Dental Water Quality Issues in Dentistry

Shannon Mills, DDS
Objectives

• Recognize the potential health risks associated with dental waterline biofilms
• Describe the recent case reports of waterborne *Mycobacterium abscessus* outbreaks in pediatric dental practices in Georgia and California
• Describe the role of biofilm in the contamination of water used for dental treatment and the challenge of maintaining acceptable water quality in dental equipment that uses small bore tubing
• List practical steps to manage the quality of water used in dental practices to ensure the safety of patients and staff members
Disclosures: Dr. Mills

Dr. Mills is Vice President for Strategy and Business Development for PreViser Corporation.

Neither he, his family members nor PreViser Corporation have any financial interest in products sold for the management of dental water quality.

The opinions expressed in this presentation are those of the speaker and do not necessarily reflect the official position of OSAP or PreViser Corporation.
Dental Equipment and Biofilms

• Dental devices are vulnerable to colonization by microbial biofilms

• Patients and staff may be exposed to water containing bacteria and bacterial byproducts
Dental Waterline Biofilm
Colonization Sequence

Photos: USAF Dental Investigation Service
Denizens of Dental Waterlines

Amoebae

Nematode
Dental Unit Design Issues
Dental Unit Design Issues

- Established biofilms resist dislodgement and disinfection
  - Dental unit waterline material are highly attractive substrates for bacterial attachment and biofilm formation
  - Biofilms flourish in both low- and high-shear stress environments
  - Viscoelastic biofilm polymers help resist dislodgement
- Laminar flow produces low shear stress on most surfaces
- Flushing does not reliably improve dental water quality
Dental Unit Design Issues

Biofilms removed by chemical treatment

Biofilm formed six weeks after installation

Richard Karpay, DDS
The Geometry Problem

- Narrow diameter tubing results in large surface area for biofilm growth relative to volume of water
Dental Unit Water Quality Issues

- Colony counts in water from untreated systems can exceed $10^6$ CFU/mL (usually $10^3$-$10^5$)
  - Primarily Gram negative heterotrophic water bacteria
  - Oral flora, *Legionella* and *Mycobacterium* species have been recovered
  - Mature waterline biofilms may also harbor potentially pathogenic fungi and amoebae.
# Potential Pathogens Isolated from Dental Units

<table>
<thead>
<tr>
<th>Organism</th>
<th>Potential Pathogenicity</th>
<th>Dental Case Reports</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>Wound infection, septicemia, pneumonia, granulomatous pneumonitis</td>
<td>Wound infection</td>
</tr>
<tr>
<td>Other <em>Pseudomonas</em> sp. <em>Burkholderia</em></td>
<td>Wound infection, septicemia, pneumonia</td>
<td>None</td>
</tr>
<tr>
<td><em>Legionella</em> sp.</td>
<td>Pneumonia, wound infection, Pontiac Fever</td>
<td>Serological markers for infection in DHCP, fatal legionellosis 2012</td>
</tr>
<tr>
<td><em>Aquatic Mycobacteria</em></td>
<td>Wound infection, pneumonia</td>
<td>Two outbreaks in pediatric dental practices 2015-2017</td>
</tr>
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<th>Potential Pathogenicity</th>
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<tr>
<td><em>Moraxella sp.</em></td>
<td>Conjunctivitis, endocarditis</td>
<td>Endocarditis (anecdotal report)</td>
</tr>
<tr>
<td>Flavobacteria <em>(Chryseobacterium)</em></td>
<td>Endocarditis</td>
<td>None</td>
</tr>
<tr>
<td>Pathogenic amoebae</td>
<td>Conjunctivitis, gastroenteritis, meningitis</td>
<td>None</td>
</tr>
<tr>
<td><em>Cladosporium</em> (fungus)</td>
<td>Granulomatous pneumonitis</td>
<td>None</td>
</tr>
<tr>
<td>Oral flora</td>
<td>Transmission of periodontal pathogens</td>
<td>None related to dental waterlines</td>
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Legionella Deaths

• Suspected dental legionellosis case (Atlas and Williams, 1995)
  – 65 y.o. orthodontist died after developing *Legionella* pneumonia
    • *Legionella* species isolated from dental water and other sites in home and office did not match lung isolates

• Confirmed fatal case in Italy (Ricci et al, 2012)
  – 82 year old woman died after contracting legionella pneumonia traced to contaminated dental treatment water.
Mycobacterium abscessus Infections in a Georgia Pediatric Practice

Morbidity and Mortality Weekly Report

Notes from the Field

**Mycobacterium abscessus Infections Among Patients of a Pediatric Dentistry Practice — Georgia, 2015**

Gianna Peralta, MPH; Melissa Tobin-D'Angelo, MD; Angie Parham, DVM; Laura Edison, DVM; Lauren Lorenzson, MPH; Carol Smith, MSHA; Cherie Drenzek, DVM

On September 13, 2015, the Georgia Department of Public Health (DPH) was notified by hospital A of a cluster of pediatric Mycobacterium abscessus odontogenic infections. Hospital A had provided care for nine children who developed presumptive or confirmed *M. abscessus* infection after having a pulpotomy at pediatric dentistry practice A (dates of onset: July 23, 2014–September 4, 2015). During a pulpotomy procedure, decay and the diseased pulp are removed to preserve a deciduous tooth. DPH initiated an investigation to identify the outbreak source and recommend prevention and control measures.

*M. abscessus* is a rapidly growing, non-tuberculous mycobacterium. No other infection control deficiencies were noted. Water samples were collected for microbiologic analysis, and patient and water sample isolates were sent to CDC for molecular characterization by pulsed-field gel electrophoresis (PFGE).

Practice A had performed 1,386 pulpotomies since January 1, 2014. As of January 1, 2016, a total of 20 patients with confirmed (*n* = 11) or probable (*n* = 9) *M. abscessus* infections were identified, resulting in an attack rate of 1%; case finding is ongoing. Median patient age was 7 years (range = 3–11 years), and median incubation period was 65 days (range = 18–164 days). All patients were severely ill, requiring hospitalization at least once for a median of 7 days (range = 1–17 days); 17 patients required surgical excision and 10 received outpatient intravenous antibiotics (Table). As of April 5, 2016, no deaths have resulted from infection.

**TABLE.** Demographic characteristics, symptoms, diagnostic evaluations, and treatment of 20 patients with confirmed or

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Median patient age was 7 years (range = 3–11 years), and median incubation period was 65 days (range = 18–164 days).

As of 1/1/2016, 20 patients confirmed (n = 11) or probable (n = 9) for *Mycobacterium abscessus* infections; No deaths.

17 patients required surgical excision and 10 received outpatient intravenous antibiotics.

The practice had performed 1,386 pulpotomies since January 1, 2014.

Attack rate 1.443/100 pulpotomies
Identifying the Source

- DPH staff visited the practice on September 22, 2015, to evaluate infection control and prevention practices
  - Tap water was used for pulpotomies
  - Water quality was not monitored
  - Daily bleach treatment of waterlines was not performed as recommended by the unit manufacturer
  - No other infection control deficiencies were noted
Water contamination suspected

- Water samples were collected for microbiologic analysis
- Patient isolates and water sample were sent to CDC for culture, id, and molecular typing
- Molecular typing confirmed dental water as source
• All dental unit water samples exceeded the CDC recommended limit of ≤500 CFU/mL (average = 91,333 CFU/mL);
• *M. abscessus* was isolated from all water samples and patient isolates indicating a common source.
• This outbreak was caused by contaminated water used during pulpotomies.
Anaheim California - 2016

- The Orange County Health Care Agency in California reported that as of December 27, 2016, 63 cases of *M. abscessus* infection are linked to an Anaheim California pediatric dental practice
- 21 are confirmed, 42 are probable; associated with pulpotomy procedures
- All have been hospitalized at some point.
- The age range is 2 to 10 years for all cases. The pulpotomy date range was 03/01-8/11/2016 for all cases.
Extensive media coverage

Mimi Morales recovers in Children's Hospital of Orange County in late September after surgery for a dental infection she contracted at Children's Dental Group in Anaheim, Calif. She had three permanent teeth, one baby tooth and part of her jawbone removed.

Mindy Schauer/The Orange County Register
California Summary

• Case count as of 01/17/2017 66 patients:
  • 21 confirmed, 45 probable
  • Age range 2-11 years
• Premise plumbing not contaminated but, *M. abscessus* identified from samples from DUWLs
• Facility installed all new equipment
  • Included routine disinfection; and system that releases free iodine into DUW.
• Investigation is ongoing
What are mycobacteria and why are they important?

- Nontuberculous mycobacteria (NTM) are commonly found in the environment (soil, water vegetation)
- Some are opportunistic pathogens and occur in drinking water; they are chlorine tolerant to resistant
- Exist in biofilms in premise plumbing
- NTM infections have been increasing over time
- Outbreaks occur in healthcare settings (in-patient, out-patient settings due to exposure to tap water)
Issues Related to Premise Plumbing

• Tap water often exceeds 500 CFU/mL HPC counts, especially
  – Outbreaks due to quality of tap water
  – Opportunistic pathogens can be found in the heterotrophic plate count bacteria (May also contain free living amoeba, Acanthamoeba spp, and Naegleria)
    • *Legionella pneumophila*
    • *Pseudomonas aeruginosa*, and other gram negative bacteria (eg. *Burkholderia, Pantoeae, Ralstonia, Stenotrophomonas, Sphingomonas*, etc)
    • *Environmental mycobacteria*

Managing Water-Premise Plumbing

➢ Depending on building type - may need to have a water management plan (currently driven by ASHRAE 188)
  ▪ Typically large buildings with complex water distribution systems
    ▪ Hospitals, Medical Center Campuses, Skilled Nursing, Long Term Care, Longterm Acute Care, etc.
    ▪ University and School buildings, residential halls
    ▪ Large Industrial Buildings

➢ Risk based approach that applies the concepts of Hazard Analysis Critical Control Points or HACCP

➢ Institute control measures
• For non-surgical treatment use water that meets EPA drinking water standards (> 500 CFU/mL of HPC bacteria)
• Consult with dental unit manufacturer for appropriate methods to maintain dental water quality
• Follow manufacturer recommendations for monitoring water quality
CDC Guidelines 2003

Surgical Irrigation

• Use sterile saline or sterile water as a coolant/irrigator in surgical procedures:
  – Incision, excision, or reflection of skin or oral mucosa exposing previously uncontaminated soft tissue
    • Examples: biopsy, periodontal surgery, apical surgery, extractions of permanent teeth
    • Procedures that involve the reflection of tissue and/or cutting of bone

### I.12 Dental Unit Water Quality

<table>
<thead>
<tr>
<th>Elements To Be Assessed</th>
<th>Assessment</th>
<th>Notes/Areas For Improvement</th>
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<tbody>
<tr>
<td><strong>A.</strong> Policies and procedures are in place for maintaining dental unit water quality that meets Environmental Protection Agency (EPA) regulatory standards for drinking water (i.e., ≤ 500 CFU/mL of heterotrophic water bacteria) for routine dental treatment output water</td>
<td>□ Yes □ No</td>
<td></td>
</tr>
<tr>
<td><strong>B.</strong> Policies and procedures are in place for using sterile water as a coolant/irrigant when performing surgical procedures</td>
<td>□ Yes □ No</td>
<td></td>
</tr>
<tr>
<td><strong>Note:</strong> Examples of surgical procedures include biopsy, periodontal surgery, apical surgery, implant surgery, and surgical extractions of teeth.</td>
<td></td>
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<tr>
<td><strong>C.</strong> Written policies and procedures are available outlining response to a community boil-water advisory</td>
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</table>
Options for Water Management

- Independent reservoirs
- Chemical treatment
  - Continuous
  - Intermittent
- Water Treatment Devices
- Antimicrobial surfaces (tubing, reservoirs)
- Sterile water delivery systems
- Combined approaches
Independent Reservoirs

• Most economical option
• Follow manufacturer instructions for use
  – Acceptable agents
  – Frequency of treatment
• **Useless** without chemical treatment!
• Must use water of acceptable quality
• Disinfect reservoirs and use aseptic technique when handling
Water Treatment Devices

- Automate water treatment process
- Passive systems use germicide impregnated resins and/or antimicrobial surfaces
- Some devices also filter and condition water
Source Water Management

• Source water treatment or polishing (these require routine preventive maintenance to maintain water quality)
  • Reverse Osmosis system
  • Distillation
  • Deionization followed by the use of Germicidal UV and an ultrafilter
• Disinfectant residual present at point of use?
• Do not connect units to potable water without treatment device!
Source Water Options

• Sources of water for independent reservoirs
  – Sterile water for irrigation (USP)
  – Sterile water (autoclaved)
  – Freshly boiled water
  – Distillers or reverse osmosis (devices may be prone to contamination)
  – Commercial bottled drinking water

• Methods to treat municipal water
  – Filtration (0.22 micron membrane filter)
  – Ultraviolet germicidal Irradiation (UVGI)
  – Continuous chemical treatment
Monitoring Dental Water Quality

• Follow manufacturer instructions for monitoring method and frequency
  – In-office chairside testing using heterotrophic plate count test kits
  – Commercial laboratory testing using standard methods (some dental spore testing services now provide waterline monitoring services)

• Do not test for specific organisms except to investigate a site infection or outbreak
Biofilms & premise plumbing

- High surface to volume ratio
- Water age
- Loss of disinfection residual
- Premise plumbing materials (copper, plastics, brass, lead, galvanized iron, stainless steel)
- Plumbing fixtures and components
Recommendations

• Dental practices should follow CDC Guidelines and manufacturer instructions for water management for all devices that provide water for dental treatment

• Isolate dental water systems from municipal water supplies using:
  – Independent water reservoirs
  – Water treatment devices
  – Point of use filtration
  – Sterile water delivery systems for oral surgery

• Use water of known microbiological quality in water reservoirs
Recommendations

• For units currently supplied by municipal water:
  – Shock treat the lines to remove existing biofilm or;
  – Replace biofilm contaminated lines with new tubing

• Follow manufacturer instructions for monitoring
  – Use drinking water standard testing methods
  – Do not test for specific organisms except to investigate a site infection or outbreak
  – Caveat: Standard test methods will not detect NTMs or Legionella

• Report suspected waterborne infection to health authorities
Questions?