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Silver coating of urinary catheters prevents adherence and growth of Pseudomonas aeruginosa

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Summary. Discs of urinary catheter material were exposed to the flow of artificial urine containing cells of Pseudomonas aeruginosa. Within 10 h an adherent biofilm composed of the bacteria and of their exopolysaccharide products had developed on the uncoated catheter material. On the silver-coated catheter material no biofilm of Pseudomonas aeruginosa had developed.

Key words: Pseudomonas aeruginosa - Exopolysaccaride - Biofilm - Silver-coated - Catheter material

Introduction

Previous studies have shown that Pseudomonas aeruginosa may grow on catheter material as a biofilm [4, 5]. Growth within adherent biofilms appears to confer upon Pseudomonas aeruginosa a measure of protection from environmental antibacterial factors [3, 10] and biocides [11].

In previous studies it has been shown that silver-coated catheters prevent catheter-associated bacteriuria [1, 6]. It was therefore of interest to see if silver-coated urinary catheter material could prevent growth of Pseudomonas aeruginosa.

Material and methods

To measure adherent sessile bacteria an artificial catheter was constructed according to the technique described by Nickel and associates [10]. The artificial catheter device was connected to a 2 liter reservoir, functioning as an in vitro bladder held in 37°C water bath. Medium containing bacteria was pumped from the reservoir through the artificial catheter by a pump set to deliver 50 ml/h. 10 cm^2 of the midsection of the catheter was tested before and after exposure to Pseudomonas aeruginosa.

The strain of Pseudomonas aeruginosa used in these experiments was isolated from a patient with catheter associated urinary tract infection. The medium used was artificial urine supplemented with 0.4% nutrient broth [8]. The bacteria were stored on a sloping agar in a test tube (slants) at −70°C and serially cultured at 10 h intervals. Bacterial growth within the in vitro bladder was monitored by using standardized turbidity as a growth parameter with a spectrophotometer at 600 nm.

Artificial urine containing Pseudomonas aeruginosa was passed through the artificial catheter for 10 h and the development of bacterial biofilm was monitored by sampling of catheter material surfaces. Sample discs bearing sessile bacteria were aseptically removed for scanning electron microscopy (SEM). Quantitative counts of viable adherent bacteria were obtained by low-output ultrasonication of surface scraping of the catheter disc in a sterile phosphate-buffered saline solution. Dilution series were made up to 10^{-4} and spread on nutrient agar from which quantitative plate counts were obtained. The cathether specimens designated for SEM were removed from the artificial catheter and placed in fixative solution consisting of 5% glutaraldehyde in cacodylate buffer (0.1 M, pH 7.2) for 1 h at 22°C, followed by dehydration in a series of aqueous ethanol solutions (20–100% and Freon 113-ethanol solutions (30–100%) and then air dried. Samples were coated with gold in a sputter coater and examinded by using a scanning electron microscope.

Results

Examination by SEM showed that the discs of catheter latex and silver-coated latex used in this study did not bear significant numbers of ethanol-killed bacterial cells. Ten minutes after exposure to cells of Pseudomonas aeruginosa in artificial urine, significant numbers of adherent bacterial cells were seen on the latex discs whereas there was no colonization on the silvercoated latex discs. After 10 h of colonization, the characteristic plate-like surface of the latex discs was completely occluded by a large number of adherent bacteria, which were embedded in large amounts of their own amorphous exopolysaccarides to form a thick adherent biofilm (Fig. 1). On the silver-coated catheter discs no biofilm of Pseudomonas aeruginosa had developed.

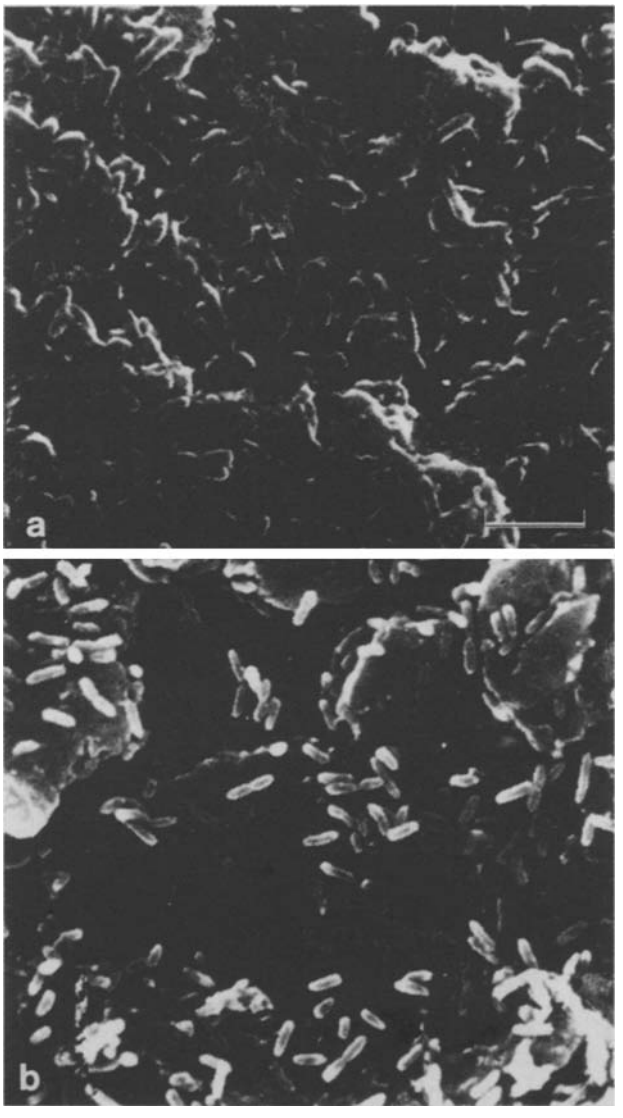

Fig. 1 a and b. SEM of the surface of a disc of latex catheter with a biofilm (**a**) and a silver-coated latex (**b**) 10 h after contact with artifical urine containing 3.0×10^6 cells per ml of Pseudomonas aeruginosa

Discussion

Catheter-acquired urinary tract infections account for as much as 35% of all nosocomial infections and are often refractory with respect to antibiotic therapy. The direct examination of the catheter surfaces removed from patients in whom they had become foci of infection has shown extensive bacterial biofilm development [7, 9]. Also, in vitro studies have described the formation of extensive bacterial biofilms on the surfaces of biomaterial used in the catheters [2]. In a study by Nickel and associates [10] it has been shown that the biofilms that develop in situ on the surfaces of catheters are very similar to those that developed on latex catheter surfaces. These numerous biofilm bacteria are embedded very extensively on an amorphous matrix which occludes the surface even after considerable condensation which follows the dehydration required in preparation for electron microscopy. The anionic alginate exopolysaccharide produced by cells of Pseudomonas aeruginosa is composed of uronic acid molecules and is highly hydrated (99% water) [12]. In this study we have shown that cells of a strain of Pseudomonas aeruginosa grow as a biofilm on the surface of catheter latex. However, there was no growth or adherence of Pseudomonas aeruginosa on the silver-coated latex material. The mechanism of this effective protection against bacteria of the silver-coated catheter material is unknown. It is likely that silver has an antibacterial effect on the catheter and thereby inhibits the adherence of bacteria [13].

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