Heater-cooler units as a source of other pathogens

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Content

1. Precautions HCU
2. Regulations tap water
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Heater-Cooler Unit

Heater-cooler units use water to control a patient’s body temperature during cardiac surgery. Water in the heater-cooler never directly touches the patient, but it does escape through the exhaust vents.
Intended use

In accordance with the applicable regulations, the heater-cooler is intended for use with a heart-lung machine featuring a separate temperature control for extracorporeal perfusion of durations of up to 6 hours.

The watercircuits are used for cooling/heating blood (in the oxygenator), hypothermia blankets or cardioplegic solutions.
Operational safety

• Use filtered tap water that has been filtered by using e.g. a disposable Pall-Aquasafe water filter with an 0.2 μm membrane.

• Alternatively, use a filter of equivalent performance that meets the requirements for bacterial retention according to the ASTM standard*, i.e. which retains *Brevundimonas diminuta* to ≥ 10^7 CFU/cm² of effective filtration area.


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• In order to prevent microbial growth, add 150 ml of medical grade 3% hydrogen peroxide solution to the tank contents.
Changing the water

• The water in the water circuits must be changed every 7 days.
• In order to prevent microbial growth, add 150 ml of medical grade 3% hydrogen peroxide solution to the tank contents.
• Pay attention to hand hygiene and protective barriers by disinfecting your hands and using disposable gloves.
Routine maintenance

The water circuits **must** be disinfected prior to operating the heater-cooler for the first time and when placing the system in storage. The disinfection cycle (solution of sodium hypochlorite) must then be repeated every 14 days (even on systems in storage).
## Timelines for disinfection and related tasks

<table>
<thead>
<tr>
<th>Time/Interval</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>prior to initial operation</td>
<td>➔ surface disinfection and disinfection of water circuits</td>
</tr>
<tr>
<td>prior to storing the heater-cooler</td>
<td></td>
</tr>
<tr>
<td>after every operation</td>
<td>➔ surface disinfection</td>
</tr>
<tr>
<td>every 7 days</td>
<td>➔ water change; add hydrogen peroxide to the tanks</td>
</tr>
<tr>
<td></td>
<td>➔ disinfection of overflow bottle</td>
</tr>
<tr>
<td>every 14 days (also applies for systems in storage)</td>
<td>➔ disinfection of water circuits</td>
</tr>
<tr>
<td>once per year</td>
<td>➔ exchange the tubings used with the system</td>
</tr>
</tbody>
</table>
Regulations for tap water

- EPA (United States Environmental Protection Agency): 2012 Edition of the Drinking Water Standards and Health Advisories
## Microbiological parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parametric value (number/100 ml)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>0</td>
</tr>
<tr>
<td><em>Enterococci</em></td>
<td>0</td>
</tr>
</tbody>
</table>

The following applies to water offered for sale in bottles or containers:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Parametric value</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Escherichia coli</em></td>
<td>0/250 ml</td>
</tr>
<tr>
<td><em>Enterococci</em></td>
<td>0/250 ml</td>
</tr>
<tr>
<td><em>Pseudomonas aeruginosa</em></td>
<td>0/250 ml</td>
</tr>
<tr>
<td>Colony count 22 °C</td>
<td>100/ml</td>
</tr>
<tr>
<td>Colony count 37 °C</td>
<td>20/ml</td>
</tr>
</tbody>
</table>
## Microbiology

<table>
<thead>
<tr>
<th></th>
<th>Status</th>
<th>MCLG</th>
<th>MCL</th>
<th>Treatment Technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cryptosporidium</td>
<td>F</td>
<td>-</td>
<td>TT</td>
<td>Systems that filter must remove 99% of Cryptosporidium</td>
</tr>
<tr>
<td>Giardia lamblia</td>
<td>F</td>
<td>-</td>
<td>TT</td>
<td>99.9% killed/inactivated</td>
</tr>
<tr>
<td>Legionella</td>
<td>F</td>
<td>zero</td>
<td>TT</td>
<td>No limit; EPA believes that if Giardia and viruses are inactivated, Legionella will also be controlled</td>
</tr>
<tr>
<td>Heterotrophic Plate Count (HPC)</td>
<td>F</td>
<td>NA</td>
<td>TT</td>
<td>No more than 500 bacterial colonies per milliliter</td>
</tr>
<tr>
<td>Mycobacteria</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>No more than 5.0% samples total coliform-positive in a month. Every sample that has total coliforms must be analyzed for fecal coliforms; no fecal coliforms are allowed.</td>
</tr>
<tr>
<td>Total Coliforms</td>
<td>F</td>
<td>zero</td>
<td>5%</td>
<td></td>
</tr>
<tr>
<td>Turbidity</td>
<td>F</td>
<td>NA</td>
<td></td>
<td>At no time can turbidity go above 5 NTU (nephelometric turbidity units)</td>
</tr>
<tr>
<td>Viruses</td>
<td>F</td>
<td>zero</td>
<td></td>
<td>99.99% killed/inactivated</td>
</tr>
</tbody>
</table>
Opportunistic Premise Plumbing Pathogens: Increasingly Important Pathogens in Drinking Water

Joseph O. Falkinham, III 1,*, Amy Pruden 2 and Marc Edwards 2

1 Department of Biological Sciences, Virginia Tech, 5008 Derring Hall, Blacksburg, VA 24060, USA
2 Via Department of Civil and Environmental Engineering, Virginia Tech, 401 Durham Hall, Blacksburg, VA 24060, USA; E-Mails: aprueden@vt.edu (A.P.); edwardsm@vt.edu (M.E.)
Opportunistic premise plumbing pathogens

- Normal inhabitants of premise plumbing
- Most frequent found: *Legionella*, NTM, *Pseudomonas*, *Aeromonas*, *Acinetobacter*

Common features of this group of waterborne pathogens:

- Disinfectant resistance
- Survival/growth in amoebae (biofilm)
- Growth at low oxygen concentrations and low levels of organic carbon
Waterborne pathogens

• Opportunistic premise plumbing pathogens are responsible for infections in individuals with predisposing conditions (health care facilities)
• Transmission: contact, ingestion, aspiration, aerosolisation
• Infectious dose is lower for immunocompromised patients
Public Health Impact

Number of people at risk are increasing:

• Increasing incidence of *Legionella* infections
• *P. aeruginosa*: pneumonia, bloodstream infections, urinary tract infections
• Nontuberculous mycobacteria infections are increasing
The Heater–Cooler Unit—A Conceivable Source of Infection

H.H. Weitkemper; A. Spilker; H.J. Knobl; R. Körfer

Heartcenter of North Rhine-Westphalia, F. R. Germany

Presented at the 40th International Conference of the American Society of Extra-Corporeal Technology, New Orleans, Louisiana, March 2002
HCU Sampling results

Initial sampling of 6 circuits:

- At 36°C more than 1000 CFU/ml were found
- At 20°C 55 CFU/ml

Membrane filter with a pore size between 0.45 and 0.2 µm was installed
HCU: A Conceivable Source of Infection

Weitkemper et al. JECT. 2002; 34: 276-280
The Journal of The American Society of Extra-Corporeal Technology
Conclusion

HCU are potential sources for infections with opportunistic waterborne pathogens
HCU-related infection incidents

Despite

- strict regulations for use, cleaning and maintenance of HC Units and
- stringent rules for tap water:
How is that possible?

1. Opportunistic waterborne pathogens are present in tap water

2. Regulations regarding cleaning and maintenance of HCU were not always that stringent. Current regulations HCU: 2014

3. Already colonised tubing is very hard to disinfect. HCU tubing often not replaceable: biofilm and presence of waterborne pathogens
How can these waterborne pathogens come into contact with the patient in the operating theatre?

Circuits of HCU are not closed systems: water escapes through exhaust vents.
Smoke Experiments in an Functional Operating Room
Sommerstein et al

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• Theoretical aerosols with *Pseudomonas*, *Aeromonas*, *Acinetobacter*, NTM, *Legionella* may reach the patient.

• We have no data with respect to HCU related infections with these pathogens except for:
Prolonged Outbreak of *Mycobacterium chimaera*
Infection After Open-Chest Heart Surgery

Hugo Sax,1,a Guido Bloemberg,2,a Barbara Hasse,1,a Rami Sommerstein,1 Philipp Kohler,1 Yvonne Achermann,1 Matthias Rössle,3 Volkmar Falk,4 Stefan P. Kuster,1 Erik C. Böttger,2,b and Rainer Weber1,b

1Division of Infectious Diseases and Hospital Epidemiology, University Hospital Zurich, 2Institute of Medical Microbiology, National Centre for Mycobacteria, University of Zurich, 3Institute of Surgical Pathology, and 4Division of Cardiac Surgery, University Hospital Zurich, Switzerland
“October 21, 2016 — The bacteria that causes Legionnaires’ disease was detected in heater-cooler units at a hospital in Seattle where four patients were infected, including two who died.”

Seattle Times
Operating-room machines test positive for Legionella at UW Medicine

Originally published September 19, 2016 at 2:19 pm Updated September 19, 2016 at 7:31 pm
“An ice machine and two sinks in the cardiac units of the UW Medical Center’s Cascade Tower were found to be contaminated with the germs that can cause a potentially deadly form of pneumonia.”

(Mike Siegel / The Seattle Times)
Heater-cooler units

Any bacteria in the water can “aerosolize” in the operating room and land on patients undergoing surgery. Patients might also breathe the bacteria and develop a severe lung infection.
It is not clear how *Legionella* got inside the heater-cooler machine, but the FDA has warned hospitals against filling the machine with tap water or ice made with non-sterile water.

It is also possible that the machines were contaminated at the manufacturer in Germany.
European incident

- HCU related *Legionella* infection in Switzerland (sternal wound infection, University Hospital Zürich)

- HCU cultures found positive for *Legionella* in German and Dutch hospitals

- All hospitals used HCU from the same manufacturer
Legionella pneumophila

- Isolates of 4 hospitals were sent to The Laboratory for Clinical Microbiology and Public Health Haarlem: the Dutch Reference Centre for Legionella infections
- One patient isolate and 11 HCU isolates
- All Legionella strains were compared according to standard procedures including ESGLI sequence-based typing (SBT) method
<table>
<thead>
<tr>
<th>Origin</th>
<th>Determination</th>
<th>Serogroup</th>
<th>ST</th>
<th>Mab 3/1</th>
<th>Mab Subtype</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCU Dutch Hospital 1</td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>OLDA</td>
</tr>
<tr>
<td></td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>New</td>
<td>Neg</td>
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<tr>
<td></td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>OLDA</td>
</tr>
<tr>
<td>HCU Dutch Hospital 2</td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>Camperdown</td>
</tr>
<tr>
<td></td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>Camperdown</td>
</tr>
<tr>
<td></td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>Camperdown</td>
</tr>
<tr>
<td>HCU German Hospital</td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>OLDA</td>
</tr>
<tr>
<td></td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>182</td>
<td>Pos</td>
<td>Knoxville</td>
</tr>
<tr>
<td></td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>OLDA</td>
</tr>
<tr>
<td>HCU Swiss Hospital</td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>Camperdown</td>
</tr>
<tr>
<td>Patient</td>
<td><em>L. pneumophila</em></td>
<td>1</td>
<td>1</td>
<td>Neg</td>
<td>Camperdown</td>
</tr>
</tbody>
</table>
Flowchart for monoclonal subgrouping of *Legionella pneumophila* serogroup 1
Isolates with a similarity <90 are considered genetically different.
Genetically indistinguishable *L. pneumophila* isolates were obtained from one patient and HCU from four different locations.

This strongly indicates that these isolates are representatives of a single strain that is introduced to these HCU from a single source.
How common is ST1?

Legionella prevention in the Netherlands: an evaluation using genotype distribution

S. M. Euser · J. P. Bruin · P. Brandsema · L. Reijnen · S. A. Boers · J. W. Den Boer
<table>
<thead>
<tr>
<th>L. pneumophila SG1, ST</th>
<th>Patient isolates (n=179)</th>
<th>Environmental strains</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Primary prevention strains (n=182)</td>
</tr>
<tr>
<td>47</td>
<td>74</td>
<td>–</td>
</tr>
<tr>
<td>62</td>
<td>23</td>
<td>1</td>
</tr>
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<td>23</td>
<td>5</td>
<td>–</td>
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<td>82</td>
<td>8</td>
<td>–</td>
</tr>
<tr>
<td>37</td>
<td>4</td>
<td>–</td>
</tr>
</tbody>
</table>
Design and application of a core genome multilocus sequence typing scheme for investigation of Legionnaires’ disease incidents

J Moran-Gilad (giladko@post.bgu.ac.il)\textsuperscript{1,2,3}, K Prior\textsuperscript{4}, E Yakunin\textsuperscript{5}, T G Harrison\textsuperscript{6}, A Underwood\textsuperscript{6}, T Lazarovitch\textsuperscript{7}, L Valinsky\textsuperscript{5}, C Lück\textsuperscript{8}, F Krux\textsuperscript{4}, V Agmon\textsuperscript{5}, I Grotto\textsuperscript{1,3}, D Harmsen\textsuperscript{1}

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3. Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel
4. Department of Periodontology, University of Münster, Münster, Germany
5. Central Laboratory, Public Health Services, Ministry of Health, Jerusalem, Israel
7. Department of Clinical Microbiology, Assaf Harofeh Medical Centre, Zerifin, Israel
8. Institute of Medical Microbiology and Hygiene, University of Technology, Dresden, Germany

Citation style for this article:

Note: The page contains a citation for another article and mentions a submission date but does not provide the main content of the document.
cgMLST

- A novel core-genome allele-based typing scheme for *L. pneumophila*
- The scheme consists of 1,521 genes
- Based on a standardised analysis of WGS of a diverse collection of genomes
- To calibrate the scheme for micro-evolutionary change and to define a cluster type threshold 3 unrelated LD clusters were analysed
Investigation of humidifier-associated LD clusters

A difference up to 4 alleles may serve as a preliminary threshold value
For our *Legionella* isolates

- cgMLST typing scheme according to Moran-Gilad (John Rossen, UMC Groningen)
- Cluster-Alert distance: 4 alleles
- Five non-related *L. pneumophila*, sg 1, ST 1 isolates were incorporated
- SeqSphere+ calculated and drew a minimum spanning tree
- The number of differing alleles is given along the branches
Ridom SeqSphere+ MST for 15 samples based on 1,521 columns, pairwise ignoring missing values
Distance based on columns from L. pneumophila cgMLST (1,521)
L. Pneumophila cgMLST Cluster-Alert distance: 4

ST New

ST 182
Conclusions

1. Opportunistic waterborne pathogens are present in health care facilities
2. These pathogens are responsible for nosocomial infections especially in patients with impaired immune systems
3. Heater-cooler units may expose patients to waterborne pathogens
4. Incidents with *Legionella* are reported
5. cgMLST cluster analysis has shown that HCU of different health care facilities are colonised with genetically different *Legionella* strains. A single source of infection seems unlikely.
6. The present ESGLI typing method (looking at 7 genes) is not discriminating enough, at least for *Legionella* ST 1 isolates.
7. Core genome multilocus sequence typing may be more appropriate for investigations of outbreaks.
Thanks to

**Switzerland**  
Hugo Sax  
Barbara Hasse  
Yvonne Achermann  
Rita Bearth  
Valeria Gaia

**Germany**  
Stefan Niemann  
Thomas Kohl

**Netherlands**  
Jan Kluijtmans  
Ruud Jansen  
John Rossen  
Jakko van Ingen  
Jacob Bruin