VirginiaTech
Invent the Future

Nontuberculous Mycobacteria and Heater-Coolers

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Disclaimers

- Dr. J.O. Falkinham has consulting agreements with:
- LivaNova
- Sorin North America
- Cincinnati SubZero

Nontuberculous Mycobacteria (NTM)

- Environmental opportunistic pathogens
- Over 200 *Mycobacterium* species:
- Rapidly growing (3 days): *M. abscessus*
- Slowly growing (14 days): *M. avium, M. intracellulare, M. chimaera*
- All are surrounded by a hydrophobic outer membrane with long chain lipids (C_{60}-C_{80})

Mycobacterium avium Complex

- **MAC includes**:
- ***M. avium* subspecies:** *avium, silvaticum, hominissuis*, and *paratuberculosis*
- ***M. avium complex species:***

M. colombiense	*M. marseillense*
M. timonense	*M. bouchedurhonense*
M. yongonense	*M. vulneris*
M. intracellulare	*M. chimaera*

NTM Hydrophobic Outer Membrane

- Slow growth: energy required for lipids
- Impermeable cells: slow nutrient entry
- Impermeable cells: disinfectant-resistant
- Prefer adherence and biofilm formation
- Grow on low organic carbon levels
- Can grow under reduced oxygen
- Concentrated in aerosols

NTM Sources

- Natural soils and waters
- Commercial potting soil
- Drinking water distribution systems
- Premise plumbing including showerheads
- Water heaters
- Refrigerator water and ice
- Hot tubs, spas, therapy pools
- Humidifiers

NTM and Premise Plumbing

Premise plumbing: an ideal habitat for NTM:

- Disinfectant kills off competitors
- Relatively heat-resistant
- Grow on available organic matter
- Large surface area for biofilms
- Regular warming of water
- Able to grow in stagnant water
- Grow in amoebae

Biofilms in Premise Plumbing and Heater-Coolers

- Many more cells in biofilm than suspension
- 100-1,000/mL versus 10,000/cm^2
- Biofilm cells embedded in matrix of: polysaccharide, lipid, DNA, and protein
- Adherence prevents washing out of cells
- Impermeable to disinfectants
- NTM always come back after disinfection

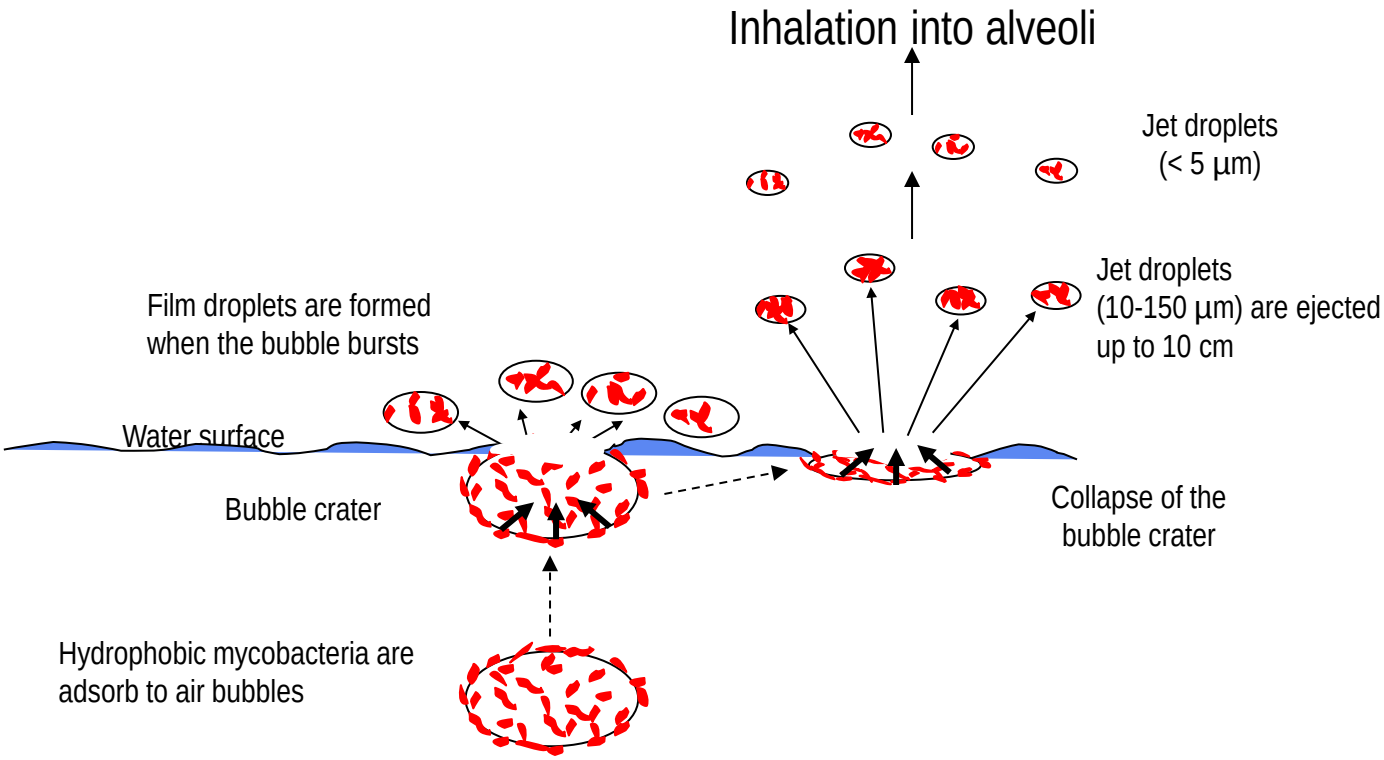
NTM Disinfectant Resistance

- $CT_{99.9}$% = Product of disinfectant concentration (ppm) and duration of exposure (min) to kill 99.9 % cells
- NTM are resistant to: chlorine, chloramine, chlorine dioxide, and ozone.
- Microbe — $CT_{99.9\%}$ (chlorine)
  - *Escherichia coli* — 0.05
  - *Mycobacterium avium* — 100-200
- Cells in biofilms 5-10 more resistant

NTM Aerosolization from Heater-Coolers

- Air bubbles collect hydrophobic NTM cells
- Bubble bursts at air-water interface
- Ejection of droplet with concentrated NTM
- Droplets 1,000–10,000-times higher NTM numbers compared to bulk suspension
- Droplets ejected to 10 cm above water
- Droplets transferred by air flow

Aerosol Concentration of NTM



Heater-Cooler Disinfection

- Disinfection a two-stage process:
  Biofilm-disruption and Disinfectant-killing
- Biofilm-disruption requires:
  detergent to break hydrophobic bonds
  salts to break ionic bonds
  enzymes to break down polysaccharides,
  DNA, lipids, and proteins
- Disinfectant-tolerance of instrument