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QUESTION 6: What is the ideal composition of antibiotic impregnated (ABI) spacers/beads in post-traumatic infections? Is preoperative microbial identification necessary?

RECOMMENDATION: There is currently limited evidence with regards to the ideal composition of ABI polymethyl methacrylate (PMMA) spacers or beads in post-traumatic infections and the need for preoperative identification of the causative organism. Available data suggests that PMMA spacers, empirically impregnated with at least 2 gm of vancomycin per 40 mg of PMMA (with or without gentamycin), may result in quiescence of infection in a high percentage of cases with an acceptable associated rate of bony union. Preoperative microbial identification is of unclear utility.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 95%, Disagree: 0%, Abstain: 5% (Unanimous, Strongest Consensus)

RATIONALE

The challenge of achieving adequate local tissue antibiotic concentrations with systemic antibiotics has prompted the addition of local antibiotic therapy in the majority of bone infection protocols. The use of ABI PMMA beads is well established in the treatment of chronic osteomyelitis. Klemm reported a cure rate of over 90% in 405 cases of chronic sequestrating osteomyelitis with the use of gentamycin-impregnated PMMA bead chains [1]. Notably, the beads were pre-manufactured with gentamycin and Klemm found no change in the gentamycin resistance profile over a seven-year period. The use of local antibiotic therapy has also been advocated in the post-traumatic setting. Numerous review articles advocate for the use of ABI PMMA or other forms of local adjuvant antibiotic therapy in the setting of septic non-union or post-traumatic infections [2–5]. Interestingly a recent comparison of the outcomes of treatment with ABI beads versus spacers revealed no difference in the rate of infection control, time to union or complication rate with either configuration [6].

The induced membrane ("Masquelet") technique has gained popularity in the management of post-infective bone defects [7]. The procedure involves the placement of a PMMA spacer in the defect, followed by a subsequent second-stage bone grafting into the resulting induced membrane [8]. Originally the procedure was described using bone cement without antibiotics. Masquelet reasoned that the inclusion of antibiotics may increase the risk of resistance to the offending organisms and that it changed the biological characteristics of the induced membrane [9]. This concern was validated, in an animal model by Nau et al., who demonstrated variations in the nature of the induced membrane with different types of bone cement and supplemental antibiotics [10]. Notably, Palacos[å] with gentamycin still resulted in a positive rate in cell growth. However, in clinical studies involving post-traumatic (not post-infective) bone defects the concerns regarding inhibition of bone healing were not realized, with reported union rates of 82% (in cylindrical defects) to 100% (in conical defects) with the use of ABI spacers [11,12].

While the original technique involved PMMA without antibiotics, several other authors have utilized the potential advantage of local antibiotic elution during the construction of the spacer [13–18]. If the data from the meta-analysis by Morelli et al. is scrutinized it appears that there may well be a therapeutic advantage with the addition of antibiotics in terms of infection control. When evalu-

ating the studies that included only post-infective bone defects it is noteworthy that there was recurrence of infection in two out of 17 cases in which PMMA without antibiotics was used, [19] compared to no recurrence in 58 cases in which ABI spacers were used [5–8]. Furthermore, the addition of antibiotics may not necessarily result in inferior bony healing with union reported in 100% of the cases in which ABI PMMA spacers were used. The heterogeneity of these studies, however, prevents drawing firm conclusions in this regard. The successful use of ABI spacers has, however, recently been corroborated in a larger series (involving 22 cases of acute post-traumatic defects and 21 post-infective defects) by Giannoudis et al., who reported an overall union rate of 93% and only one case of recurrent infection at 2-years follow-up.

Despite the promising results that have been achieved with ABI PMMA, the optimal composition of the spacers remains to be determined. Rathbone et al. examined the effect of 21 different antibiotics on the viability and osteogenic activity of osteoblasts. Amikacin, tobramycin and vancomycin were found to be the least cytotoxic agents [20]. No well-designed comparative clinical studies to asses different spacer compositions have yet been performed in the post-infective setting. The choice of antibiotic appears to be empirical in most studies and none have reported it is necessary to preoperatively determine the causative organism. The most popular composition appears to be 2 to 4 gm of vancomycin added to 40 gm of PMMA with or without gentamycin (or tobramycin) [5,6,10–12].

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QUESTION 7: Should antibiotic cement rods (ACRs) be left permanently in situ?

RECOMMENDATION: If the ACR is used as a temporary non-locked implant for infection control, it should be removed and replaced by a biomechanically stable construct (e.g., locked intramedullary nail). If the ACR is used as a locked implant for both local delivery of antibiotics and provision of stable biomechanical conditions for consolidation of the non-union site, it can be left in place.

LEVEL OF EVIDENCE: Limited

DELEGATE VOTE: Agree: 70%, Disagree: 30%, Abstain: 0% (Super Majority, Weak Consensus)

RATIONALE

ACRs can be used for two different indications.

1. ACRs are used as non-locked temporary implants for the local delivery of antibiotics into the intramedullary canal to eradicate the infection. In cases with stable bone conditions, e.g., chronic osteomyelitis in long bones, missing rotational stability of the ACR is not relevant, whereas in infected non-unions with unstable bone conditions, the ACR is removed after infection control and replaced by a biomechanically stable implant, in most cases by a standard interlocking nail in a subsequent revision procedure.

For this indication, only technical notes, case reports and small case series with a maximum of 19 cases in one study exist [1–8]. In the 18-patient case series by Qiang et al., the mean indwelling time of the ACR was 57 days, ranging from 35 to 123 days [6]. Sancineto et al. published 19 cases with removal of the ACR between 6 and 76 weeks after surgery [7]. Badhra and Roberts reported some difficulties in