50f Staphylococcus Epidermidis Adhesion on Modified Silicone Rubber

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Cerebrospinal fluid (CSF) shunts for the treatment of hydrocephalus contain intracranial catheters made exclusively of silicone rubber. The development of bacterial adhesion and colonization on the catheter surface leads to frequent CSF shunt complications, and 30-40% mortality rate from post-operative infections have been reported. Modifications of silicone surface have been attempted in order to reduce the incidence of shunt infections. However, the influence of surface hydrophobicity, roughness, and various functional groups on bacterial adhesion has not been fully elucidated and conflicting results have been reported. The objective of this study was to perform a systematic analysis of the effect of silicone surface modification on bacterial adhesion and microbial colonization. Silicone was modified with different biopolymers and silanes, including: heparin, hyaluronan, octadecyltrichlorosilane (OTS), and perfluorodecyltrichlorosilane (FAS), in an attempt to provide a stable, and biocompatible surface with different degrees of hydrophobicity, roughness and functional groups. The quality and stability of these biopolymer and self-assembled monolayer coatings were examined by contact angle, Fourier-transform infrared spectroscopy (FTIR), X-ray photoelectron spectroscopy (XPS), and atomic force microscopy (AFM). Contact angle measurement of modified silicone surfaces after different exposure times to saline solution at 37°C indicated that coated surfaces were stable for over 30 days (Table 1). Adhesion of Staphylococcus epidermidis to the modified silicone surface was investigated as a function of incubation times by scanning electron microscopy (SEM) and the colony counting method. After 4 hr of incubation, the SEM images showed that very few bacteria were attached to the FAS/silicone surface, while large colonies (>40 um) were found on the heparin/OTS/silicone. After 12 hr, the size and number of colonies increased significantly, but FAS/silicone still showed the least amount of bacterial adhesion. Similarly, using the colony count method, at 4 h the pattern of bacterial adhesion on the five different surfaces was found to be FAS/silicone< OTS/silicone < hyaluronan/OTS/silicone < silicone < heparin/OTS/silicone. The P-values between the coated silicone and uncoated silicone are all less than 0.05, indicating significant difference among the samples. For 12 hr, there was less bacterial adhesion on hyaluronan/OTS/silicone while most bacterial adhesion on heparin/OTS/silicone (Figure 1). In this case, the P-values for FAS/silicone and OTS/silicone between the coated silicone and uncoated silicone are higher than 0.05, suggesting no significant difference among FAS/silicone, OTS/silicone, and silicone. The data indicated that for the 4 hr experiment, FAS coated silicone surface can reduce bacterial adhesion as compared to uncoated silicone rubber by as much as 80% ; while for 12 hr study, hyaluronan/OTS/silicone can reduce bacterial adhesion by as much as 60%. However, there appears to be no direct correlation between bacterial adhesion and the degree of hydrophobicity of materials. It was because bacterial adhesion on the hyaluronan-OTS-silicone was much less than on the heparin-OTS-silicone, although both have almost same degree of hydrophobicity. The effects of other factors on bacterial adhesion, such as surface roughness and the nature of functional groups, will be discussed. These findings are helpful for devising novel strategies to reduce shunt infections.

Average ± Stdev. Contact Angle (°)				
Days	OTS/Silicone	FAS/Silicone	Heparin/OTS/Silicone	Hyaluronan/OTS/Silicone
Control	102.3±1.4	112.2±2.6	55.3±1.8	55.3±3.9
5days	101.7±3.1	113.2±1.6	58.2±4.2	54.7±1.6
10days	100±2.8	112.2 ±1.5	57±4	54.4±2.8
20days	102.3±1.9	110±2.0	53.3±2.2	56.7±2.2
30days	102±2.8	112.8±1.7	55.2±3.2	54.5±2.9
P value	0.455	0.068	0.124	0.609

Table 1. Contact angle measurements of modified silicone surfaces as a function of exposure times to saline solution at 37°C. Coated surfaces were found to be stable for a period of 30 days. The P-values were higher than 0.05, suggesting the difference of contact angles measured at different time was not significant.

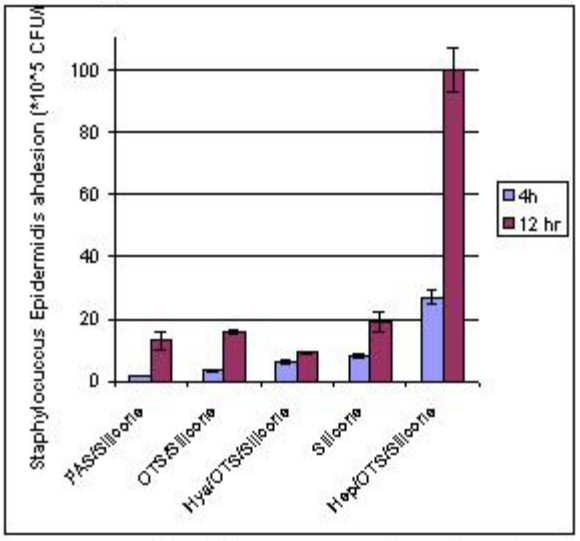

Figure 1. *Staphylococcus epidermidis* adherence on silicone, FAS/silicone, OTS/silicone, hylauronan/OTS/silicone, and heparin/OTS/silicone for 4h, and 12h incubation as measured by plate counting. Data presented were as mean value ± standard deviation of three determinations.