Materials and Methods

The Presence of Biofilms on Adult Tracheotomy Tubes

Danny Meslemi MD1, Kathleen Yaremchuk MD1, Michael Rontal MD2

Rontal Clinic, Farmington Hills, Michigan2

The study was approved by Henry Ford Health Systems’ Institutional Review Board. Seven adult tracheotomy tubes were collected during routine outpatient and inpatient tracheotomy tube change for biofilm analysis at Henry Ford Hospital in Detroit, MI. The tubes were all Shiley tubes, four uncuffed and three cuffed tubes. All collected tubes were placed in 2% gluteraldehyde solution and refrigerated.

Methods: Seven tracheotomy tubes had 2-3 mm samples taken from the posterior aspect of the outer cannula and three cuffed tracheotomy tubes had samples taken additionally from the cuff to test for the presence of biofilms by scanning electron microscopy.

Results: Bacterial biofilms were found to be present on four adult tracheotomy tubes. Biofilms were found on a cuffed tube that had been inserted 10 days previously and on the outer cannuulas of 3 uncuffed tubes that had been inserted 14 days, 4 months, and 2 years previously. The biofilms were composed of gram-positive cocci in pairs likely consistent with S. epidermidis.

Conclusions: Bacterial biofilms are present on adult tracheotomy tubes in an outpatient and inpatient setting. Both cuffed and uncuffed tubes had development of biofilms as early as 10 days and as long as 2 years after placement. Biofilms have been found on indwelling catheters elsewhere in the body as a source of chronic inflammation and infection with the formation of granulation tissue. This study demonstrates the presence and location of bacterial biofilms found on adult tracheotomy tubes at the time of routine tracheotomy tube changes.

Abstract

Objective: To 1) identify the presence and location of bacterial biofilms on adult tracheotomy tubes 2) determine length of time from placement of tracheotomy tubes that biofilms develop 3) identify bacterial organisms that form biofilms on adult tracheotomy tubes.

Study Design: Prospective observational study with collection of seven adult tracheotomy tubes that were changed during a routine outpatient clinic visit or hospital consultation. The tubes were examined for the presence of biofilms at the location of the cuff, if present, and the posterior aspect of the outer cannula of the tracheotomy tube.

Methods: Seven tracheotomy tubes had 2-3 mm samples taken from the posterior aspect of the outer cannula and three cuffed tracheotomy tubes had samples taken additionally from the cuff to test for the presence of biofilms by scanning electron microscopy.

Results: Bacterial biofilms were found to be present on four adult tracheotomy tubes. Biofilms were found on a cuffed tube that had been inserted 10 days previously and on the outer cannuulas of 3 uncuffed tubes that had been inserted 14 days, 4 months, and 2 years previously. The biofilms were composed of gram-positive cocci in pairs likely consistent with S. epidermidis.

Conclusions: Bacterial biofilms are present on adult tracheotomy tubes in an outpatient and inpatient setting. Both cuffed and uncuffed tubes had development of biofilms as early as 10 days and as long as 2 years after placement. Biofilms have been found on indwelling catheters elsewhere in the body as a source of chronic inflammation and infection with the formation of granulation tissue. This study demonstrates the presence and location of bacterial biofilms found on adult tracheotomy tubes at the time of routine tracheotomy tube changes.

Discussion

A late complication of a tracheotomy is the development of granulation tissue at the stoma and within the trachea resulting in bleeding, drainage, and difficulty with maintaining a patent airway. Biofilms have been implicated as causes of inflammation and chronic infection in clinical settings where stents or cannulas are present.

Certain characteristics of biofilms are detrimental to indwelling catheters especially tracheotomy tubes and can lead to device failure. The presence of biofilms increases the risk for nosocomial infections in patients with tracheotomy tubes. The two most common bacteria for tracheotomy associated pneumonia are P. aeruginosa and S. epidermidis, which are the same bacteria implicated in biofilms on other indwelling catheters. During the dispersion phase, bacteria can be shed into the airway causing infection and formation of additional biofilms. In tracheotomy patients with decreased mucociliary clearance, these individuals are at risk for development of extensive biofilm formation and subsequent infections.

Not all biofilms are pathogenic but they are capable of causing significant inflammation, which later produces severe damage to local tissues with proteolytic, cytotoxic, and proinflammatory effects. Infected catheter sites develop surrounding edema, erythema, and inflamed tissue (Figure 3). In tracheotomy tubes, chronic infections leads to the development of granulation that is a polypropylic vascular tissue during the proliferative phase of inflammation, that arises peristemally and can cause bleeding and prevent removal of tracheotomy tubes. During accidental decannulation or routine tracheotomy tube changes, the granulation tissue can become obstructive and result in tracheotomy tube changes becoming difficult and potentially life threatening.

Table 1. Specimen Results

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Days trach in place</th>
<th>IPD vs OPD</th>
<th>Sex</th>
<th>Biofilm present outer cannula</th>
<th>Biofilm present cuff</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10 days</td>
<td>IPD</td>
<td>M</td>
<td>+ (matrix no lact seen)</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td>14 days</td>
<td>IPD</td>
<td>M</td>
<td>+ ( cocci)</td>
<td>n/a</td>
</tr>
<tr>
<td>3</td>
<td>14 days</td>
<td>IPD</td>
<td>F</td>
<td>+ ( cocci)</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>16 days</td>
<td>IPD</td>
<td>F</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>3 months</td>
<td>OPD</td>
<td>F</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>4 months</td>
<td>OPD</td>
<td>M</td>
<td>+ ( cocci)</td>
<td>n/a</td>
</tr>
<tr>
<td>7</td>
<td>2 years</td>
<td>OPD</td>
<td>M</td>
<td>+ ( cocci)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Figures

Figure 1. SEM picture of cocci on the surface of a tracheotomy tube.

Figure 2. SEM photo reveals the intricate network of a biofilm.

Figure 3. Infected Trach stoma with extensive granulation tissue.

Figure 4. Life Cycle of a Biofilm. The figure was taken from Singh et al. 6

Introduction

Biofilms are becoming a significant source of acute and chronic infections. It is estimated by the Centers for Disease Control and Prevention (CDC) that 65% of human bacterial infections are due to the presence of biofilms. Extensive research has been performed by microbiologists and clinicians to evaluate the role of biofilms in acute and chronic infection. Biofilms are intricate networks of microorganisms (mainly bacteria) that form surface attached communities. Infections from biofilms are exceedingly difficult to eradicate. They are held together with a durable matrix composed of an excreted polymeric substance (EPS). The EPS enhances a strong communication of the bacteria within a biofilm creating an increased resistance to degradation and prevents antibiotics from reaching the bacteria. Within each colony, the bacteria develop several defenses against phagocytosis, ultraviolet radiation, bacteriophages, mechanical stress, dehydration, antibiotics, and other immunological defenses. Biofilms are capable of survival and persist in concentrations of antibiotics 100 to 1000 times the levels that would normally kill free floating, planktonic organisms.

The highly resistant nature of biofilms to treatment has led to chronic infections and device failures. Within Otolaryngology, biofilms have been identified on mucosal surfaces in chronic rhinosinusitis and otitis media, voice prostheses, and on pediatric tracheotomy tubes. Biofilms are speculated to cause chronic inflammation that leads to chronic infection and granulation tissue formation. The granulation tissue develops when fibroblasts are activated from an immune response and can cause obstruction of indwelling catheters such as gastrostomy tubes and tracheotomy tubes. A common complication of tracheotomies is development of granulation tissue with subsequent bleeding and airway obstruction. The granulation tissue increases the risk of bleeding and stenosis that can be life threatening to the patient and result in a delay or decreased incidence of decannulation.

A previous study identified the presence of biofilms in 10 of 11 tracheotomy tubes from hospitalized pediatric patients at time of routine tracheotomy care. The tracheotomy tube specimens were visually inspected for the presence of mucus and tracheotomy tube specimens taken for analysis. Because all of the pediatric patients received endotracheal humidification as inpaitents, it was hypothesized that the highly humidified environment surrounding a pediatric tracheotomy tube was a causative factor in biofilm creation.

The current study evaluates the presence of biofilms on adult tracheotomy tubes in an outpatient or inpatient setting, the location and type of biofilm and the duration the tracheotomy tube was present in the patient at the time the biofilm was identified.

Conclusions

Biological biofilms are present on adult tracheotomy tubes in an outpatient or inpatient setting and can develop within relatively short time frames. The presence of humidification that is present during ventilator dependent respiratory failure or an inpatient setting does not appear to be necessary in formation of biofilms in tracheotomy tubes. Proper care and management of the tracheotomy stoma and tracheotomy tube site needs to be addressed to avoid the complications that arise from biofilms and the host’s reaction to the chronic infection. Regular tracheotomy tube changes and other treatments for eradication of biofilms that have been used elsewhere may be helpful to prevent the complications that occur with long term tracheotomy tube placement.

Bibliography