Biofilm: The Hidden Menace

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Learning Objectives

• List the various types of biofilms and describe how they are formed.
• Discuss how biofilm formation increases the risk of disease transmission.
• Identify those instruments and devices that are most prone to biofilm formation.
• Explain why biofilm is so difficult to remove from surfaces.
• Compare the different methods for the control and removal of biofilm formation on surgical instruments and medical devices.
Biofilms in our daily life
What do these photos have in common?
Biofilm in nature

Yellowstone Nat’l Park

Cleaning a ship hull

Wastewater treatment
Biofilm can be difficult to see!

Photos: Center for Biofilm Engineering, Univ. of Montana
Biofilms Impact...

- Teeth
- Oil Recovery
- Paper Manufacturing
- Medical Implants
- Drinking Water
- Cooling Water
- Food Processing
- Ship Hulls

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What is a biofilm?

- A collection of microbes
- Encased in slime
- Attached to a surface

A survival mechanism
How do biofilms form? A recipe

-- Any surface will do
-- Presence of water
  - Hot, cold, acid, clean, dirty, low oxygen, no light, high pressure, disinfectants
  - Supply can be intermittent; high humidity
-- Microbes
  - All types of microbes can be found in biofilms
  - Yeast, molds, bacteria, viruses, protozoa, algae
  - Biofilms can be polymicrobial (more than one kind of microbe)
How Biofilms form: A closer look

1. Attachment
2. Growth
3. Detachment

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**Biofilm Formation: Attachment**

Microbes can exist in two states:
- Free floating (planktonic) or Attached (sessile)

Free floating bacteria encounter a surface and attach
- Can take only minutes

Microbes attach to a surface by means of a molecular “glue”
- Extra cellular polymeric substance (EPS)

After a certain amount of time (minutes), attachment is permanent and irreversible
Biofilm Formation: Growth

Growth can be slow or fast depending on environment
- A full community can form within hours.
- Can survive starvation and dessication

Cells are held together by EPS to form complex 3D structures
- Can be several cells thick to many inches thick

Very resistant to
- Antibiotic treatment
- Killing by disinfectants
- Physical removal
Biofilm Formation: Detachment

- Large or small clumps of the biofilm detach
- The microbes in these detached clumps “travel” downstream
- Find a new surface to attach and grow
- Mechanism for disease transmission
- Impacts microbial counts, ATP readings. (shower effects)

Interesting…but why should we care?

➢ At any one time in the United States, 1 out of every 25 hospitalized patients are affected by an HAI

Biofilm-related diseases

- Otitis media (ear infection)
- Bacterial endocarditis (infection of heart)
- Cystic fibrosis (lung)
- Legionnaires Disease
- Periodontitis (gums)
- Sinusitis (sinuses)
- Osteomyelitis
- Surgical Site Infections
- Blood-stream Infections
- Urinary Tract Infections
Sources of Biofilm

- Implants
- Stents/Shunts
- Orthopedic Prostheses
- Catheters
- Wound Dressings
- Surgical Instruments
- Medical Devices
- Flexible Endoscopes
- Environmental Surfaces
What are the issues for reprocessing?

• Biofilms form anytime there is water, a surface and microbes
• Biofilms can be microscopic therefore *you can’t see them* most of the time
• Surgical instruments and medical devices are prone to biofilm formation
• Biofilms are very resistant to mechanical cleaning, enzymatics and disinfectants
• Fast turn around or [delayed reprocessing](#) promote biofilm formation
Instrument/Device Surfaces: What promotes biofilm formation?

Complexity/Damage

- Crevices
- Pores
- Edges
- Serrations
- Shape
- Lumens
- Pitting, Corrosion, Scratches
Water Quality Is Important!!!

✓ Water quality affects detergents and disinfectants
  • Presence of minerals (hard water)

✓ Contaminated water
  • Does rinse water contain bacteria, organic material?

✓ Rinsing
  • Volume
  • Type of water
  • Duration
How you do your job affects Biofilm formation.

**Handling**
- Scratches, lubricant not removed, poor assembly
- Presence of particles (lint, hair, fibers, glove powder)

**Practices**
- **Time** – *too much time* between use and reprocessing
- Multiple reprocessing of single-use items
- Loaner instruments
- Poor rinse techniques
  - Leave behind particles, soil, detergents

Partially adapted from: Wava Truscott, Ph.D, IAHCSMM 2011, Biofilms in Medicine and What it means to Central Services
Preventing biofilm formation

Meticulous cleaning is the primary mechanism for preventing biofilm formation

Factors for success

• Proper training
• Effective Policies and Procedures
• Supportive monitoring to make sure process is in control
• Time to do the job correctly
• Up-to-date IFUs
• Proper tools
  • Chemicals
  • Brushes (size, diameter, length, design)
Cleaning (Manual and Automated)
Points to Consider.....

- Water quality
- Quality, concentration, and type of detergent or enzymatic cleaner
- Acceptable washing method, *Manufacturer Instructions*!!
- Proper rinsing and drying
- Time, temperature parameters for equipment
- Load capacity of the equipment
- Operator performance
Biofilm Removal
Enzymatics + Mechanical Action

- Instruments/Scopes should not be allowed to dry out before reprocessing
- Enzymatics – “chews up” the molecular glue that holds the biofilm to the surface.
  - Most enzymatics do not have biofilm removal claims (EPA)
- Enzymatics do not kill microbes so they also can be contaminated with bacteria
- Contact time – extremely important to get this right!
- Elbow grease!
Biofilm: Remove it….or….Kill it?

Many commonly used enzymatic cleaners fail to remove biofilm and reduce numbers of live bacteria.

On-going research shows a combination of mechanical actions (brushing, water turbulence during rinsing) plus properly used enzymatics may increase biofilm removal efficacy.

*If you remove, no worries about having to kill it*

Biofilm Resistance

Back to the Slime Layer and 3D structure

➢ Protects microbes from action of detergents, enzymes, disinfectants, antibiotics

➢ Biofilms are up to 1000 times more resistant to cleaning and disinfectants and stress than their planktonic form

➢ Proper use of detergents:
  • temperature, dilution, pH, contact time
  • EPA claim for biofilm removal?

Photo: Center for Biofilm Engineering,
Make sure the instruments/devices are dry!!

➢ No water = Biofilm cannot grow
➢ Store instruments so they stay dry
But……Dry Biofilm….Really????

New research shows the presence of “dry biofilm” on some surfaces. The microbes will find a way….they always do
Biofilm Formation: Flexible Endoscopes

• Flexible endoscopes are associated with more documented cases of healthcare-acquired infections than any other type of reusable medical device.

• Of these scopes, bronchoscopes and duodenoscopes account for the highest number of transmitted infections.

“The biggest problem is that we can’t see inside these scopes. To put it bluntly, we’re just taking a shot in the dark with reprocessing.”

*Nancy Chobin, RN, St. Barnabas Health Care System. Livingston, New Jersey*

“Probing the Challenges of Endoscopes”

Biomedical Instrumentation & Technology  May/June 2011
“Flexible endoscope reprocessing has been shown to have a narrow margin of safety. Any slight deviation from the recommended reprocessing protocol can lead to the survival of microorganisms and an increased risk of infection.”

Why are flexible endoscopes difficult to reprocess?

- Complex design
- Multiple, long, narrow, channels that are difficult to clean
- Lack of consistent effective training
- Lack of time and resources for adequate reprocessing
- Visual inspection not adequate to monitor efficacy of reprocessing.
Reprocessing Flexible Endoscopes

- Pre-cleaning – Bedside
- Transport to Reprocessing - <1 hour
- Manual Cleaning
- Rinsing
- Visual Inspection
- High-level disinfection (HLD) – Manual, Automated (AER)
- Drying (Alcohol flush, Air flush)
- Storage

Everyone of these steps impacts biofilm formation
Biofilm Formation: Flexible Endoscopes
Water, microbes, suitable surface.....

Surface
- As a scope is used the surface is “coated” or “conditioned” with body fluids that contain proteins, polysaccharides
- Changes to the surface allow attachment of microbes
- Damaged surface harbors biofilm

Water
- Residual moisture left after reprocessing

Microbes
- Poor handling/storage of clean scopes (environmental)
- Contaminated water/tubing/filters (environmental)
- Incomplete removal of microbes from endoscope (patient derived)
Biofilm Prevention

Goal? Don’t let biofilms establish a “foot hold”

• Manual pre-cleaning – bed side flush!
  • Critical to removing bioburden
  • Prevents biofilm formation

• Reprocess immediately, hold time should be less than 60 min.

• Brushing accessible channels
  • Use proper tools that fit the channel size

• High level disinfection (Sterilization?)
• Thorough drying
• Proper storage (always vertical!)
Drying – A Critical Step in Reprocessing

• The drying step
  • Between cases
  • At the end of the day
  • Hang vertically

• Drying agents
  • Air
  • Alcohol

• How to tell if a scope is not dry?
  • Look for fluid underneath scopes that are vertically stored
  • Smell – any odors?
  • A QC test for this step is sorely needed!
Scopes are not getting dry!!

When evaluated using a boroscope, flexible endoscopes thought to be dry… weren’t dry.
Biofilm formation may cause disinfection failure.

- Biofilms form a protective barrier around infectious microbes; allows infectious microbes to survive the disinfection process.
- Young biofilm may be more susceptible to disinfection when compared to "old" biofilm.
- Most biocides are not tested against biofilms
  - More susceptible free (planktonic bacteria) are used to test biocides
- Oxidizing agents, high concentration enzymatics plus mechanical efforts (water/brushing) may be effective
Common belief that is now under scrutiny

“Failure to adhere to established reprocessing guidelines accounts for most, if not all, of the reported cases of bacterial and viral transmissions.”

Major article

Persistent contamination on colonoscopes and gastroscopes detected by biologic cultures and rapid indicators despite reprocessing performed in accordance with guidelines

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A Biofilm issue???
CRE Outbreaks – A Wake Up Call

- Tampa
- Chicago
- Pittsburgh
- Seattle
- Wisconsin
- Los Angeles (1-4)
- Denver
- >25 (US Senate 2016 report)

In many cases, no breaches in reprocessing were found.
The Outbreaks: The microbes are changing the game

- Carbapenem-resistant Enterobacteriaceae – CRE
- Limited or no treatment
- High transmission rate 6-46%
- High mortality rate ~ 50%
- No common root cause
- Did they look at biofilm??

www.cdc.gov/drugresistance/threat-report-2013/
Conclusions

- Biofilms will form anywhere there is water, a surface and microbes
- Biofilms are almost impossible to remove once they have been established.
- Failure to completely clean and dry instruments and endoscopes using the current guidelines may lead to biofilm formation
- Biofilm must be completely removed or
  - Risk continued growth
  - Risk disease transmission
- Ensure that reprocessing personnel:
  - Are properly trained
  - Have access to current IFU’s and proper tools
  - Have time to perform their job
Thank you