Engineered Infection Prevention: A New World

Is the world flat or round?

Prior to 1492, the vast majority of people in the middle ages believed the world was flat. Brave adventurers, such as the Vikings, who sailed across the vast Atlantic Ocean to the Atlantic seaboard and the Chinese who sailed across the Pacific began the process of challenging this supposition. It then took several hundred years of voyages of discovery to map out the perimeter of North and South America in addition to inland expeditions such as the mapping experiences of Lewis and Clark and the Hudson Bay Company in Canada to define the nature of this vast land mass.

Let's take that valuable piece of history to where we are today. We do believe the earth is round, men have set foot on the moon, probes have landed on Mars, and a trip on a Boeing 787 Dreamliner from Vancouver to Paris takes only 10 hours while we sit in comfort sipping a glass of wine. The moral of this story is that new ideas take time to become accepted, practiced, become the new normal and pave the way for the next new idea…albeit slowly.

Clinical History

We are all aware of the statistics that in Canada there are approximately 220,000 healthcare acquired infections (HAI), 10,000 deaths, $5 billion in additional costs and the most startling statistic that about one in ten in-patients is the recipient of a HAI. Let's state that last statistic somewhat differently. Ten of us are invited to our favourite restaurant for a great dinner, BUT one of will get an illness from that dinner. Yikes!! Nobody is hungry now. In our medical world, we have progressed through the times of Florence Nightingale, the discovery of penicillin by Alexander Fleming, the subsequent expansion and contraction for the use of antibiotics and now the emerging world of the innovative use of engineering infection prevention (EIP).

Vancouver Coastal Health and Innovation

Vancouver Coastal Health (VCH) is a regional health authority providing direct and contracted health services including primary, secondary, tertiary and quaternary care, home and community care, mental health services, population and preventive health and addictions services in part of Greater Vancouver and the Coast Garibaldi area. VCH is a Canadian leader in the prevention and control of HAI's by several different means including rigorous hand hygiene training, surveillance, teamwork coordination with Environmental Services and their industry partners in disinfection, working with Facilities Maintenance and Operations staff to ensure the Canadian

Standards Associations standards for infection control, plumbing and HVAC are applied, and advocating for new technologies in infection prevention.

Many HAI's are caused by building impacts such a high touch surfaces containing bacteria that are potentially harmful to patients and their subsequent transmission by people from surface to surface. Aerosols and droplets can also act as vehicles of microbial transmission. Examples of these include medical procedures, poor air flow/filtration, or even from the simple act of flushing the toilet. Recent articles have nicely illustrated that aerosols from the toilet plume can be potential vehicles for C.difficile and norovirus with deposition of infectious particles on bathroom or patient room touch surfaces. While environmental cleaning and hand washing are a foundation of prevention and control, VCH has taken innovative steps in the battle with bacteria and viruses involving EIP.

GEnBMT Takes Off

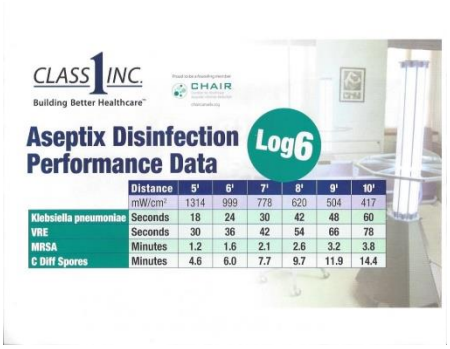
VCH was the first healthcare organization in Canada to adopt the use of portable ultraviolet (UV) lights to sanitize in-patient and specialty rooms such as operating theatres following a thorough assessment of several manufactures. The successful candidate was the R-D (Rapid Disinfector) system which started use in 2014. Also in late 2014, the new Canadian non-profit organization CHAIR (Coalition Healthcare Acquired Infection Reduction) Canada started to work with VCH on a clinical study within the Bone Marrow Transplant (BMT) unit at Vancouver General Hospital. This study is called GEnBMT **G**enetic & **E**ngineering a**n**d **B**one **M**arrow **T**ransplant.

The purpose of this pilot project is to demonstrate that the bacterial communities of bone marrow transplant patients, their health care workers, and their environment can be followed over the course of each individual patient's stay. The hope is that valuable insights regarding the relationship between the patient, their healthcare providers and their environment can be obtained using both traditional microbiology methods and genomics. This information can then inform and improve infection control practice, ultimately reducing healthcare acquired infections (HAI's). Because the patients are in a highly controlled environment, it is an ideal opportunity to re-engineer the environment and assess this intervention on microbial populations.

CHAIR Canada member organizations donated the following engineered materials as well as the labour components for installation in three rooms of the BMT. CHAIR Canada facilitated the project management in collaboration with the grant team, the BMT staff, and VCH Facility Maintenance.

Aereus Technologies from Burlington, ON provided a copper – nickel coating onto washroom sinks in association with the sink manufacturer Franke from Midland, ON. Copper alloys have been registered with Health Canada as an antimicrobial product that kills bacteria at 99.9% within 2 hours. Aereus Technologies and Class 1 Inc from Cambridge ON also provided this coating onto toilet seats as well for the bathroom and main bedroom electrical switch plates. Trimco Hardware from Los Angeles provided solid copper - nickel alloy fixtures for other high touch surfaces. These include bathroom grab bars, bathroom and main door hardware, over bed table surfaces, bedside table surfaces plus door handles, wardrobe handles and a unique clamp-on copper – nickel surface for the bed rail that can be easily removed for bed replacement and maintenance, flush handles for the toilet and finally a clamp-on surface for various visitor chair arm rails. Both the Aereus and Trimco products do not look like copper as the combination of copper and nickel give appearance of stainless steel. If the products were pure copper, they would have scratched easily and be susceptible to theft.

Class 1 Inc and Sanuvox from Montreal provided a wall mounted UV system that was installed in the patient bathroom that cycled on and off when no patient was in the bathroom. Security features included a door contact system to ensure the door was closed and sensors to ensure no person was in the room. This UV system kills both bacteria on surfaces and viruses in the air within minutes including Clostridium Difficile.



Class 1 Inc provided Titanium Dioxide (TiO2) that was painted on the bathroom walls plus bedroom walls and the headwall. TiO2 has antimicrobial features as well as a unique ability to reflect the UV light which assists UV to rebound around the room into the shadow areas. Class 1 Inc also donated brass (copper and zinc) chains for the patient call bells.

The Environmental Services contracted company Compass was trained that these three control rooms had unique features and appearance but the same cleaning protocols would be used as with the non-control rooms. They have been excellent partners in this project.

The installations of all of these products were donated by a local Vancouver contractor CDC Construction. (Only coincidental that CDC is also Centre Disease Control). The Vancouver General Hospital Facilities and Maintenance department also assisted with some installations and supplied all no-touch sink faucets, paper towel dispensers and gel/soap dispensers as well as confirming that sinks and faucets conformed to CSA standards and faucets specifically did not have aerators.

The air in the BMT unit was supplied via a HEPA (high efficiency particle air) system which was verified to be operating properly and the pressurization of the air was positive (BMT to adjacent corridors). CHEM Aqua from Brampton, ON provided high quality water filters for both the bathroom sink faucets and the shower heads.

The logistics of re-engineering the rooms were considerable. All parties worked around patient admissions and discharges as not to effect any delays in patient care though the cooperation of the BMT unit managers.

Research Process:

During the year-long pilot project, a minimum of six patients will be randomized to either a regular room or a re-engineered room. The patients, their environment and their care-giver are then followed during that patient's entire stay. High touch surfaces, water and the air are sampled. In addition, patient and healthcare worker samples that represent gut, respiratory and skin microflora are collected. The microbiota from all these samples are assessed using both traditional microbiological cultures and stats-of-the –art DNA sequencing technology. In addition, ATP sampling and colony counts of key bacteria of interest are performed. It is hoped that the results will lead to a better understanding of the interactions of microbes, environment and people over a patient admission. It is also hoped that the pilot can provide insight into how re-engineered surfaces affect the microbiota. Key bacteria that are of interest in this study are:

- *Staphylococcus aureus* (methicillin sensitive and resistant)
- Enterococcus (vancomycin sensitive and resistant)
- *Pseudomonas aeruginosa*
- *Escherichia coli*
- *Aspergillus species*
- *Clostridium difficile*

Funding from Genome BC has allowed the team to use DNA sequencing to examine both the bacterial communities that are not normally cultured with traditional microbiology. As you can imagine the DNA sequencing is logistically daunting but the potential to apply the information gained is great.

Outcome Strategies

The specific strategies for the GEnBMT clinical study, even within a small sample range, are targeted to what could lead to further expanded clinical trials as well as practical applications that can be addressed by all healthcare organizations at the present time.

- Determine if the re-engineered rooms alter and/or reduce the microbial in patients who by their very nature are very immune suppressed during their long length of stay
- Determine if the better and earlier detection of potential pathogens reduces the risk of transmitting and/or acquiring infections
- Determine the durability and sustainability of products such as the copper nickel alloys and titanium dioxide
- Determine the cost effectiveness and potential return on investment of the products and processes

An example of the durability issues is as follows. The intent of using a copper – nickel material was to show if these coated or solid alloys would tarnish under real life clinical conditions. Anybody with a copper bracelet or a copper pot knows that copper does oxidize and may not look attractive. Early indications from the study showed that the copper – nickel alloys had mild tarnishing potentially from the uric acid splashing on the toilet seat or food spilled on the over bed table. Our Environmental Services staff was not able to remove most of the tarnish with their regular hospital disinfectant chemicals. Via a brief investigation with our colleagues at Diversey (Sealed Air), they provided a product called Emerel

Plus Multi-Surface Cream Cleanser that quickly removed virtually all of the tarnish with minimal impact to the cleaning staff budgeted time and costs. CHAIR Canada members in cooperation with Vancouver Coastal Health are now collaborating with Diversey (Sealed Air) to determine what exact chemical reaction causes the mild tarnish and then how their product removes it.

Another real life example is that in course of patient room utilization, the room walls get chipped from the movement of beds and chairs, thus requiring the re-painting of walls. Then the TiO2 must be re-applied.

Preliminary Results

It is early days yet and this is a pilot project so it is not possible to provide any detailed assessment of the culture, ATP or DNA sampling at this time but the preliminary results suggest the project should be extended to the next phase i.e. clinical trials and applications. One result that the GEnBMT leadership was not expecting was the reaction of patients to the re-engineered rooms. When staff explained the various materials and processes in the room, it was a description of what can be seen and touched. Everybody knows that copper is used in piping and wiring, but to see a copper- nickel surfaces that kills bacteria or a UV system mounted in the bathroom that kills bacteria and viruses, brings out a very positive emotional response from the patients.

Let us conclude this article by stating that in the new world of engineered infection prevention the world is definitely round and progressing to reduce a significant amount of HAI's in our Canadian healthcare organizations.

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