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Inhibition of Biofilm Formation on Ventilation Tubes by Surface Modification

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Abstract

Aim: The purpose of this study was to modify the surface characteristics of a ventilation tube (VT) with polyethylene glycol (PEG) coating and to evaluate the effect on biofilm formation. Materials and Methods: VTs made of polyethylene were coated with PEG. Streptococcus pneumonia R6 strain was used and a crystal violet assay was carried out to measure the in vitro and in vivo biofilm formation of rats bearing VTs. Results: In the in vitro experiment, the optical density of the uncoated VT was 0.34±0.09 and the optical density of the PEG-grafted VT was 0.22±0.06 ($p<0.05$). In the in vivo experiment, the optical density of the uncoated VT was 0.54±0.12 and that of the PEG-grafted VT was 0.32±0.13 ($p<0.05$). Scanning electron microscopy showed that surface modification, roughness and hydrophilic characteristics improved and biofilm formation decreased. Conclusion: The reduced biofilm formation on the VT may be explained by the alteration of surface tension and roughness induced by PEG coating.

Biofilm | ventilation tube | PEG coating | *streptococcus pneumoniae* R6

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Abstract. *Aim: The purpose of this study was to modify the surface characteristics of a ventilation tube (VT) with polyethylene glycol (PEG) coating and to evaluate the effect on biofilm formation. Materials and Methods: VTs made of polyethylene were coated with PEG. Streptococcus pneumonia R6 strain was used and a crystal violet assay was carried out to measure the in vitro and in vivo biofilm formation of rats bearing VTs. Results: In the in vitro experiment, the optical density of the uncoated VT was 0.34±0.09 and the optical density of the PEG-grafted VT was 0.22±0.06 ($p<0.05$). In the in vivo experiment, the optical density of the uncoated VT was 0.54±0.12 and that of the PEG-grafted VT was 0.32±0.13 ($p<0.05$). Scanning electron microscopy showed that surface modification, roughness and hydrophilic characteristics improved and biofilm formation decreased. Conclusion: The reduced biofilm formation on the VT may be explained by the alteration of surface tension and roughness induced by PEG coating.*

Otitis media (OM) is caused by bacterial infection of the middle-ear cavity and is the most common reason for pediatric patients to visit a physician and to undergo ventilation tube (VT) insertion (1). Postoperative otorrhea is a common complication following VT insertion and is thought to be caused by pathogenic bacteria present in acute OM (2). Most cases are curable with otic drops, however, in severe cases, the VT should be removed.

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Key Words: Biofilm, ventilation tube, PEG coating, *streptococcus pneumoniae* R6.

Bacterial biofilm is found attached to surfaces, and co-exists with an extracellular exopolysaccharide matrix. The bacteria present have greatly-reduced metabolic and divisional rates (3) and this often leads to failure of diagnosis by conventional culture techniques and eradication by antibiotic treatment in cases of biofilm infection (4).

Bacterial biofilm formation has been implicated in high rates of persistent otorrhea after VT insertion (5). It has been shown that coating medical implants with antimicrobial agents may effectively prevent the initial adherence of staphylococcal biofilm to the implants (6, 7).

Factors affecting biofilm formation include surface characteristics such as roughness (8). There were reports that surface roughness affects biofilm formation of various pathogens (9, 10). Van der Mei reported that prevention of bacterial adhesion can be achieved by coating the surface with a hydrophilic polymer (11).

Thus, we hypothesized that by performing a surface modification of polyethylene VT, using a hydrophilic polyethylene glycol (PEG) coating, biofilm formation can be inhibited. The purpose of this study was to test this hypothesis by evaluating the preventive effect of PEG coating on biofilm formation of *Streptococcus pneumoniae* R6.

Materials and Methods

Materials. Polyethylene film from NamilEnpla (Hwaseong, Korea) was used for the surface tension analysis and morphological analysis. VTs made of polyethylene (Tecfen, Santa Barbara, CA, USA) were used for the biofilm formation analysis. PEG-diacrylate and 2,2-dimethoxy-2-phenyl acetophenone (DMPA), were purchased from Sigma (St. Louis, MO, USA).

Oxygen plasma treatment and grafting of PEG. After loading the polyethylene film and VT in a low-pressure plasma reactor (PTS-003IDT; IDT-ENG, Seoul, Korea), oxygen gas was supplied at a flow rate of 100 standard cubic centimeters per minute (sccm). After

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