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Concise Communication

A bridge over troubled water: reverse osmosis to maintain patient care in a boil water notice

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Abstract

A citywide boil water notice necessitated an alternative solution for treating contaminated water. We report our experience using portable reverse osmosis machines to treat the municipal water to provide purified water to patient care areas where non-sterile water was needed, preventing interruptions in services like elective surgeries.

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Day 1, September 12, 2023

On day 1, there was a water main break in the city of Springfield Massachusetts for which the municipal water authority issued a boil water notice (BWN) to the entire city due to the potential of bacterial contamination of the water supply. The expectation was that the BWN would last for 48 hours.

Our facility, Baystate Medical Center (BMC), is a 746-bed urban academic medical center with a catchment area of 800,000 patients and the region's only Level 1 Trauma Center. In response to the BWN, BMC established an emergency operation center and identified multiple areas in the hospital that used municipally supplied potable, non-sterile water. Various purposes of non-sterile water included handwashing and patient bathing, scrub sinks outside of operating rooms, dilution of cleaning solutions for daily cleaning of shared patient care equipment, ice machines for patient consumption and control of swelling, and eyewash stations.

Our initial response was to use 5-gallon jugs of water from a commercial vendor to aid in patient care activities. These 5-gallon jugs were obtained from the kitchen and food services department, which maintained a 96-hour supply for food preparation needs in case of emergency. We obtained spigots from local hardware stores to convert the jugs into dispensing stations to help facilitate handwashing and patient bathing. Because we repurposed the 5-gallon jugs from the kitchen to support patient care needs, we risked depleting the kitchen's emergency supply.

Day 2, September 13, 2023

To maintain normal patient care activities without depleting the bottled water supply, the emergency operations team collaborated with the medical director of our dialysis unit to explore the feasibility of temporarily re-purposing portable reverse osmosis machines (ROM).

Our facility utilizes reverse osmosis (RO) to purify municipal water for dialysis sessions that occur outside of the dialysis unit as ROM successfully removes 99% of bacterial cells and endotoxins[1] in accordance with AAMI standards for water used in dialysis,[2] which are stricter than water used as potable water.[3] We have a fixed plant for our dialysis unit and portable machines for dialysis that occur outside of the dialysis unit. We perform monthly bacterial and endotoxin testing on our ROM to ensure these levels remain within acceptable AAMI range. In collaboration with the dialysis director, infection control, and clinical engineering, it was determined that ROMs could be deployed to treat the municipal water to provide the hospital's patient care areas with purified water for hand washing, bathing, and other patient care activities outlined above. Both untreated municipal water and ROM-treated water were tested during this period, but the results were obtained 48 hours after the samples were collected and thus were not available before ROMs were deployed.

After accounting for the current inpatient hemodialysis needs and ensuring that the hemodialysis unit RO plant was functioning normally, we had 10 portable ROMs that could be re-deployed. We kept 2 in reserve and deployed 8 to patient care areas: the emergency department, the labor and delivery unit, 3 adult intensive care units, a medical inter-care floor, a medical/surgical floor, and the neonatal intensive care unit. These locations were selected with input from clinical engineering, the chief infection prevention officer, and a nurse director. This arrangement balanced the acuity of need along with geographic distribution across the various inpatient buildings of our hospital. Clinical engineering installed each portable RO unit via attachment to a faucet and plug insertion into a power outlet. The portable ROMs were used to refill water jugs, providing water for handwashing and patient bathing. Healthcare workers from neighboring units came to refill their jugs as needed if a ROM was not available on their unit. The deployment of these machines to strategic locations across the hospital to support refilling 5-gallon jugs for handwashing and patient care needs was cited by staff as extremely effective.

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Table 1. Internal water testing from the municipal water supply and water from the reverse osmosis machines for bacteria, endotoxins, and chemical particles during the boil water notice

	9/13/2023		09/14/23		
Test	Source: RO[a] outlet		Source: RO[a] outlet		Reference range
Bacterial colony count	2 CFU[b]/ml		<2 CFU[b]/ml		0–199 CFU/ml
Endotoxin	<0.010		<0.010		0.000–1.999 EU[c]/ml
Test	RO Outlet	Untreated water	RO Outlet	Untreated water	Reference range
Aluminum	<0.005	0.008	<0.005	0.007	0.000–0.010 mg/l
Antimony	<0.005	<0.005	<0.005	<0.005	0.000–0.006 mg/l
Arsenic	<0.002	<0.002	<0.002	<0.002	0.000–0.005 mg/l
Barium	<0.005	0.008	<0.005	0.008	0.000–0.100 mg/l
Beryllium	<0.0004	<0.0004	<0.0004	<0.0004	0.0000–0.0004 mg/l
Cadmium	<0.0010	<0.0010	<0.0010	<0.0010	0.0000–0.0010 mg/l
Calcium	<0.100	**2.718 (H)[d]**	<0.100	**2.694 (H)[d]**	0.000–0.014 mg/l
Chromium	<0.005	<0.005	<0.005	<0.005	0.000–0.014 mg/l
Copper	<0.005	0.0097	<0.005	0.009	0.000–0.100 mg/l
Fluoride	<0.10	<0.10	<0.10	<0.10	0.00–0.20 mg/l
Lead	<0.002	<0.002	<0.002	<0.002	0.000–0.005 mg/l
Magnesium	<0.100	1.087	<0.100	1.049	0.000–4.000 mg/l
Mercury, water	<0.0002	<0.0002	<0.0002	<0.0002	0000–0.0002 mg/l
Nitrate	<0.20	<0.20	<0.020	<0.20	0.00–2.00 mg/l
Potassium	<0.100	0.625	<0.100	0.608	0.000–8.000 mg/l
Selenium	<0.005	<0.005	<0.005	<0.005	0.000–0.090 mg/l
Silver	<0.003	<0.005	<0.003	<0.003	0.000–0.005
Sodium	0.244	16.643	<0.242	16.048	0.000–70.000 mg/l
Sulfate	<1.0	2.8	<1.0	2.8	0.0–100.0 mg/l
Thallium	<0.002	<0.002	<0.002	<0.002	0.000–0.002 mg/l
Zinc	<0.005	0.009	<0.005	0.008	0.000–0.010 mg/l

[a]Reverse osmosis.
[b]Colony-forming units.
[c]Endotoxin units.
[d]High.

Day 3, September 14, 2023

The BWN was canceled on day 3; at this time, we believed we were well situated to continue our response for at least another 5 days without needing to curtail any patient care activities or procedures. Due to our intervention with ROM, patient care activities including elective surgeries, endoscopy procedures, dialysis, and routine patient care were not affected by interruptions or delays, which differed from other hospitals in our area. To return to routine care, clinical engineering flushed all main pipes for 5 minutes. Then healthcare personnel flushed each faucet for 30 seconds to ensure that fresh water from the repaired main was being supplied to the points of use. Clinical engineering performed internal water testing from the municipal water supply and water from the ROM for bacteria, endotoxins, and chemical particles during the boil water advisory. Test results are compared with AAMI guidelines, and all found to be within acceptable levels (see Table 1).

Discussion

In response to a citywide BWN, we responded with the novel approach of treating municipal water with portable ROM to supply water to inpatient units to avoid delays in patient care including elective surgeries. This approach distinguished us from other local hospitals, where elective surgeries were canceled.

To our knowledge, this is the first report of ROM being used to supply water to inpatient units during a water emergency. The only other report of RO use in water emergencies was in Toledo, Ohio, in 2018, where RO was used for dialysis units, but not for broader inpatient care.[4] As a result, elective surgeries and other services were canceled or delayed.[4]

Hospital emergency water plans often involve backup water storage tanks, additional pipelines, and underground wells, water trucks, or purchased water bottles.[5,6] However, limitations exist, such as many facilities depending on the same vendor for supplies, affecting resource availability.[4]

RO is listed as an option in the Environmental Protection Agency's Emergency Water Supply Planning Guide for Hospitals and Health Care Facilities (2011), but not generally recommended due to the complexity and expense of the process.[7] RO requires trained clinical engineers for monitoring of water purity and upkeep of the filtration membranes, electricity, and sufficient water pressure for use which limits its generalizability. Although RO is

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highly effective at removing bacterial pathogens, endotoxins, and other chemical contaminants,[1,8,9] there are compounds such as low-molecular-weight chemical contaminants that are not retained by the RO filter, limiting the use in other instances such as a Do Not Use water order depending on the contaminant.[1]

Despite limitations, we used ROM effectively in a BWN to treat municipal water for use in patient care activities. With increasing threats from climate change, aging infrastructure, and other natural disasters, a robust emergency water plan is essential for healthcare facilities, and ROM could play a significant role.

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