REVIEW ARTICLE

The challenge of biofilm in Chronic Rhinosinusitis

Author

Dale H. Rice, M.D

Correspondence

Email; dale.rice@med.usc.edu

Biofilm is a bacterial community protected by a 3-dimensional extracellular polymeric substance. Costerton in 1978 [1] first identified the mass of tangled polysaccharide fibers that make up most of the biofilm. This complex community is typically polymicrobial and embedded in this self-secreted matrix. The biofilm structure itself provides resistance to detergents and antibiotics as generally their molecular size is too large to penetrate the biofilm. Bacterial biofilm have been implicated in many diseases including chronic rhinosinusitis (CRS). Table.

Table

- Dental and periodontal disease
- Chronic purulent otitis media/OME
- Prostatitis
- Osteomyelitis
- Bacterial endocarditis
- Cystic fibrosis
- Pneumonia
- Chronic tonsillitis
- Necrotizing fasciitis
- Biliary tract infection
- Crohn's disease
- Ulcerative colitis
- Diabetic foot ulcers
- Implanted medical devices

  PETs

  Cochlear implants

  Endotracheal tubes

CRS is a common health problem and is said by the Centers for Disease Control and Prevention {CDC) to be the most common chronic disease in the United States. It affects 13% of the population in the U.S. The hallmark is a prolonged inflammatory response that is probably multifactorial. Superantigens, fungi, "frustrated phagocytes" and others have been implicated [2].

It is now believed that 99% of all bacteria exist in biofilm, while those in the free-floating planktonic state cause most of the symptoms usually associated with bacterial disease. The CDC states that approximately 65% of bacterial infections involve biofilm [3].

Chronic rhinosinusitis affects 13% of the population in the United States and according to the CDC is the most common chronic disease in the United States. It is increasing in frequency. More than $2 billion is spent each year on over-the-counter medications for the symptoms, while $4 billion is spent on direct medical treatment. It has been shown that biofilm can be found in 80% of CRS patients [4].

Bacteria within biofilm demonstrate a 100-1000-fold increase in antibiotic resistance [5]. This resistance is probably multifactorial. The resident bacteria may be in a quiescent state. The antibiotic molecule may be too large to penetrate the biofilm. Other factors may also be at play. For instance, most biofilm is polymicrobial. There is often a severe and sustained local inflammatory response caused by phagocytes trying to penetrate the biofilm. Biofilm serves as a reservoir for the release of planktonic bacteria.

Traditionally biofilm has been detected by scanning electron microscopy or confocal scanning laser microscopy. More recently FISH (fluorescence in situ hybridization) has been used. These methods are all expensive and require special equipment. Our lab was the first to demonstrate that biofilm can actually be detected with standard H&E stains [6]. This can be done on fresh or archival tissue. This discovery grew out of a study looking at the relationship of biofilm to tissue eosinophilia and to polyps. This knowledge markedly decreases the cost of study.

The presence of biofilm makes recurrence of chronic rhinosinusitis more common. We noted in another study that biofilm can cause persistent chronic inflammation following otherwise successful surgery [7]. This has been noted by others [8]. This persistent chronic inflammation may or may not lead to eventual failure of surgery.

Knowing that bacteria and biofilm are resistant to antibiotics we sought to find a bactericidal substance with a molecular structure small enough to penetrate biofilm. Our lab compared tincture of iodine to SSKI in the ability to penetrate biofilm and kill bacteria. Fresh tissue was exposed to both for 10 minutes and 30 minutes. Baclight assay was used with confocal microscopy to discriminate live from dead bacteria. We found that 30 minute exposure to tincture of iodine was statistically superior to SSKI in actually killing bacteria within biofilm [9].

Clearly more research needs to be done. A number of techniques attempting to disrupt biofilm mechanically have not been successful. In our lab, while a 30 minute exposure worked well, it is impractical in an actual patient.

Thus, infections caused by biofilm are difficult to treat [10]. As mentioned, bacteria in biofilm display increased resistance to antibiotics and the natural immune system [11]. Research needs to find a practical method of dealing with biofilm.

References

1. Costerton JW, Geesey GG, Cheng KJ: How bacteria stick. Sci. Am 1978; 238:86-95.

2. Ferguson BJ, Seiden AM: Chronic rhinosinusitis . Otolaryngol Clin North Amer. 2005; 36:1-21.

3. Research on microbial biofilms; NIH, National Heart, Lung, and Blood Institute. 2002; 12-20.

4. Sanclement J, Webster P, Thomas J, Ramadan H: Bacterial biofilms in surgical specimens of patients with chronic rhinosinusitis. Laryngoscope 2005; 115:578-82.

5. Stewart PS, Costerton JW: Antibiotic resistance of bacteria in biofilms. Lancet 2001; 358:135-8.

6. Arjomandi H, Gilde J, Zhu S, Delaney S, Hochstim C, Mazhar K, Wrobel B, Markarian A, Masood R, Rice DH: Relationship of eosinophils and plasma cells to biofilm in chronic rhinosinustis. Am J Rhino! All 2013; 27:e85-e90.

7. Hochstim CJ, Masood R, Rice DH: Biofilm and persistent inflammation in endoscopic sinus surgery. Otolaryngol Head Neck Surg. 2010; 143 :697-698.

8. Keir J, Pedelty L, Swift AC: Biofilms in chronic rhinosinusitis: systematic review and suggestions for future research. J Laryngol Otol 2011;125 : 331-337.

9. Rizwan M, Bozena W, Dale HR: A comparison of the effectiveness of tincture of iodine and potassium iodide on chronic sinusitis patients with biofilm. Otolaryngol Open Access J 2017, Vol 2, issue 1.

10. Bjarnsholt T: Biofilm infections New York; Springer. 2011.

11. Bryers JD: Medical biofilms. Biotechnology and Bioengineering 2008; 100: 1-180

