement reduces infection recurrence rates, particularly in cases of vertebral osteomyelitis and discitis.[4]

They also suggested that in case of florid infection we may consider removing the implants. However, there is enough literature to support that if there is no florid infection we may retain the implants. Also, early onset infection may be treated with implant retention but late onset requires implant removal.[4]

Edelstein et al and Savas et al in their prospective and retrospective cohort respectively stated that nephrotoxicity, neurotoxicity and drug fever are commonly associated with antibiotic cement beads, more commonly with PMMA since it has a longer duration of elution if not removed.[10,11]

Other studies, like those of Fernando et al and Lee H G et al have also suggested that beads may often require subsequent removal, adding to patient management complexity. The surface of bone cement is a suitable substrate for bacterial growth, even in the presence of antibiotics causing superadded infections. These are again common with PMMA.[12,13] However, the newer mediums like calcium sulfate, calcium phosphate, hydrogels and ceramics being bioabsorbable, do not require removal.

Wassif et al in their study pointed out that though some of the concerns regarding local antibiotic delivery systems include the cytotoxic effect of antibiotics on the osteogenic stem cells (especially tobramycin) and the possibility of systemic toxicity (especially nephrotoxicity) during drug elution over time, neither of these issues have been reported as major clinical problems so far.[9]

References:

1. Dhole S, Mahakalkar C, Kshirsagar S, Bhargava A. Antibiotic Prophylaxis in Surgery: Current Insights and Future Directions for Surgical Site Infection Prevention. Cureus. 2023 Oct 28;15(10):e47858.

2. Deng H, Chan AK, Ammanuel SG, Chan AY, Oh T, Skrehot HC, Edwards CS, Kondapavulur S, Nichols AD, Liu C, Yue JK. Risk factors for deep surgical site infection following thoracolumbar spinal surgery. Journal of Neurosurgery: Spine. 2019 Nov 1;32(2):292-301.
3. Shing SR, Hoyt AK, Levack AE. Defining the shelf-life of calcium sulfate beads embedded with tobramycin and vancomycin. Journal of Orthopaedics. 2024 Jun 1;52:74-7.
4. Viswanathan VK, Shetty AP, Kanna RM, Rajasekaran S. Use of antibiotic-impregnated beads in the treatment of lumbosacral surgical site infection: A retrospective case series. J Clin Orthop Trauma. 2022 Aug 8;32:101984.
5. Hou T, Xu J, Li Q, Feng J, Zen L. In vitro evaluation of a fibrin gel antibiotic delivery system containing mesenchymal stem cells and vancomycin alginate beads for treating bone infections and facilitating bone formation. Tissue Eng Part A. 2008 Jul;14(7):1173-82.
6. Madadi AK, Sohn MJ. Pharmacokinetic Interpretation of Applying Local Drug Delivery System for the Treatment of Deep Surgical Site Infection in the Spine. Pharmaceutics. 2024 Jan 10;16(1):94.
7. van Vugt TAG, Arts JJ, Geurts JAP. Antibiotic-Loaded Polymethylmethacrylate Beads and Spacers in Treatment of Orthopedic Infections and the Role of Biofilm Formation. Front Microbiol. 2019 Jul 25;10:1626.
8. Edelstein AI, Okroj KT, Rogers T, Della Valle CJ, Sporer SM. Systemic Absorption of Antibiotics From Antibiotic-Loaded Cement Spacers for the Treatment of Periprosthetic Joint Infection. J Arthroplasty. 2018 Mar;33(3):835-839.
9. Wassif RK, Elkayal M, Shamma RN, Elkheshen SA. Recent advances in the local antibiotics delivery systems for management of osteomyelitis. Drug delivery. 2021 Jan 1;28(1):2392-414.
10. Edelstein AI, Okroj KT, Rogers T, Della Valle CJ, Sporer SM. Nephrotoxicity after the treatment of periprosthetic joint infection with antibiotic-loaded cement spacers. The Journal of Arthroplasty. 2018 Jul 1;33(7):2225-9.
11. Savas MJ, Gray KF, Blackburn BE, Pelt CE, Gililland JM, Certain LK. Association of Acute Kidney Injury With Antibiotic Loaded Cement Used for Treatment of Periprosthetic Joint Infection. J Arthroplasty. 2023 Dec;38(12):2704-2709.e1
12. Lee HJ, Kim GU, Kang SY, Lee JS, Jung HJ. An improved technique for removing intramedullary antibiotic beads in osteomyelitis of the tibial shaft. Surg Infect (Larchmt). 2014 Dec;15(6):838-42.
13. Fernando N, Werner S, Elhaddad M, Davies J, Firoozabadi R. Do Antibiotic Beads Need to be Removed? Arch Bone Jt Surg. 2020 Jul;8(4):502-505.