Preparation and Testing of a Chest Drain Containing an Antimicrobial Agent

Todd R. Meyer, Melissa Kelsey
Bacterin International, Inc., Belgrade, MT 59714

Statement of Purpose: The occurrence of nosocomial infections is an urgent problem which appears to require multiple solutions. A prominent sub-category of these are surgical site infections, which can be caused by direct wound contamination, deficient aseptic technique, or migration of exogenous flora to the interior of a surgical site along a catheter track [1]. After a surgical procedure, a drain is frequently placed within the wound and through an exit site to facilitate discharge of serosanguinous fluid via suction, thus avoiding collection of such fluid within the wound cavity. As with any such externally communicating catheter, skin flora have access to the wound along the length of the drain. Given sufficient levels of microorganism migration, colonization, and growth, an infection can result. This requires surgical intervention: sterilization of the site and replacement of the drain. A potential solution to migration of flora along the drain is a coating containing an antimicrobial agent. Such a coating would potentially decrease the number of microorganisms present on the drain surface, and thereby inhibit their migration into the surgical site.

Chest drains have typically ranged in size from 24 Fr to 42 Fr. More recently, in response to perceived patient and surgeon need, use of 19 Fr drains for cardiothoracic applications has increased. We have conducted coating and testing experiments using 19 Fr chest drains to model larger drains, on which extensions of these experiments will be based. The purpose of these activities is to assess the viability of a coating on a chest drain. Infection rates associated with postoperative cardiothoracic surgical site drainage have been reported to be as high as 35% [2].

Methods: Silicone channel drains (Accusil, Inc., Merrillville, IN) were oxidized via argon and oxygen plasma treatment, followed by plasma treatment with a functionalized silane [3]. After silanization the drains were coated with a poly(vinyl) alcohol coating containing silver sulfadiazine, followed by cross linking via acetal formation. The coating was applied to the channels of the drains and to the more exposed exterior portions.

Antimicrobial activity was tested using the Kirby-Bauer method, by pressing cross-sections of drains into Mueller Hinton agar inoculated on the agar surface with various relevant organisms. Zones of inhibition (ZOI) versus positive (10 µg gentamicin disk) and negative (uncoated drain) controls were observed after incubation for 16 hours at 34 °C. Additionally the exterior portions of the drains were progressively removed to test the efficacy of the coating of the channels. These were plated and incubated in the same manner.

Further antimicrobial testing was performed using a time kill assay. Coated chest drain segments and uncoated control drains were placed into nutrient solutions (2% tryptic soy broth in phosphate buffered saline) inoculated with *S. aureus*, the concentration of which had been adjusted so as to maintain consistent or slightly increasing organism concentrations throughout a seven day period. At day 7 these were agitated, sampled, diluted, plated on 5% sheep blood agar, incubated at 34 °C for approximately 12 hours, and enumerated. The coated drains were tested for total silver load by immersion of the drain segments in dilute nitric acid followed by atomic absorption (AA) spectroscopy. Likewise, elution testing was performed by immersing drain segments in phosphate buffered saline, replacing the fluid every 24 hours, and testing the residual fluid for silver content using AA. Coating adhesion was tested with a Taber Linear Abraser by applying approximately 350 grams of force normal to the surface of the drain. The contact material was neoprene cord (Shore durometer 40A), which was drawn repeatedly across the surface of the drain.

Results: The ZOI testing showed moderate to large zones (13 – 21 mm) against all organisms tested. Progressive removal of the exterior portions of the drains showed a significant quantity of coating in the channel (ZOI of 6-7 mm). The time-kill assay produced impressive results for the coated drain, showing a 6.4 log reduction in colony counts between the coated and control articles. Total silver loads in the range of 5 – 12 µg/cm^2 of drain surface were obtained, although this quantity can be adjusted at will. Elution experiments showed significant silver release over 7 days (Figure 1).

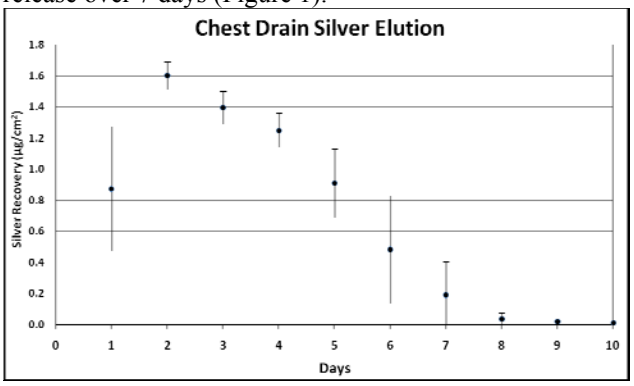

Figure 1: Chest Drain Silver Elution Profile (n=14)

The adhesion test method was able to discriminate against drains coated in an inferior manner. Drains subjected to plasma treatment with unsuitable silanes or plasma treatment for a shortened duration showed unsuitable adhesion results.

Conclusions: A chest drain containing a hydrogel coating with silver sulfadiazine performed well under the aforementioned chemical and microbiological tests. In particular, the microbiological testing shows pronounced efficacy versus the uncoated control drain. These studies will be extended to larger drain sizes and into clinical use.

References:

[1] Weber DJ. *Chest*, **1999**; *115*, 34.
[2] Grover FL. *J Thorac Cardiovasc Surg* **1977**; *74*; 528.
[3] Grill, A. Cold Plasma in Materials Fabrication. Piscataway, NJ, IEEE Press, 1993.