Floatation tank associated *Pseudomonas aeruoginosa* infection

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Abstract: Floatation tank water contains a high concentration of magnesium sulfate ($MgSO_4$), which should be unfavorable to most microorganisms that are not salt tolerant. The high salt concentration also means that users of floatation tanks are more likely to shower after floating and are less likely to float with open sores, get water in their eyes, or ingest the floatation tank water. In addition, the number of daily users is relatively stable. However, despite these factors, pathogens commonly associated with pool or hot tub use can still be found in floatation tanks. A clinical case of *Pseudomonas aeruginosa* infection associated with exposure to a floatation tank was investigated by Vancouver Coastal Health. The investigation resulted in the issuance of a closure order to the operator of the facility. A clinical specimen obtained from the complainant and a water sample from the implicated floatation tank both tested positive for *Pseudomonas aeruginosa*, although, the isolates were markedly different. The possible explanations for this laboratory outcome are presented. This case study illustrates that a disruption of floatation tank water filtration, disinfection, salinity, or a combination of some or all of these factors, may result in conditions favorable for bacterial survival, growth, and disease transmission.

Key words: floatation tank, *Pseudomonas*, health protection.

Floatation tanks are typically soundproof, lightless chambers filled with a near-saturated (25%–30% by weight) solution of magnesium sulfate ($MgSO_4$). Commonly, floatation tanks have a shallow depth of water (7–18 inches deep) that is maintained at a temperature similar to the human body (34°C–37°C). The addition of $MgSO_4$ (also known as Epsom salt) gives the water buoyancy, allowing people using these chambers to “float” while experiencing sensory deprivation. Given that floatation tanks are usually designed to be relaxing and stimulation free, the water filtration systems are typically not operated during a float session. A single person floatation tank can serve 8–12 clients per day, with filtration of the water taking place after each session and at the end of the day. The $MgSO_4$ solution is generally replaced once every few months to a year depending on the tank’s usage (Eykelbosh and Beaudet, National Collaborating Center for Environmental Health (NCCEH), 2016; Nadolny and MacDougall, Ontario Agency for Health Protection and Promotion, 2016).

Two Canadian public health reviews discussed the survival of pathogens in floatation tank solutions, exposure pathways, and the effectiveness of treatment (Eykelbosh and Beaudet, NCCEH, 2016; Nadolny and MacDougall, Ontario Agency for Health Protection and Promotion, 2016). These reviews found that, despite the $MgSO_4$ solution being inhospitable to the growth and reproduction of most microorganisms that are not highly salt tolerant, pathogens commonly associated with pool or spa use can survive in $MgSO_4$ solution for hours to days after they are introduced. No cases of illness associated with floatation tanks were found in a literature search, but pathogens have been detected in the water of poorly managed floatation tanks (Eykelbosh and Beaudet, NCCEH, 2016).

In British Columbia (BC), facilities with floatation tanks are considered personal service establishments and fall under the authority of the BC Public Health Act, Regulated Activities Regulation (B.C. Reg. 161/2011. O.C. 423/2011). A comprehensive inspection and plan review checklist can be found in the BC Ministry of Health Guidelines for Floatation Tanks (BC Ministry of Health, 2016). At Vancouver Coastal Health (VCH), Environmental Health Officers (EHOs) inspect facilities with floatation tanks on a bi-annual basis, testing each floatation tank’s water for residual disinfectant, pH, and alkalinity. Also included in the inspection is a review of the facility’s record keeping and an assessment of the facility’s sanitation, maintenance, and equipment operation as well as a check of the lighting, ventilation, and chemical storage area. Given the high salinity of the water and humid conditions, these facilities are often prone to equipment corrosion and building material degradation (Beaudet and Eykelbosh, NCCEH, 2016).

The BC Ministry of Health Guidelines for Floatation Tanks recommends that floatation tanks for public use be equipped with both a filtration system and automatic disinfection. Primary disinfection of a floatation tank should be accomplished using chlorine or bromine, with ozone generators and

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ultraviolet (UV) bulbs encouraged as supplemental forms of disinfection. It is recommended that floatation tank filtration systems allow for three turnovers of the floatation tank water between tank users and that the recirculation system operates continuously when the floatation tank is not occupied and overnight. Floatation tank operators should test the concentration of disinfectant, pH, total alkalinity, and water temperature before each client or every 4 h. Tanks are to be inspected and cleaned daily, with more thorough cleaning conducted weekly.

Event summary

Case description and health authority investigation

On 19 October 2017, VCH received a complaint from an individual who was clinically diagnosed with *pseudomonas folliculitis* and who reported recent use of a floatation tank. On 15 October 2017, the complainant had a 60 min float session at a personal service establishment in Vancouver. The complainant subsequently developed symptoms consistent with *pseudomonas* infection. During a site investigation of the personal service establishment on 20 October 2017, it was determined that a staff member had accidently placed the complainant in a floatation tank that had been out of service since the end of September. The floatation tank's recirculation and chlorination systems had not been in operation for several weeks due to an equipment breakdown. The complainant had been floating in a tank where the water had not been filtered, had not received any primary disinfection from the automatic chlorinator, and had not received any supplementary disinfection from the 2 UV bulbs and 6 Corona ozone generators for at least 2 weeks. The complainant, however, reported that the recirculation system appeared to be running, as it could be heard for the duration of the float experience.

There was no detectable chlorine residual in the floatation tank water at the time of the on-site complaint investigation. It is also worth noting that the complainant had reported an inability to "float" freely in the tank, which may have indicated a low $MgSO_4$ level; however, the concentration was not measured during the investigation. A review of the facility's reservation information confirmed that no other persons had been placed in the malfunctioning floatation tank prior to this incident. A Public Health Act Closure Order was issued to the owner of the floatation tank (Fig. 1). In addition, a sample of the floatation tank water was taken and delivered to the BC Centre for Disease Control Public Health Laboratory (BCCDC PHL) for analysis. The water sample taken from the floatation tank during the investigation subsequently tested positive for *Pseudomonas aeruginosa*.

A communicable disease follow-up was conducted on 20 October 2017. Although pseudomonas infections are not reportable, VCH investigates cases that are brought forward to determine if water-borne sources such as whirlpools, spas, swimming pools, and floatation tanks are associated with identified infections. An interview was conducted with the complainant to determine if there were any other potential exposures during the 1–10 day incubation period prior to symptom onset. The interview identified that, during the incubation period, the complainant had not been in any other pools, floatation tanks, spas, hot tubs, or in any other bodies of water or wet areas. The only reported exposure was the 15 October 2017 1-h floatation tank session; prior to this session, the complainant had been healthy. About 2 days after the float session, the complainant reported developing symptoms consistent with *Pseudomonas* infection: multiple sites of itchy, tender red bumps on the skin as well as fever, headache, sore throat, swollen lymph nodes, fatigue, and infections in both ears. The complainant was clinically diagnosed by a physician based on the presentation of symptoms and was prescribed oral Amoxicillin 500 mg/Clavulin 125 mg to be taken three times a day for a week. A week later the complainant was prescribed a round of Ciprofloxacin ear drops.

Fig. 1: Floatation Tank. Photo taken by K. Rehbein Oct 2018.

When the water sample from the floatation tank tested positive for *Pseudomonas aeruginosa*, VCH and BCCDC PHL became interested in obtaining a clinical specimen to potentially link the clinical isolate to the environmental isolate. The decision to submit a clinical specimen was because the complainant was still suffering ill effects from the infection, despite completion of the antibiotics. The complainant was contacted and agreed to submit a clinical specimen. A swab from the ear was obtained on 1 November 2017 and *Pseudomonas aeruginosa* was isolated from the clinical sample by Vancouver General Hospital Microbiology Laboratory. By request, the isolate was forwarded to BCCDC PHL for comparison with the environmental isolates recovered from the water sample by pulse field gel electrophoresis (PFGE). The complainant indicated that a second round of oral antibiotics (Ciprofloxacin Hydrochloride 500 mg to be taken twice daily for a week) was commenced on the same day of the ear swab. The complainant did not clear the *Pseudomonas* infection until mid-November, with a negative ear swab taken on 15 November 2017.

Mitigation

As a condition of the Public Health Act Order, the operator of the floatation tank was directed to undertake repairs of the floatation tank's mechanical system, thoroughly clean and disinfect the floatation tank and its re-circulation system, change the filter, develop equipment maintenance and water monitoring records, ensure stabilization of water chemistry, and provide training to staff. Super-chlorination of the floatation tank (increased concentration of free available chlorine to >10 ppm) and the recirculation system piping was conducted several times by the operator. The filter was changed multiple times, repairs were made to the malfunctioning equipment, comprehensive checklists were developed, and the operator achieved a much greater understanding of floatation tank operation. Additionally, the operator attended compliance meetings with EHOs at Vancouver Coastal Health. It was impressed upon the operator that the reservation system must reflect when a floatation tank is out of service to ensure that this type of error does not happen again. The operator acquired new testing equipment and implemented a policy requiring staff to measure and record water chemistry parameters before each floatation tank user. When all the requirements had been satisfied, a follow-up water bacteriology sample was taken, which tested negative for *Pseudomonas aeruginosa*. The Closure Order was lifted on 16 February 2018.

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Public health laboratory analysis

Water testing

A 200 mL water sample was collected from the implicated floatation tank using a sterile container containing dechlorinating agent. IDEXX Pseudalert with the Quanti-Tray system (IDEXX Laboratories Inc., Westbrook, Maine, USA) was used to determine the presence and quantification of *Pseudomonas aeruginosa*. A total of 100 mL of the water sample was used for testing, which was prepared according to the manufacturer's instructions. After the required incubation, *Pseudomonas aeruginosa* was detected from the sample with the quantification of greater than 200.5 most probable number (MPN)/mL, which is the upper limit of detection by this assay. To obtain *Pseudomonas aeruginosa* isolate, several incubated wells from the Quanti-Tray were cultured onto blood agar plate and further purified. Three isolates of *Pseudomonas aeruginosa* were obtained. Identification of all isolates were confirmed by both the commercial test API 20NE (Biomerieux, Marcy-l'Étoile, France) and 16s rRNA gene sequence analysis (Kolbert and Persing, 1999; Lane et al., 1985).

A total coliform test was also performed on 50 mL of water sample by multiple tube fermentation using lauryl tryptose broths and brilliant green broths (APHA et al., 2017). Greater than 16 MPN/mL of total coliforms were detected, which is the upper limit of the method.

Comparison of isolates

The clinical isolate of *Pseudomonas aeruginosa* obtained from the complainant's ear was compared with the three environmental isolates recovered from the water sample by PFGE. The assay was performed based on the standard PulseNet protocol (Swaminathan et al., 2001), using restriction enzymes XbaI and BlnI (Tenover et al., 1995). The clinical isolate was determined to be not closely related to any of the three environmental isolates. Two of the three environmental isolates were identical and were closely related to the third environmental isolate.

Discussion and lessons learned

Questions have been raised whether floatation tanks pose a potential health risk. Indeed, floatation tanks are different from hot tubs and other recreational water facilities. Users are predominately adults, users shower after a floatation tank experience to remove the salts, and the stinging, bitter solution means that users will typically avoid contact with their mouths and eyes and are unlikely to float with open sores. Additionally, the total daily bather load is low and constant. These factors should theoretically reduce the risk of disease transmission (Eykelbosh and Beaudet, NCCEH, 2016). However, this case suggests that if there is a disruption of filtration, disinfection, salinity, or a combination of some or all of these, then conditions may become favourable for bacterial survival, growth, and disease transmission.

To our knowledge, this is the first reported case of *Pseudomonas* infection associated with a floatation tank. Although *Pseudomonas aeruoginosa* is not a reportable communicable disease, this case illustrated that *Pseudomonas* infection can be of public health significance. The complainant had to be seen by a physician on multiple occasions and was treated with multiple rounds of antibiotics to resolve the infection. Considerable pain, discomfort, and expense were experienced. This case demonstrates the importance of maintaining floatation tanks and taking measures to ensure that clients are not placed in floatation tanks that are broken or undergoing maintenance. It also demonstrates the importance of routine inspections of these facilities by public health authorities.

Despite *Pseudomonas aeruginosa* being present in both the water sample and clinical specimen and despite a public health investigation suggesting that the case was associated with this particular flotation tank, isolates from the water sample and patient were not similar by PFGE. There may be a number of reasons for this. There was an interval of 5 days between the exposure of the complainant and the collection of the single water sample. In addition, the clinical sample was obtained after the complainant was treated with antibiotics and from only one site of infection. In the future, clinical samples should be obtained early in the investigation, before the administration of antibiotics, and from multiple sites of infection. Additionally, it may be prudent to obtain more than one water sample.

Since *Pseudomonas* isolates are generally not archived by front-line laboratories, extra effort was required in this investigation to ensure the clinical isolate was retained for further testing. It is important to have advanced communication with the local public health laboratory for any suspected case related to environmental exposure so that proper coordination can occur among laboratories to aid the investigation.

It was noted by the operator that this floatation tank was designed to have an automatic chlorination system that was originally designed for hot tubs. Automatic chlorination systems for hot tubs have been designed to chlorinate larger volumes of water and are not well suited to small, single-person floatation tank designs. The operator explained that when operating a floatation tank with an automatic chlorinator designed for a hot tub, it is very difficult to maintain a free chlorine residual of <10 ppm even on the lowest setting. Auto-dosers, which dispense too much chlorine, make it extremely difficult to achieve a safe concentration of chlorine per volume in floatation tanks. This can lead to operators turning off the automatic chlorinator resulting in zero residual. Equipment incompatibility may lead to increased frequency of equipment failures and an increased likelihood of inadequate or excessive chlorine concentrations. The industry needs to develop automatic chlorination systems that are specific to floatation tanks.

Future challenges

This report demonstrates the potential for infectious disease transmission associated with floatation tanks. Future challenges will mirror the present-day challenges of float tank operators needing to have a good working knowledge of floatation tank operation, disinfection requirements, and procedures to follow to prevent health hazards from occurring. Testing instruments must be established that more accurately measure water chemistry parameters without interference from high salt concentrations. The industry needs to develop automatic chlorination systems that are specifically designed for floatation tanks. On the contrary, the floatation tank industry appears to be advocating the use of hydrogen peroxide, ozone generators and UV bulbs as primary disinfection modes for floatation tanks (Crandall, 1986; Jahromi, 2017; Floatation Tank Association, 2017). The effectiveness of these disinfection methods for floatation tanks has not been studied and the potential disadvantages and advantages of these disinfection approaches are discussed in detail elsewhere (Eykelbosh and Beaudet, NCCEH, 2016). Finally, EHOs will continue to face challenges as they strive to stay abreast of recreational trends, population preferences and technological advances.

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