HIGH PRESSURE PULSATILE LAVAGE IRRIGATION OF INFECTED FRACTURES: EFFECTS ON FRACTURE HEALING

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PURPOSE: High pressure pulsatile lavage irrigation of fresh intraarticular fractures has previously been shown, in an animal model, to devitalize bone at the site of irrigation and decrease the rate of new bone formation in the first week following irrigation. Although it appeared from that investigation that bulb syringe irrigation would be less likely to impair fracture healing than would pulsatile lavage irrigation, the model used in that investigation did not include the presence of bacteria or foreign material, both of which are common in open fractures treated in clinical practice. The purpose of the present investigation is to expand on the results of previous investigations by examining the effects of high pressure pulsatile lavage irrigation on the rate of new bone formation and fracture healing in infected intraarticular fractures.

METHODS: Forty-five adult New Zealand white rabbits were divided into three equal groups. The control group (C) underwent arthrotomy of the knee, osteotomy of the medial femoral condyle, contamination with 5 x 10^6 colony forming units of Staphylococcus aureus in one gram of a standardized clay and sand mixture, stabilization with a 2.7 mm lag screw, and closure of the wound in layers. The bulb syringe (B) and pulsatile lavage (P) groups underwent the same procedure, with the addition of irrigation with 1 liter of normal saline, delivered from a standardized distance with either a bulb syringe or a commercially available pulsatile lavage system, prior to fracture stabilization. Each rabbit was administered two fluorescent bone stains: xylene orange at the time of operation, and calcein green 7 days following operation. The rabbits received no postoperative antibiotics, were euthanized 14 days after operation and the operated femurs were retrieved for culture and histological analysis of the fracture site. Fracture union was determined by analysis of microradiographs, and the density of new bone formed in the osteotomy site was determined by computerized digitization of standardized areas of the osteotomy site. The presence and location of orange and green fluorescent bands in relation to the osteotomy were determined by fluorescent microscopy.

RESULTS: At the time of sacrifice, purulence was present in 44 of 45 knee joints and cultures were positive in all knees. Xylene orange bands, representing viable bone immediately following irrigation, were present a mean of 20+14% (mean + SD), 27+15%, and 26+22% of the distance along the osteotomy from proximal to distal in groups C, B, and P, respectively (p=0.5). Calcein green bands, representing viable bone 7 days following irrigation, were present a mean of 34+16% (mean + SD), 53+16%, and 60+27% of the distance along the osteotomy in groups C, B, and P, respectively (p=0.005 for comparison of group C to B or P). 66% of the osteotomies in group C and 50% of those in groups B and P had not united. Digitization of the microradiographs at the proximal (metaphyseal) end of the osteotomy line revealed 45+3% (mean + SEM) of the area to be filled with calcified new bone in group C, 44+3% in group B, and 52+4% in group P.

Similar measurements at the distal (articular) end of the osteotomy line revealed 23+2% of new bone in group C, 24+3% in group B, and 37+5% in group P (p=0.04). There was a statistically significant difference in the amount of calcified new bone formed in the proximal and distal measurement sites in each study group. Retained foreign material was identified in the distal (articular) end of the osteotomy in all group C specimens, and in one-half of group B and P specimens.

DISCUSSION: The addition of infection and foreign material to an intraarticular fracture model in rabbits seems to result in marked decrease in viable bone immediately following contamination and irrigation. That there was no difference in the amount of viable bone immediately following operation between the control and irrigation groups seems to indicate that the effects of infection on decreased bone viability seem to outweigh the deleterious effects of pulsatile lavage seen in previous studies. The data from the microradiographs indicates that contaminated intraarticular fractures, with or without irrigation, have greater amounts of foreign material retained and less new bone formed at the end of the fracture line nearest the contaminating source that do noninfected fractures. That the pulsatile lavage group had significantly greater new bone formation in the first two weeks after operation within the distal end of the osteotomy than either the control or bulb syringe groups indicates that the benefits of pulsatile lavage irrigation are best demonstrated in areas with the highest initial concentration of bacteria and foreign material. In addition, since all specimens in this study were infected at the time of sacrifice, the effectiveness of this study in detecting differences in the viability of bone at the osteotomy site between the bulb syringe group and pulsatile lavage group may have been blunted somewhat. Viable bone 7 days following irrigation (calcein green stain) was improved from baseline in all study groups, but was much more improved in the bulb syringe and pulsatile lavage irrigation groups than in the control group (p=0.005); these results support the beneficial effects of irrigation in contaminated fractures.

CONCLUSIONS: The addition of infection and foreign material to an intraarticular fracture model results in a marked decrease in viable bone immediately following infection and irrigation. The effects of contamination on decreasing bone viability seem to outweigh the deleterious effects of pulsatile lavage irrigation seen in previous studies. In this infected fracture model, pulsatile lavage irrigation was more effective than bulb syringe irrigation in improving the amount of new bone formation at the end of the osteotomy site with the greatest initial load of contaminant. In an infected intraarticular fracture model, irrigation with a bulb syringe or pulsatile lavage system is superior to no irrigation at all, and irrigation with a pulsatile lavage device is superior to bulb syringe irrigation in areas where there are very high levels of contamination.

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