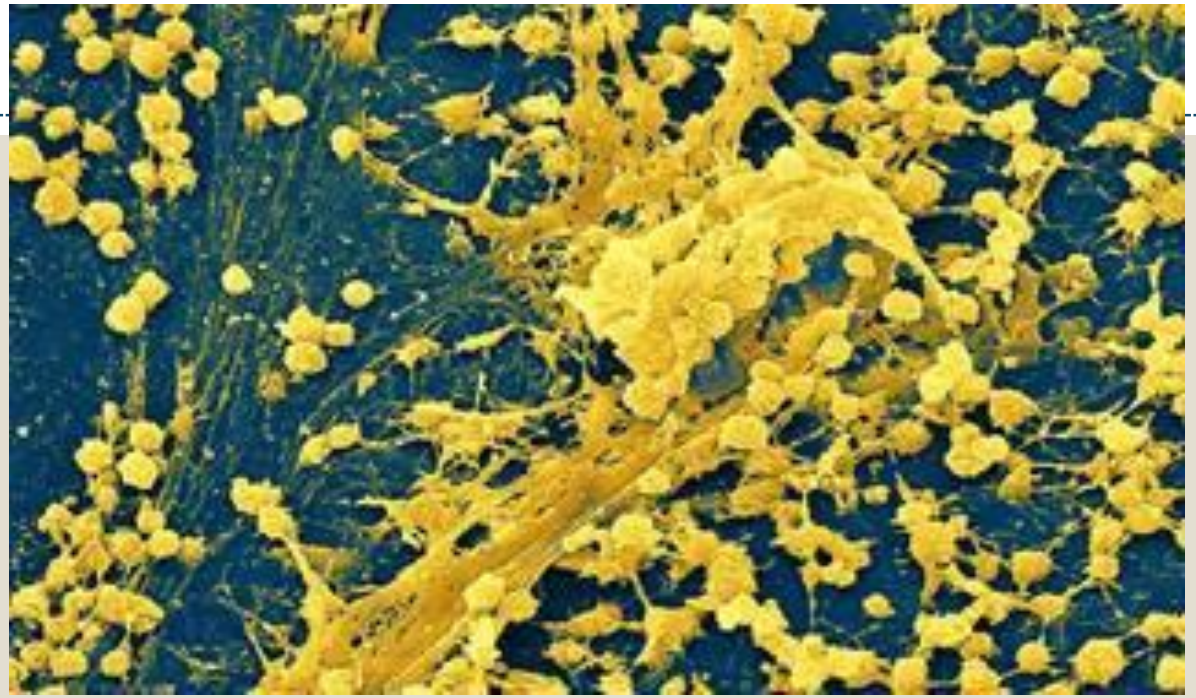
Biofilm:
Instruments & Environmental Surfaces



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CME Disclosure

Michelle Alfa:

- consultant and on the Advisory board for 3M, Olympus and J&J ASP.
- consulting services for Ofstead Associates, and Novaflux Inc. –
- royalties from the University of Manitoba for a patent licence to Healthmark.

None of this funding is related to the research and information she will be presenting.

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St Boniface Research Centre

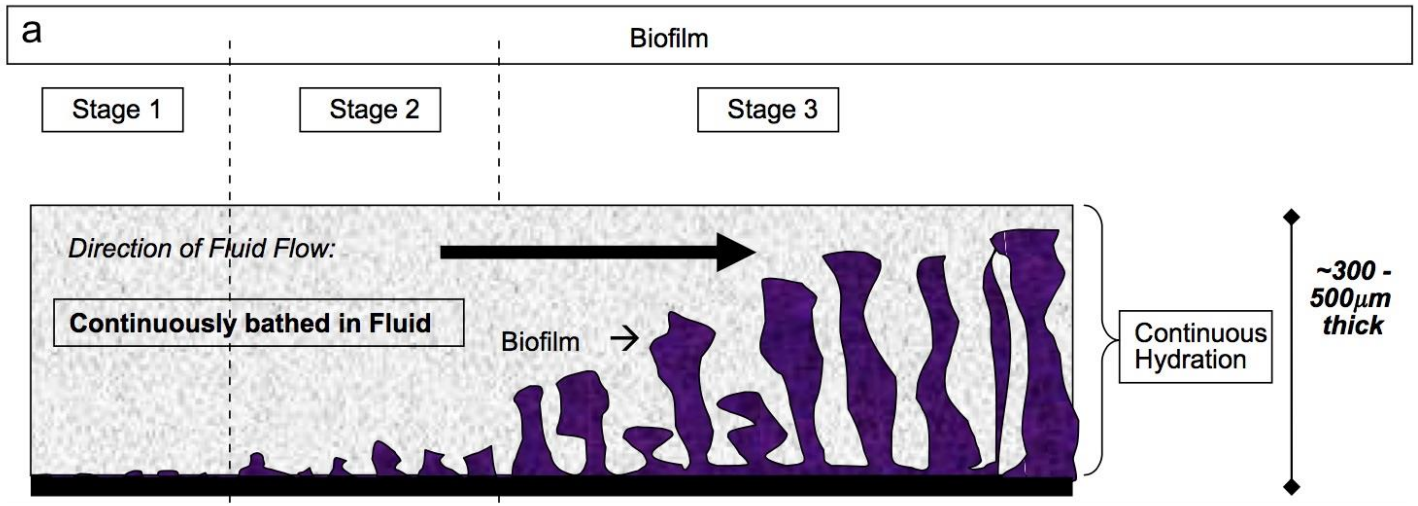
Winnipeg, Manitoba Canada

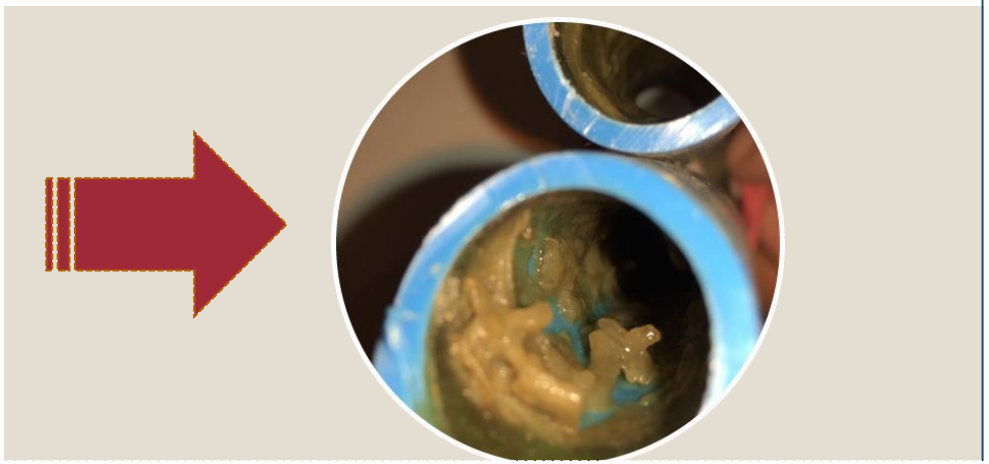
Pat DeGagne Nancy Olson Michelle Alfa

Overview

- How does Traditional biofilm differ from Build-up and Dry surface biofilm?
- Evidence: Impact of Biofilm on Instrument Reprocessing & Surface Disinfection
- Summary

Comparison: Traditional to Non-traditional Biofilm

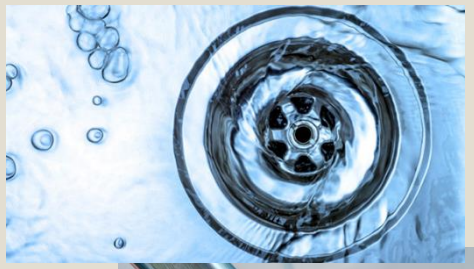


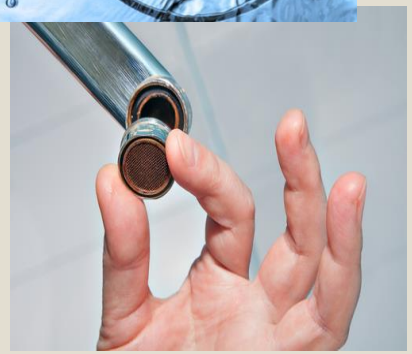


Zhong W, **Alfa M**, Howie R, Zelenitksy S.
Simulation of cyclic reprocessing buildup on reused medical devices. Comput Biol Med 2009 Jun; 39(6): 568-577.

Biofilm in Healthcare

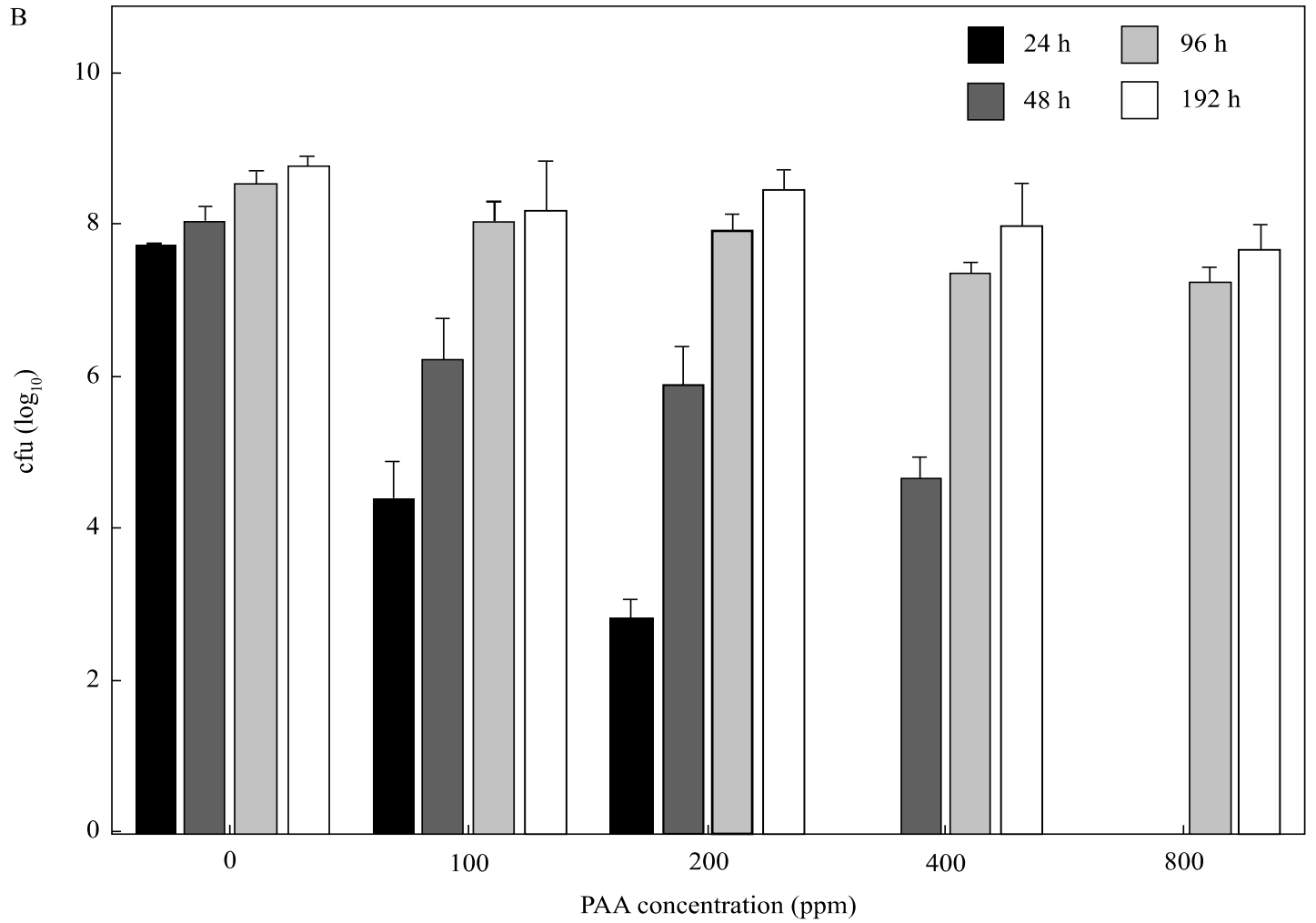
Wounds, Implants | Water | High Touch Surfaces | Medical devices





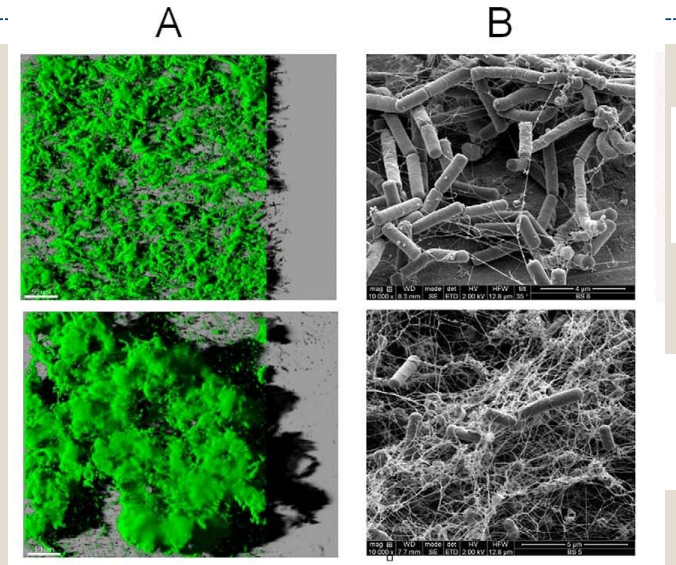
Efficacy of Peracetic acid to kill *P.aeruginosa* in biofilm

- *P. aeruginosa* in mature biofilm not eliminated by 800 ppm PAA after 5 mins exposure



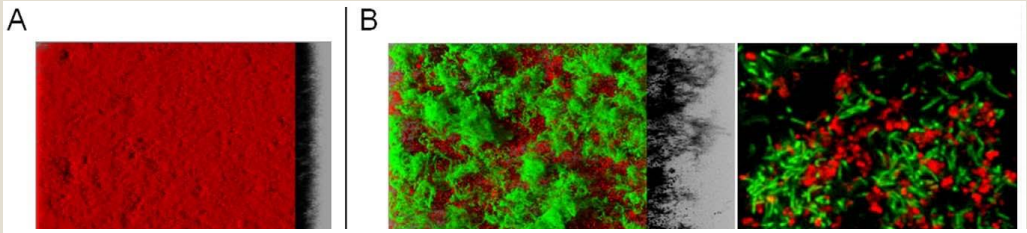
Akinbobola A et al J Hosp Infection 2017. http://dx.doi.org/10.1016/j.jhin.2017.06.024

Protection of *S. aureus* by Bacillus biofilm resistant to PAA



Bacillus subtilis 168: Genetic Stock Centre

Bacillus subtilis ND: Isolated from AER



S.aureus *B. subtilis-ND* Joint Biofilm

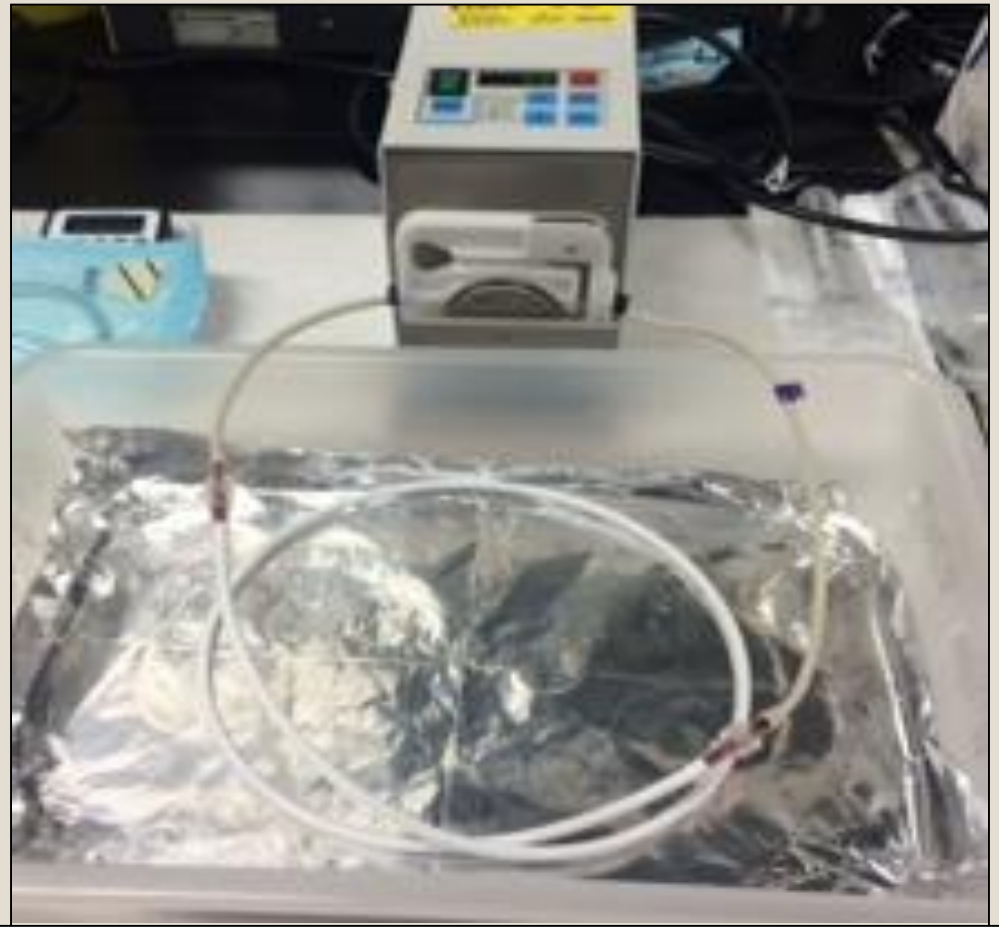
Bridier et al Biofilms of a *Bacillus subtilis* Hospital Isolate Protect Staphylococcus aureus from Biocide Action. PLoS ONE 2012 doi:10.1371/journal.pone.0044506

Table 2. Bactericidal activity of water and 0.35% PAA on single and mixed species biofilms after 5 min of treatment.

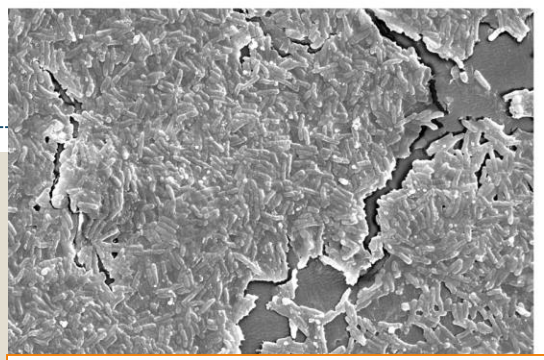
		log (CFU/well)	
	Strain	**Water**	**PAA (0.35%)**
Single species biofilm	*B. subtilis* 168	7.6±0.2	–
	B. subtilis NDmedical	7.7±0.1	3.9±0.6
	S.aureus AH478	9.3±0.1	–
Mixed species biofilm	*B. subtilis* 168	7.5±0.5	–
	S.aureus RN4220	8.2±0.4	–
	B. subtilis NDmedical	7.3±0.3	3.9±0.3
	S.aureus RN4220	8.4±0.1	2.6±0.5

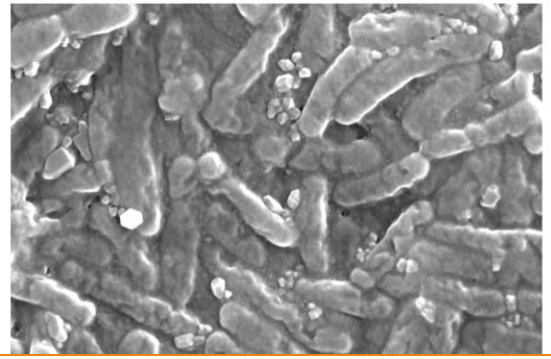
Can MIFU eliminate traditional biofilm?

- Biofilm allowed to form overnight in PTFE channel
- Manufacturer's pump-assisted cleaning combined with liquid chemical sterilization (SS1E)
- Process repeated for 5 times (i.e. 5 consecutive days)
- Optimal culture method



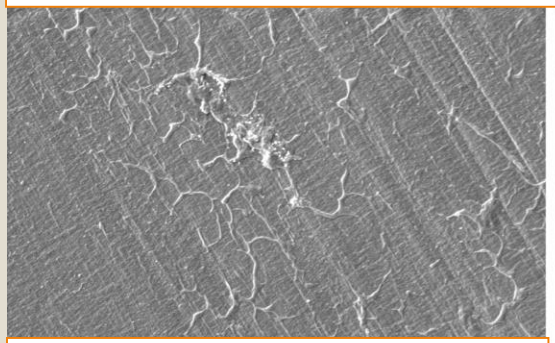
Alfa MJ, et al Simulated-use polytetrafluorethylene biofilm model: repeated rounds of complete reprocessing lead to accumulation of organic debris and viable bacteria. ICHE 2017 http://dx.doi.org/10.1016/j.gie.2017.05.014

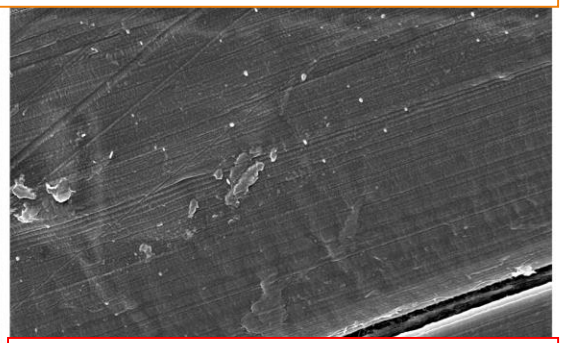




Positive Control

Positive Control
No cleaning

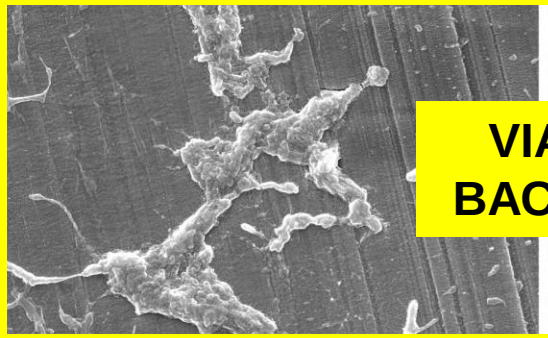


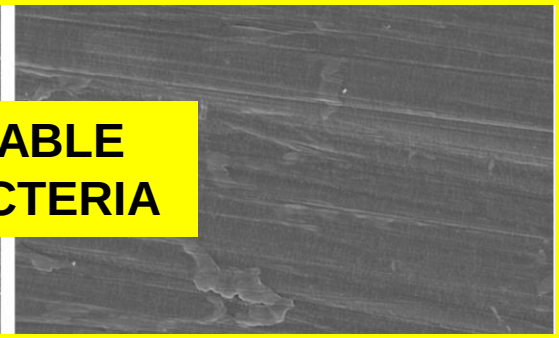


Bristle brush

Pull-through cleaner

Enzymatic detergent



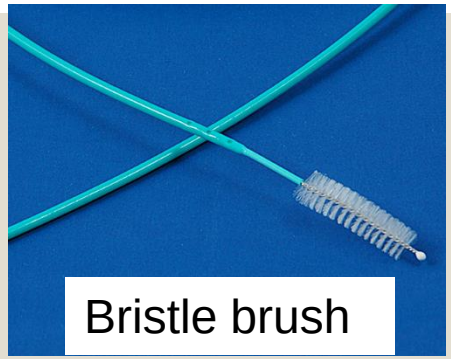


VIABLE BACTERIA

Bristle brush

Pull-through cleaner

Non-Enzymatic detergent



Bristle brush

Pull-through cleaner

Traditional Biofilm take home messages:

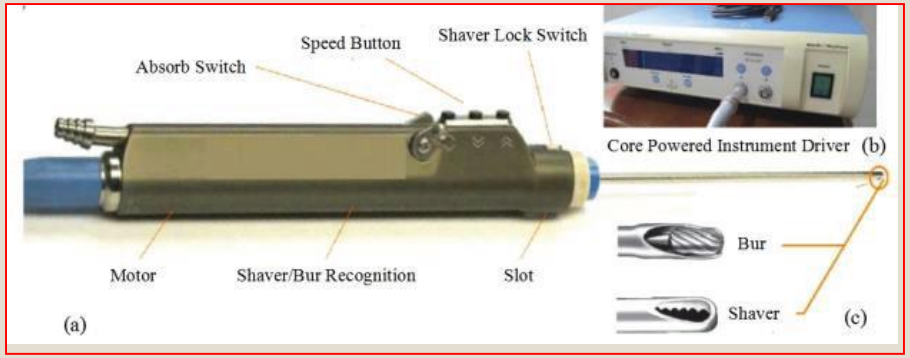
Traditional biofilm:

- Mature biofilm not easy to disinfect
- Protection from disinfection for other bacteria integrated into biofilm
- If cleaning inadequate → disinfection fails

- ***PREVENT*** Biofilm formation

Surgical Power Tools

" Each surgical power tool has the potential to be contaminated with proteinaceous material that aids the adsorption of bacteria to the instrument & may inhibit sterilization processes."



Deshpande et al 2015 Biofouling of surgical power tools during routine use. http://dx.doi.org/10.1016/j.jhin.2015.03.006

Surgical Power Tool contamination after use & after disinfection

Table I
Summary of contaminants detected in surgical power tools

Power tool	Specialties	Contaminants detected before decontamination	Contaminants detected after decontamination
Rotary	Dentistry	Coagulase-negative staphylococci, *Staphylococcus aureus*, *Bacillus* spp., *Streptococcus* spp.	Bacteria including S. *aureus*[20] Hepatitis B DNA[5] Hepatitis C DNA[21]
	Orthopaedic	*Staphylococcus* spp.	Protein[10] DNA[11] Pseudomonas[3]
Ultrasonic	Ophthalmology, neurosurgery, dentistry		Blood[9] Protein[9] Bacteria[4] Fungi (unidentified)[9] Eye lens tissue[9] Viruses[22]
Laser	Dermatology		Cellular debris[23] Herpes simplex virus[6] HIV viral DNA[24]
Robotic			Bacteria[7] Protein[25–28]

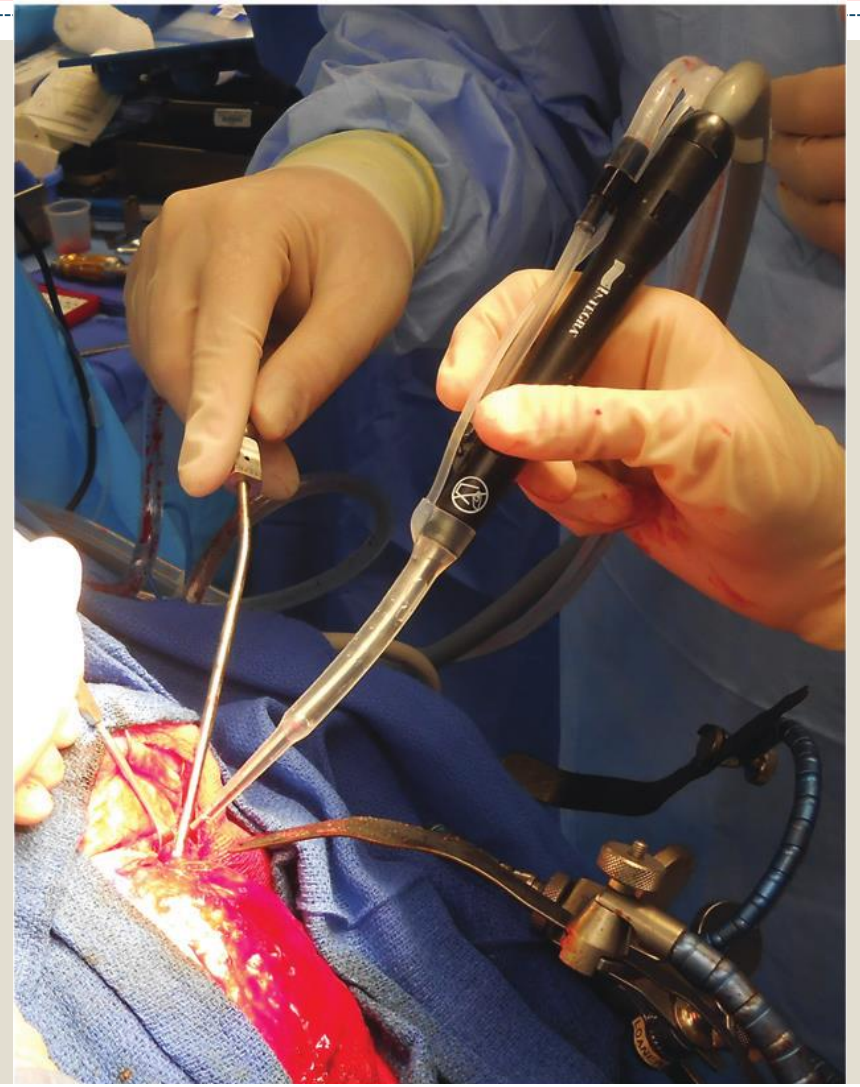
Deshpande et al 2015 Biofouling of surgical power tools during routine use. http://dx.doi.org/10.1016/j.jhin.2015.03.006

Summary of Clinical Infections in Surgical Instruments: disinfection/sterilization failure

Year [Ref]	Surgical Device	Disinfection/ Sterilization	Pathogen & Infection	Issue
1999 [Zaluski	Phacoemulsifier [Eye surgery]	Steam	*P.aeruginosa:* - endopthalmitis	Contamination of internal lines
2007 [Gillespie]	Needle guide for transrectal biopsy	HLD with OPA [overnight soak]*	*P.aeruginosa:* - Septicemia	Encrusted channel contamination
2011 [Tosh]	Arthroscopic handpiece	Steam	*P.aeruginosa:* - knee infections	Tissue retained inside handpiece*
2012 [Dancer]	Orthopedic & Opthalmologic surgical instruments	Steam: wet-packs & intact packs	Bacillus sp, Coag negative Staph. - SSIs	Instruments in intact packs contaminated
2017 [Pesant]	Ultrasonic surgical aspirator	Steam	*P.acnes, CNS, Grp B Strep, E.faecalis* - brain abscess, meningitis	Inadequate cleaning due to process change

Pesant et al AJIC 2017;45:433-5

http://dx.doi.org/10.1016/j.ajic.2016.11.020



Cavitron Ultrasonic Surgical Aspirator (CUSA)
a surgical power tool for tumor resection

Change:

- CUSA sent from OR to CPD for cleaning,
- CUSA sent back to OR for assembly
- CUSA sent to CPD for sterilization

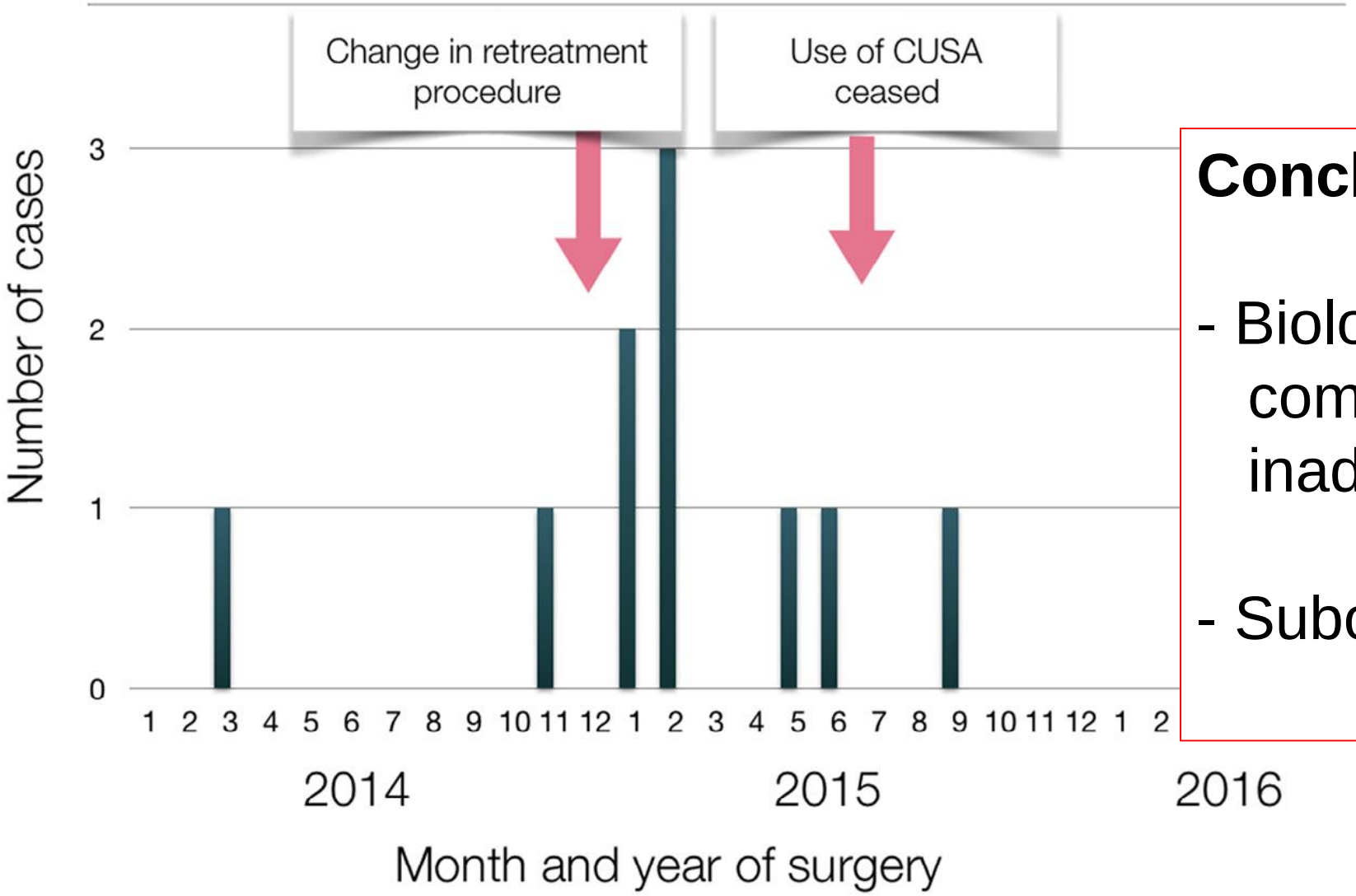
Image from: Wladis E et al Orbit, 2014; 33(3): 234–235

Infections post-craniotomy

Date:	Age:	Days between surgery & infection	Infection	Pathogen grown:
01/23/2015	65	107	Cerebral abscess	*P. acnes*
02/11/2015	74	89	Cerebral abscess, epidural empyema	*None (Abx given prior to culture)*
02/19/2015	42	88	Cerebral abscess	*S. aureus, P. acnes*
02/25/2015	22	25	Meningitis	*S. capitis*
05/01/2015	39	3	Meningitis	*S. agalactiae*
06/18/2015	69	22	Meningitis	*E. faecalis*

Pesant et al AJIC 2017;45:433-5 http://dx.doi.org/10.1016/j.ajic.2016.11.020

C. Sheitoyan-Pesant et al. / American Journal of Infection Control 45 (2017) 433-5



Conclusions:

- Biological fluid dried in complex device → inadequate cleaning

- Suboptimal sterilization

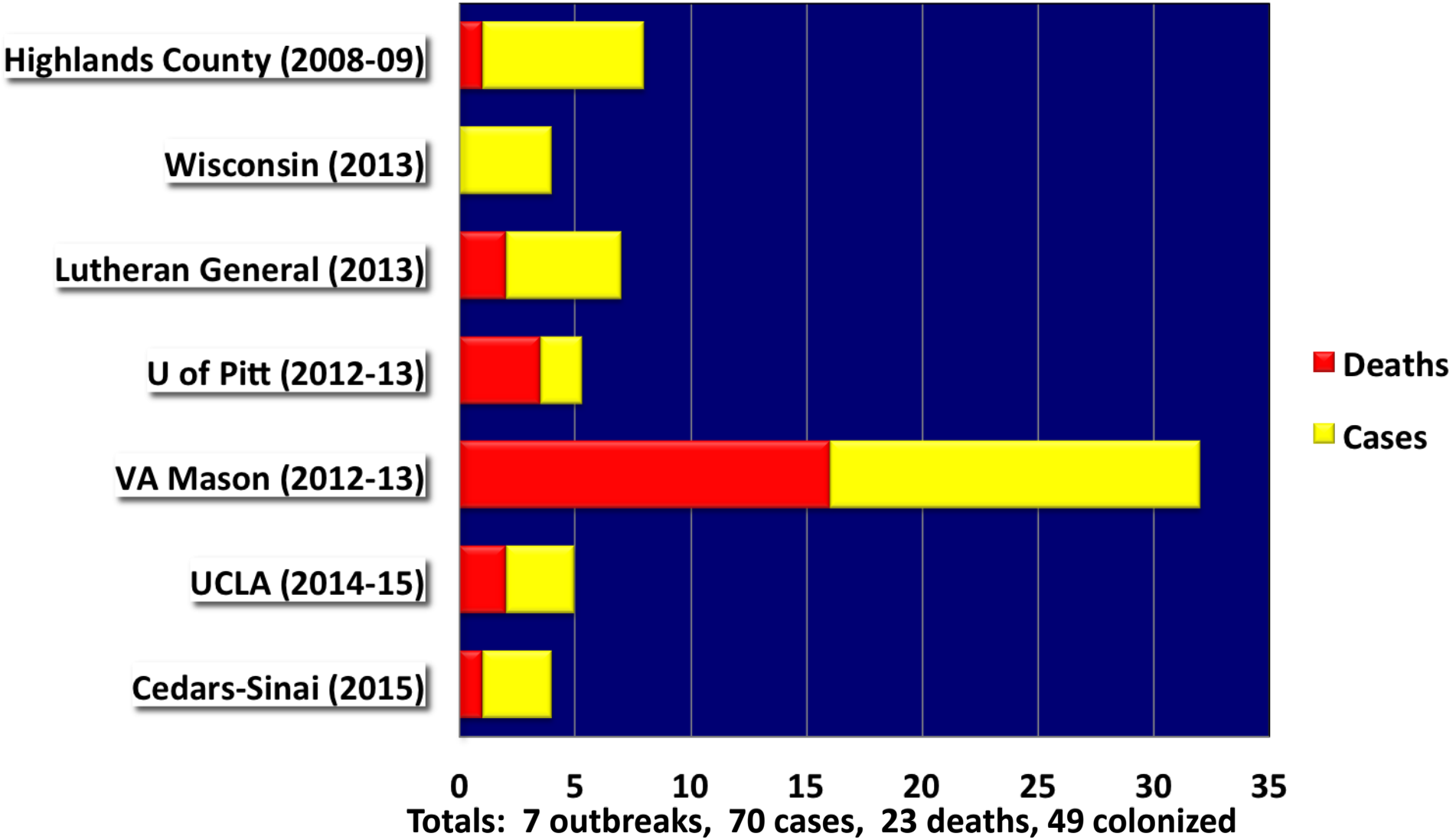
Infection transmission due to contaminated Surgical Instruments

- **Data from USA 2010:**
  - 1.6 million endoscope procedures/year
  - 51.4 million surgical procedures/year

- Many infection transmissions related to incorrect use of HLD rather than steam sterilization
- Risk of infection from reusable surgical instruments is lower than for reusable flexible endoscopes

Southworth P.M. Infections and exposures: reported incidents associated with unsuccessful decontamination of reusable surgical instruments. J Hosp Infect 2014;88:127-131

Duodenoscope-Related MDRO Outbreaks



Slide courtesy of Dr. David Lichtenstein, Boston University Medical Centre

Recent Publications using new FDA recommendations

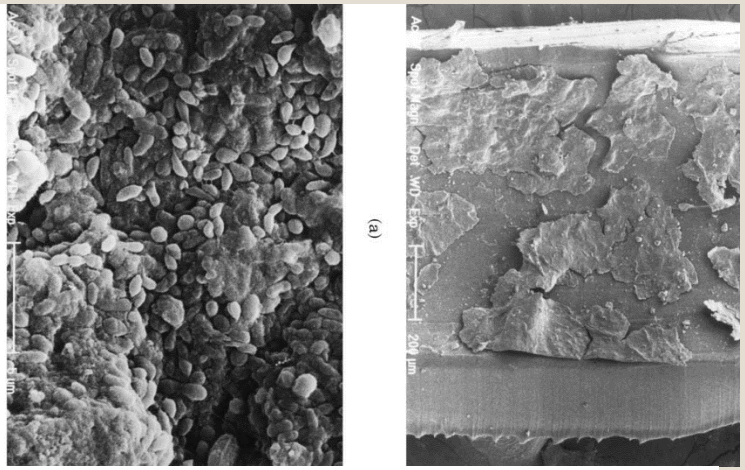
Perform High Level Disinfection (HLD) two times:

- ***Visrodia*** et al GIE 2017
  Persistent regrowth of same organism:
  K. pneumoniae, P.aeruginosa, S.maltophilia
- ***Bartels*** et al GIE 2018
  Presistent regrowth of same organism: *E.coli*
  No improvement HLD x 2 versus HLD once
- ***Snyder*** et al Gastroenterology 2017
  No improvement HLD x 2 versus HLD once

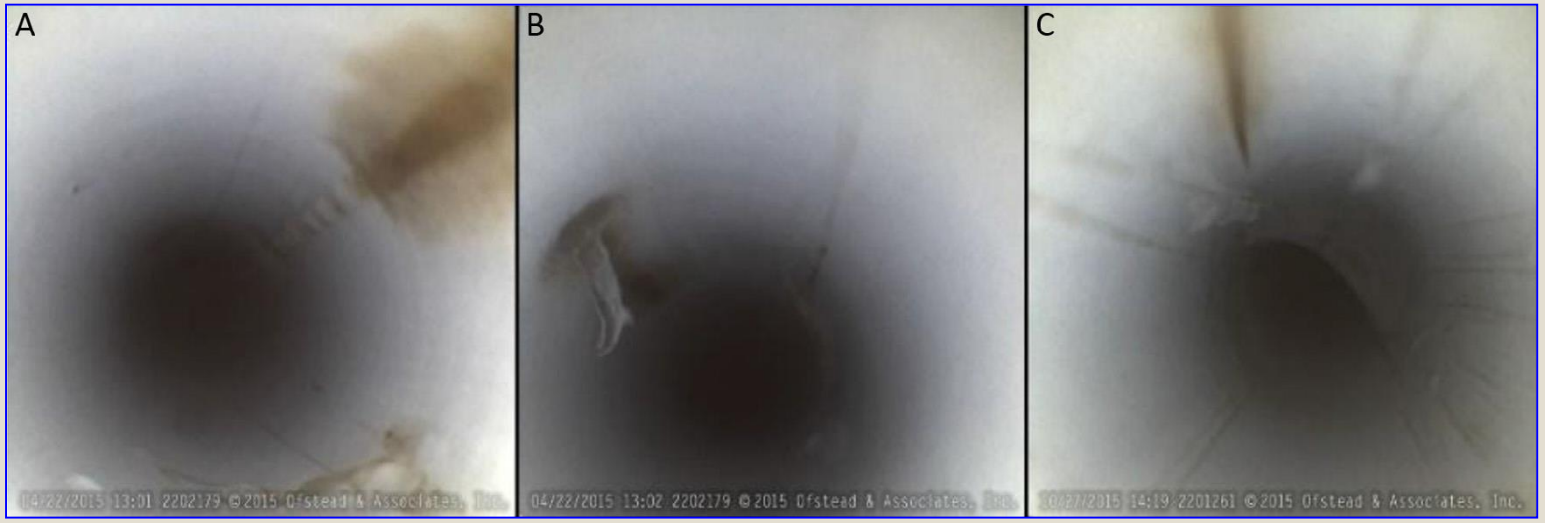
Perform HLD followed by Ethylene Oxide sterilization:

- ***Narzhny*** et al GIE 2016: CRE in 1/84 duodenoscopes
- ***Bartels*** et al GIE 2018: No improvement over HLD once

Debris in fully reprocessed patient-used Endoscope channels



Air/Water Channels:
Pajkos 2004, Ren-Pei 2014



Instrument Channels: Ofstead et al AJIC 2017

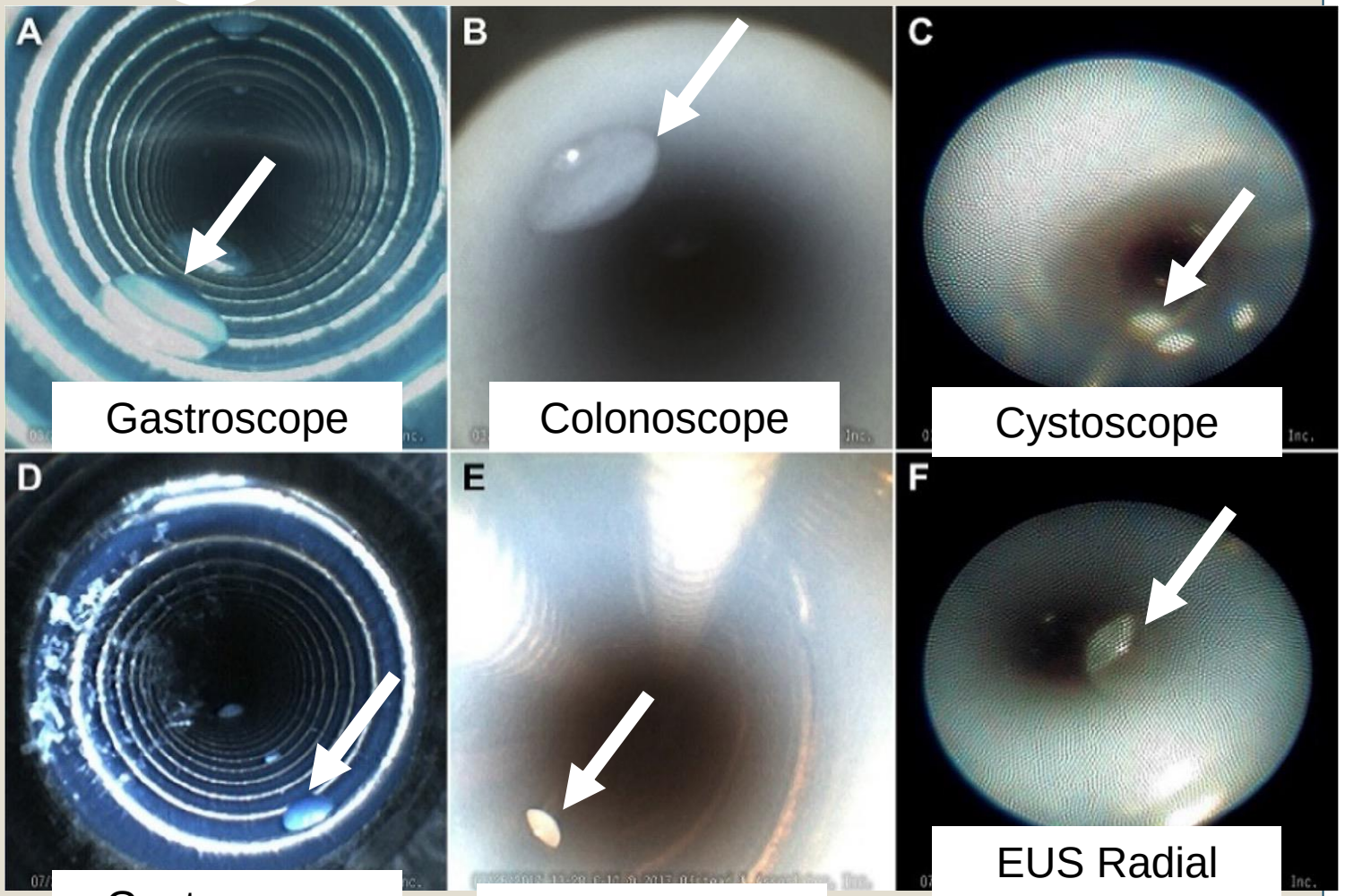
Gradual accumulation of residual material:

- Inadequate HLD
- Inadequate Low Temperature Sterilization

Endoscope storage: Inadequate Drying

<u>Patient-Ready</u> Scopes: After AER alcohol flush and forced air dry and overnight storage

- ***Ambulatory Clinics; Visible fluid*** in 95% of channels (Ofstead 2017)
- ***Large Joint commission accredited Healthcare system*: Visible fluid** in 49% of channels
  Sites A & D; 85%, Site B; 0% (Ofstead 2018)



Evidence of GI Endoscope Contamination

Rauwers AW et al. Gut 2018 doi: 10.1136/gutjnl-2017-315082

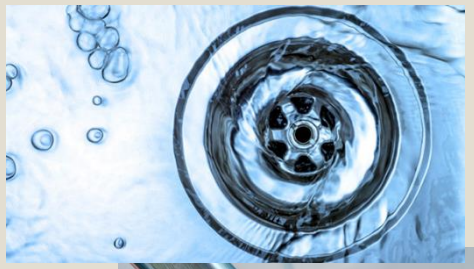
Culture: Neutralizer & sample concentrated by filtration

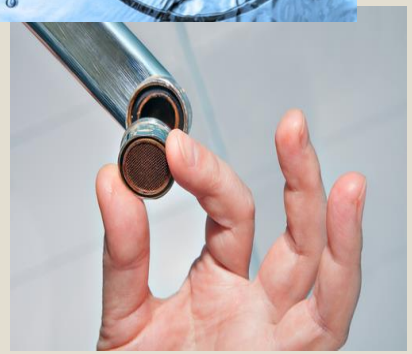
Organism grown: GI flora	Number of Duodenoscopes	Quantity Range
Yeast	7	6-100 CFU
Klebsiella pneumoniae	4	100 - > 100 CFU
Enterobacter cloacae	3	100 - > 100 CFU
Escherichia coli	2	50 – 100 CFU
Klebsiella oxytoca	2	100 - > 100 CFU
Enterococcus faecium	1	1 CFU
Enterococcus faecalis	1	100 CFU
Pseudomonas aeruginosa	1	100 CFU
Staphylococcus aereus	1	> 100 CFU

- **Duodenoscopes: 15% of 150 tested were contaminated (represents 67 Dutch ERCP centres)**
- **Current reprocessing & process control procedures not adequate**

Biofilm in Healthcare

Wounds, Implants | Water | High Touch Surfaces | Medical devices



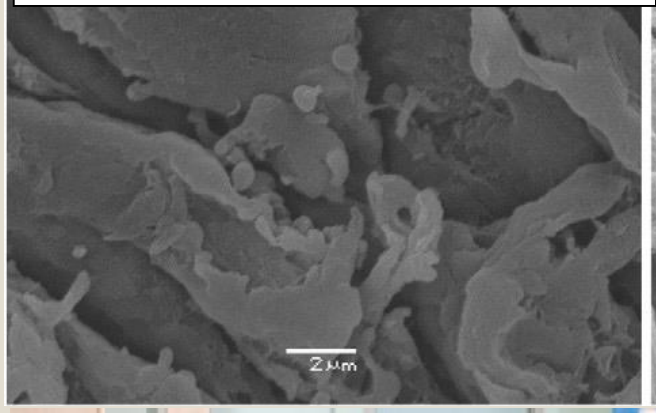


Dry Surface Biofilm

- Accumulation of material after repeated surface cleaning
- Protein, DNA, Glycoconjugate

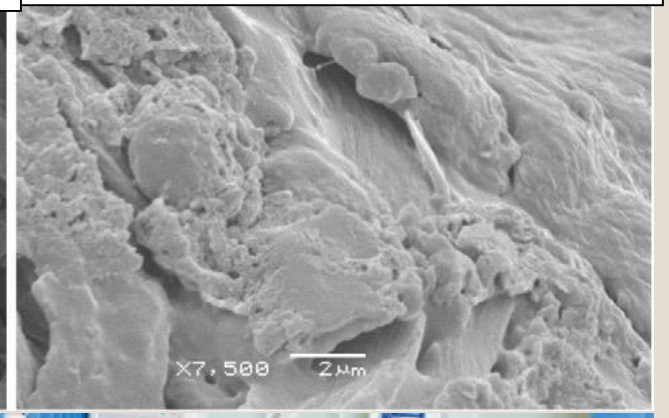
A

Dry Surface Biofilm Model

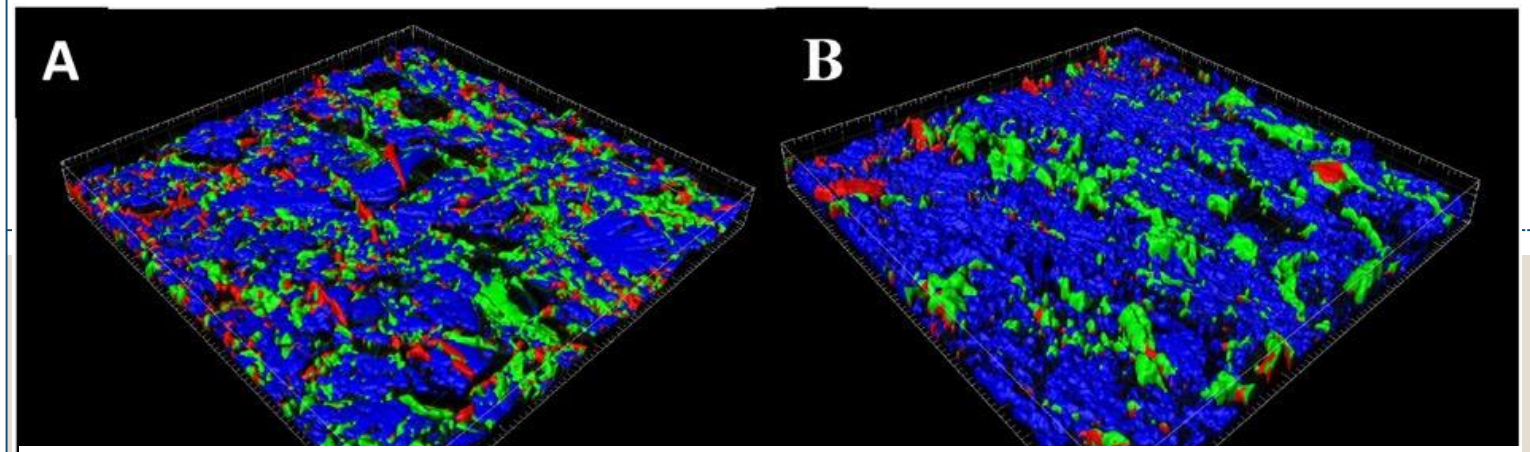


B

Surface: Sterile supply box



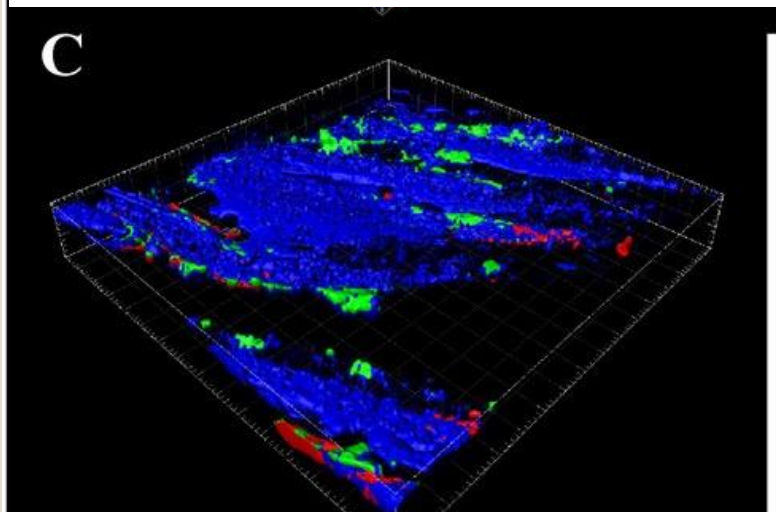
Almtroudi et al J Microbiological Methods 2015;117:171-176



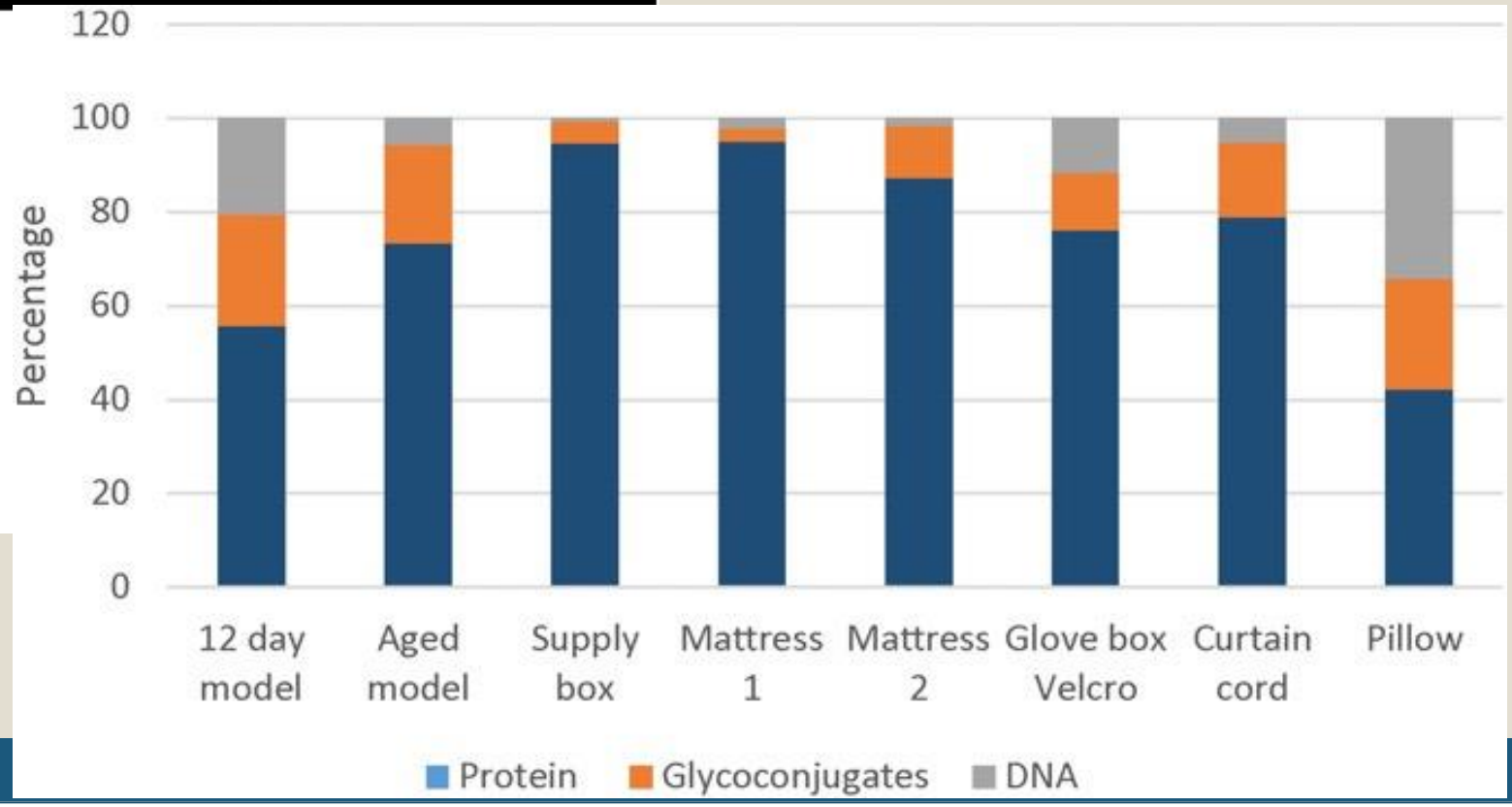
Dry Surface Biofilm 12 days

Dry Surface Biofilm 18 days

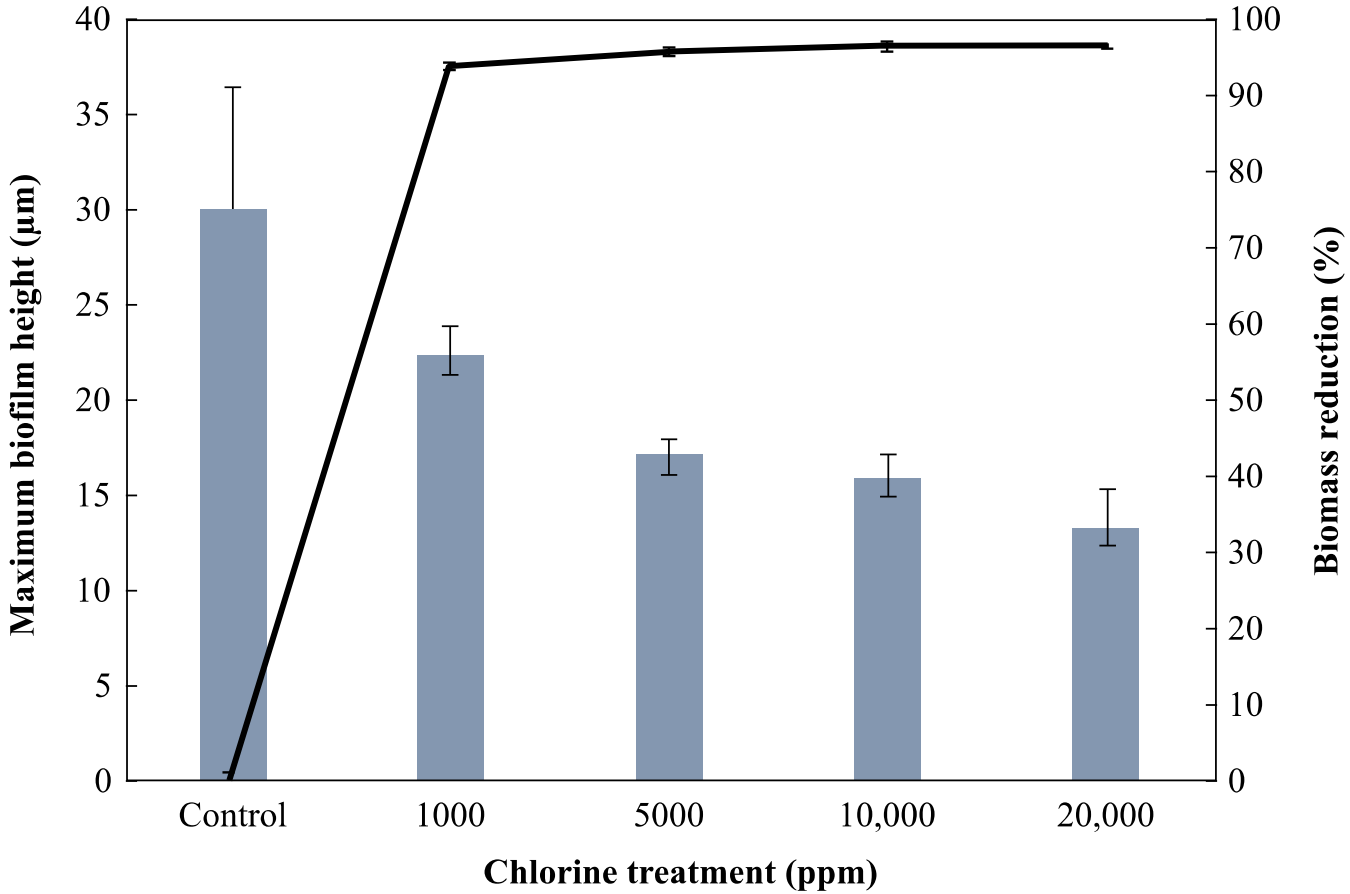
Blue: Protein
Red: Bacterial DNA
Green: Gycoconjugate

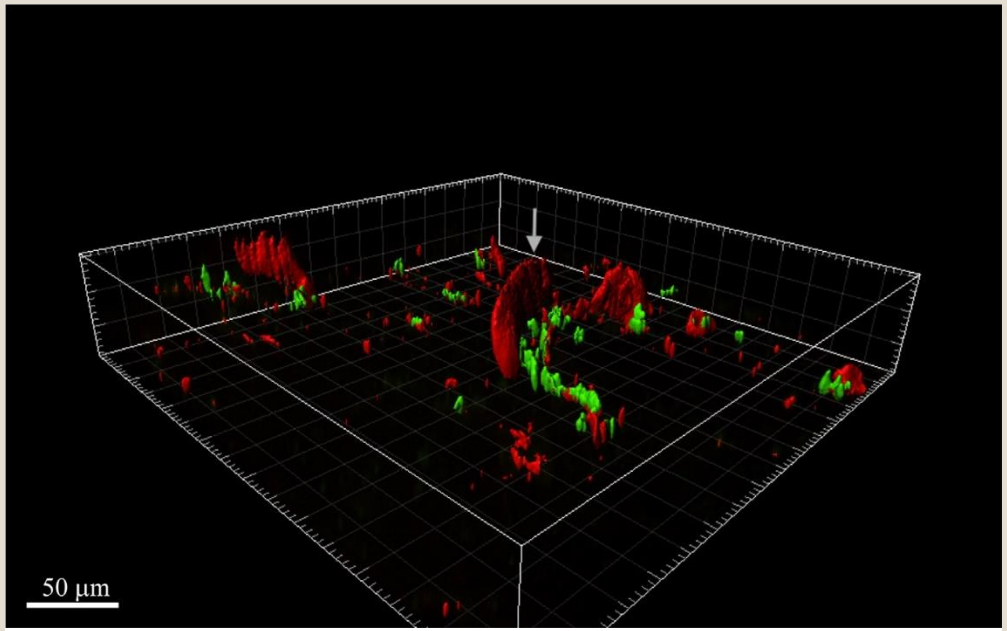


Clinical Glove box Velcro Biofilm



Chlorine killing ineffective against *S.aureus* in Dry-surface biofilm





Dry-surface biofilm treated with 20,000 ppm chlorine for 10 mins.

RED: Dead cells
GREEN: Live cells

Almatroudi A et al Journal of Hospital Infection 93 (2016) 263e270

Unanswered Questions:

- **Repeated cleaning/disinfection of Environmental Surfaces:**

  - Is physical removal of dry-surface biofilm in healthcare adequate?
  - Are various healthcare surface disinfectants able to penetrate and kill microbes in dry-surface biofilm?
  - Does dry-surface biofilm facilitate infection transmission from environmental reservoir?

Conclusions

- **Surgical Instruments:**
  - Residual patient material build-up from improper cleaning can protect organisms from steam sterilization
- **Flexible Endoscopes**
  - Wet storage facilitates biofilm formation
  - Organisms in Build-up biofilm or traditional biofilm can survive HLD and low temperature sterilization
- **Dry-surface Biofilm:**
  - Better represents healthcare environmental surfaces
  - Protects microbes from chlorine

Help to Ban the Biofilm!

1. Southworth P.M. Infections and exposures: reported incidents associated with unsuccessful decontamination of reusable surgical instruments. J Hospital Infection 2014;88:127-131
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