Bacterial Challenge of Percutaneous Implants

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Introduction

Percutaneous devices are critical for medical care, but are associated with significant risk of infections costing over 1 billion dollars annually. Current animal models of biomaterial-associated infections, with biomaterials inoculated with bacteria either before implantation or through peri-implant injection, are not suitable to study the effectiveness of skin biointegration in preventing infection.

The goal of this study was to:
1. Develop an animal model for bacterial challenge of a percutaneous implant.
2. Characterize skin integration in implants challenged with bacteria.

Materials and Methods

Bacterial biofilm was developed by transferring planktonic S. aureus to donut shape polycarbonate membrane filters placed on LB agar plates for 24 hours. The bacterial load on the membrane reached ~10⁷ colony forming units (CFU). Two different S. aureus strains were compared.

Rod-shaped implants made of solid silicone, porous silicone, solid poly(2-hydroxyethyl methacrylate) (polyHEMA), or porous polyHEMA, were implanted percutaneously on the back of C57BL6 mice². Bacteria were transferred around the insertion site of implants.

Outcome - CFU
Samples were harvested 2, 7 or 28 days after implantation. In the control group (without bacterial challenge), the implant, peri-implant tissue and skin were harvested en bloc, and bisected to two halves (insertion half and exit half). In the bacterial challenged group, the skin covering the implant was removed and quantified separately and the implant with peri-implant tissue was cut into three parts. The samples were homogenized and plated to quantify bacterial load.

Outcome - Morphology
Implants were also sectioned and processed for H&E staining and tissue Gram staining.

Results

Comparison of different S. aureus strains

Figure 1. Human S. aureus challenge, compared to Mouse S. aureus, of solid silicone or solid pHEMA resulted in more significant inflammation, infection and skin erosion at the challenge site (*). Most solid implants without bacterial challenge were not retained in place. The photographs were taken 2 days after implantation and challenge. Subsequent experiments were performed with Human S. aureus strain UAMS1.

Table 1. More bacterial-challenged implants remained in place, suggesting that bacterial challenge stimulated an adherent inflammatory response (cell infiltration and matrix deposition). Solid implants, especially solid silicone, were lost due to their smooth surface property.

Bacterial Quantification

Figure 2. Bacteria were quantified by counting CFU in homogenized tissue.

Conclusions

- This animal model is valid for evaluation of anti-infection effect of percutaneous devices.
- Bacterial challenge resulted in significant inflammation and infection at the challenge site (earlier from day 2) than non-challenge site (from day 7).
- Under these conditions there was no significant difference among different implants.

Significance

- These studies serve as excellent positive controls for bacterial challenge of percutaneous implants.
- Development of biomaterials that impede infection at the site of medical device insertion will reduce morbidity, decrease health care costs, and bolster the economy of Washington State.

References


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