Model for Assessing Infection in Percutaneous Implants

Emily L. Perry1,2, James P. Beck1,2, Dustin L. Williams3, Linda A. Schmidt4, Roy D. Bloebaum1,2

1Orthopaedics, University of Utah, Salt Lake City, UT; 2Bone and Joint Research Lab, Veterans Affairs Health Care System, Salt Lake City, UT; 3ARUP Institute for Clinical and Experimental Pathology, Associated Regional and University Pathologists (ARUP) Laboratories, Salt Lake City, UT; 4Dermatology, University of Utah, Salt Lake City, UT

emily.oliphant@hsc.utah.edu

Introduction: Prevention of infection remains a challenge to the implementation of the percutaneous osseointegrated implant technique of prosthetic limb attachment in amputees1. One of the goals of this investigation was to develop an animal model of the distal region of a patient amputee with a percutaneous osseointegrated implant. Another focus was to determine if this model would allow the testing of the efficacy of a broad spectrum antimicrobial in preventing infection. The purpose of this investigation was to determine if a broad spectrum antimicrobial used as a medical device could prevent pin track infections in a percutaneous pin wound site in a sheep model.

Materials and Methods: A 5-mm diameter pin, 95-mm long and threaded for a length of 28-mm, was screwed through a pre-dilled hole traversing both cortices of the proximal end of the tibia of Rambouillet sheep (weight 75-90 kg, age 2.5–6 years). The pin protruded through the skin on the medial side of the hind leg. Twenty sheep received a smooth titanium alloy pin (Ti-6Al-4V). Ten sheep were treated with a foam pad saturated with 200-300 mg of CerageninsTM (CSA - 13) which have been developed and found to be bactericidal2. Ten sheep served as controls and received an untreated but sterile foam pad of the same dimensions as the CSA-treated pad. The study endpoint was six months or infection.

The sheep were to be euthanized at the end of the 24-week trial or when they presented with Grade II3 clinical signs of pin track infection.

After euthanasia and using aseptic technique, cultures were obtained of muscle, blood, and bone. In addition to the clinical signs of infection, the sheep was considered infected if at least one tissue culture was positive.

Statistical analysis, for comparing infection rates, included a log-rank test for equality of survivor functions.

Results: The data demonstrated that, when compared to the control pads, the CSA-13 did not prevent pin track infection (p=0.788, Figure 1). All sheep were euthanized, because of the presence of the clinical signs of infection, during the first 40 days after implantation. This was prior to the intended sacrifice schedule.

Kaplan-Meier survival estimates, by group

CSA treated

Untreated control

Figure 1: Kaplan-Meier curve showing that CSA-13 treated pads did not significantly prevent infection compared to untreated control pads (p=0.788).

CSA-13 was also found to be associated with pin loosening within the bone. In contrast to 1 of 10 control sheep, 9 of 10 CSA-13 treated sheep had loose pins at the time of sacrifice. A log rank test for equality of survivor functions showed that CSA-13 statistically affected pin loosening (p=0.016).

Large gaps around the pin indicated a lack of skin-pin adhesion (Figure 2).

Discussion: Because CerageninsTM are amphiphilic and target cell membranes, they can target both prokaryotic (bacterial) as well as eukaryotic cell membranes.2 Their selectivity for prokaryotes must be further examined.

CSA-13 was not effective in preventing pin track infections in a percutaneous sheep model in the application used. CSA-13 also caused a significant impact on loosening of the implants, and was determined to be hemolytic in follow-up sheep blood agar (SBA) culture studies. Chlorhexidine Gluconate was also found to be hemolytic in a comparison SBA study. CerageninsTM need to be further tested to fully characterize and understand the positive bactericidal properties of the material weighted with the negative properties that caused pin loosening in this study. The data suggests that pin-skin attachment is essential before applying antimicrobials because of their potential hemolytic properties. Further testing on the hemolytic activity of antimicrobials could show contraindications for use around percutaneous implants without a tight skin seal.


Acknowledgements: We wish to thank TATRC for providing funding (W81XWH-05-1-0628), along with Ed Kinder, Julian Bowman, and Tyler Epperson.

Figure 2: Skin gap at pin (P) site created by movement of muscle and skin.