Water As A Source Of Infection Or Colonization By Gram-Negative Non-Fermenters At Intensive Care Units

Thesis

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By

Nadia Elsayed Khalaf Alla

M.B.,B.Ch.Ain Shams University

Supervised By

Professor / Magda Salah El Din Gabr

Professor of Clinical and Chemical Pathology
Faculty of Medicine - Ain Shams University

Doctor / Hala Mahmoud Hafez

Assistant Professor of Clinical and Chemical Pathology
Faculty of Medicine - Ain Shams University

Faculty of Medicine
Ain Shams University
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قَالُوا سُبْحَانَكَ
لاَ عِلْمَ لَنَا
إِلاَّ مَا عَلَّمْتَنَا
إِنَّكَ أَنتَ
الْعَلِيمُ الْحَكِيمُ
صدق الله العظيم
الآية (32) سورة البقرة

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Nadia Elsayed Khalaf Alla

List of Abbreviations

AAMI	Association for the Advancement of Medical Instrumentation
AAMs	Ameba-associated microorganisms
AIA	American Institute of Architects
AIDS	Aquired immunodeficiency syndrom
APIC	Association For Professionals In Infection Control
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
ASUM	Australasian Society for Ultrasound in Medicine
CDC	Centers for Disease Control and Prevention
CF	Cystic fibrosis
CFU	Colony Forming Unit
CONS	Coagulase Negative Staphylococci
DI water	Demineralized water
EPA	Environmental Protection Agency
GNNF	Gram-negative non fermenter
Hads	Human adenoviruses
HAIs	Hospital-acquired infections
HAV	Hepatitis A virus
HEV	Hepatitis E virus
HRVs	Human rotaviruses
HuCVs	Human caliciviruses
ICU	Intensive care unit

List of Abbreviations

JCAHO	Joint Commission on Accreditation of Healthcare Organizations
MAC	Mycobacterium avium complex
NFGNB	Non fermenter gram-negative bacteria
NNIS	National Nosocomial Infections Surveillance
NTM	Non Tuberculous Mycobacteria
PCA	Plate Count Agar
PVC	Polyvinyl chloride
RO	Reverse Osmosis
WHO	World Health Organization

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Introduction

Hospital-acquired infections (HAIs) constitute a major fraction of the adverse events complicating hospital treatment ***(Gastmeier, 2004).*** For intensive care unit (ICU) patients, the risk of HAIs is 5 to 10 times greater than for those on general medical wards. This increased risk of HAIs results from three major factors: (1) intrinsic risk factors related to the need for intensive care, such as severe underlying disease, multiple illnesses, malnutrition, extremes of age, and immunosuppression; (2) invasive medical devices, such as endotracheal tubes for mechanical ventilation, intravascular catheters, and urinary tract catheters; (3) crowding (e.g., neonatal ICU) and animate reservoirs (e.g., colonized or infected patients), which increase the risk of cross-infection in the ICU ***(Weber et al., 1999).***

The last decades have witnessed significant changes in the spectrum of microorganisms causing nosocomial infections. Gram-negative enterobacteria, which in the 1970s and 1980s accounted for 30% to 50% of all disease-associated isolates in ICUs ***(Allen et al., 1981; Weber et al., 1992)*** have been to a large extent replaced by gram-positive microorganisms such as Staphylococci, Enterococci, and Corynebacteria ***(Spencer, 1996; Pfaller et al., 1999).*** This relative decrease of infections because of enterobacteria has

been attributed to the successful implementation, in most ICUs, of clinical prevention strategies aimed to interrupt the transmission of these organisms from their intestinal reservoir to potential sites of infection ***(Trautmann et al., 2005).***

In spite of these significant changes, *Pseudomonas* (*P.*) *aeruginosa* has held a nearly unchanged position in the rank order of pathogens causing ICU-related infections for more than 4 decades. In the US ***National Nosocomial Infections Surveillance (NNIS) system report (2004)***, *P. aeruginosa* represented the third most frequent organism associated with wound or pulmonary infections, the fourth most frequent organism causing urinary tract infection, and the fifth most frequent organism isolated from blood cultures in cases of septicemia**.**

Of particular concern is the increasing antibiotic resistance of *P. aeruginosa* isolated from ICUs. The NNIS data showed a rise of resistance rates against commonly used antibiotics such as imipenem, ciprofloxacin, and ceftazidime by 15%, 9%, and 20%, respectively, between the periods 1998-2002 and 2003 ***(NNIS, 2004)***. Antibiotic resistance in *P. aeruginosa* does not only predict a poor clinical outcome but represents a significant economic burden for the health system. The development of resistance during treatment of *P.*

aeruginosa infection is associated with increases in treatment duration, mortality and costs ***(Carmeli et al., 1999)***.

Various possible sources of *P. aeruginosa* infection in hospitals have been identified, such as tap water, medical equipment, hospital personnel, and other patients. Water systems appear to play a leading role ***(Reuter et al., 2002)***.

Hospital tap water has been recognized as the most over looked, important and controllable source of healthcare associated infections (HAI) caused by *P. aeruginosa* ***(Steven et al., 2008).*** In 2002, ***Anaissie and colleagues*** estimated that 1,400 deaths occur each year in the United States as a result of water borne nosocomial pneumonias caused by *P. aeruginosa*. ***Trautmann et al. (2005)*** reported that *P. aeruginosa* could be frequently recovered from tap water outlets in ICUs and that the same genotypes were recovered from colonized or infected patients. Moreover, ***Wang and coworkers (2009)*** recovered *P. aeruginosa* and numerous NFGNB from tap water during their recent investigation to determine the source of an outbreak of multi-drug resistant *Acinetobacter baumanii*.

Aim of the Work

The present study aims at identifying the frequency of isolation of non fermenter gram-negative species from tap water at the ICUs and to determine the strength of association between these organisms and the infections occurring among ICU patients.

HOSPITAL WATER

Hospital water is commonly described either in terms of its nature, usage, or origin. According to its uses, hospital water can be classified to:

- Tap water (*running water*, *municipal water*)
- Purified water
  - Distilled water
  - Double distilled water
  - Deionized water
  - Reverse osmosis plant
- Water for heamodialysis

(Hobson et al., 2007)

A) Tap Water (*running water*, *municipal water*):

Tap water, delivered by domestic water systems, refers to water piped to homes and delivered to a tap or spigot. For these water sources to be consumed safely, they must receive adequate treatment and meet drinking water regulations ***(Hall et al., 2012).***

In hospital, tap water is basically used for the normal **domestic purposes** of drinking, cooking, food preparation and personal washing (such as washing hands, laundry and

showering) ***(Health Protection Units in England and Wales, 2009).*** It is also used in cleaning of medical instruments that is an essential prerequisite for all effective disinfection processes because organic residue may prevent the disinfectant from contacting the item being processed and may also bind and inactivate chemical disinfectants ***(Australasian Society for Ultrasound in Medicine (ASUM), 2012)***.

Parameters for drinking water quality typically fall under two categories: chemical/physical and microbiological. Chemical/physical parameters include heavy metals, trace organic compounds, total suspended solids (TSS), and turbidity. Microbiological parameters include Coliform bacteria, E. coli, and specific pathogenic species of bacteria (such as cholera-causing Vibrio cholerae), viruses, and protozoan parasites. Originally, fecal contamination was determined with the presence of coliform bacteria (like E.coli), a convenient marker for a class of harmful fecal pathogens. Additional contaminants include protozoan oocysts such as Cryptosporidium sp., Giardia lamblia, Legionella, and enteric viruses. Microbial pathogenic parameters are typically of greatest concern because of their immediate health risk ***(Enviromental Protection Agency (EPA), 2010).***

B) Purified Water :

Purified water is water from any source that is physically processed to remove impurities. Distilled water and deionized (DI) water have been the most common forms of purified water, but water can also be purified by other processes including reverse osmosis, carbon filtration, microfiltration, ultrafiltration, ultraviolet oxidation, or electrodialysis ***(Centers for Disease Control and Prevention (CDC), 2009).***

Distilled water is often defined as bottled water that has been produced by a process of distillation and has an electrical conductivity of not more than 10 µS/cm and total dissolved solids of less than 10 mg/litre ***(Health Canada, 2009).*** Whereas, deionized water, also known as demineralized water (DI water, DIW or de-ionized water), is water that has had its mineral ions removed, such as cations from sodium, calcium, iron, copper and anions such as chloride and bromide ***(World Health Organization (WHO), 2004).***

Purified water is suitable for many applications, including autoclaves, laboratory testing, and laser cutting. It is preferable to tap water for use in automotive cooling systems, used as an "ingredient" in many pharmaceuticals and in appliances which evaporate water, such as steam irons and humidifiers. Purification removes contaminants which may