



Current Perspective on Hospital Acquired Infection

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Authors' contributions

This work was carried out in collaboration between both authors. Author BSR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author AL managed the analyses of the study and managed the literature searches. Both authors read and approved the final manuscript.

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ABSTRACT

Health care associated infections (HCAI) are a major complication faced by the healthcare sector leading to high morbidity and mortality. These infections are caused via the persistence of microbial pathogens in the hospital environment for extended periods (weeks to months) on contaminated surfaces. Foodborne illness is another significant source of infection in hospitals due to improper cleaning practices in the food operating sectors. Thus, frequent hygiene monitoring and efficient cleaning practices may reduce the rate of hospital-acquired infections. Contamination detection by traditional microbiological techniques is laborious, which has paved the way for the development of rapid biotechnological testing kits such as the ATP bioluminescence assay, which can be used as a rapid indicator of contamination.

Keywords: Nosocomial infections; microbial persistence; food borne illness; ATP bioluminescence; microbial viability.

1. BACKGROUND

Nosocomial infections also known as the hospital acquired infection. Typically, these infections

were seen in the patients who were monitored by doctors and kept under observation by the hospital management. These infections include blood stream infection, urinary tract infection,

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hospital acquired pneumonia and surgical site infections. To prevent such outbreaks, the Infection control team (ICT) follows certain guidelines to strictly monitor hygiene levels and cleaning practices in the hospitals. Risks on the nosocomial infections depends on certain factors such as longer incubation periods in the hospitals, low immunity among the patients, chronic illness, improper decontamination practices of the medical devices in the Intensive care unit. Apart from spread of infection in the hospital vicinity there is high demand of good hygiene levels to be maintained in the hospital catering facilities to prevent spread of foodborne diseases and provide quality food to the patients & hospital staff.

2. INTRODUCTION

Nosocomial acquired infections in the hospitals may be caused due to bacteria, virus or fungi. Among the causative agents' infections caused by bacteria is much more prominent and leads to the environmental contamination. Bacterial infections are generally caused by antibiotic multidrug resistant strains which are difficult to treat. Studies have revealed that both gram positive and gram-negative bacteria contribute to the outbreak of infection [1]. Gram negative bacteria have longer persistence on the surfaces

compared to that of gram-positive bacteria leading to contamination in hospital environment and pose threat to in giving good healthcare services to the society [2]. Research has revealed that persistence of bacteria does not depend on the surface materials but widely subjected to environmental temperatures [3-4]. Experimental studies have proven that the presence of microbes is much higher in the temperatures ranging from 4 degree Celsius – 10 degree Celsius compared to that of humid environment [5-6]. Table 1 gives a brief description of persistence rate of 10 different bacteria causing 90% of hospital acquired infections.

3. SOURCES OF INFECTIONS

3.1 Hospital Acquired Infection through Catering Food (Foodborne Illness)

3.1.1 Hospital catering services

Catering management system is a group of people working together to deliver hygienically prepared food to large number of consumers in the hospital. Cooked food is delivered to consumers either through deferred system or via cook serve system.

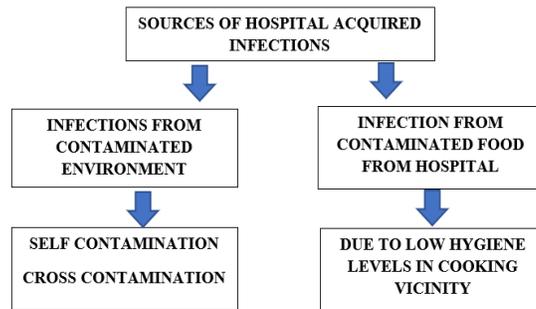


Fig. 1. Sources of hospital acquired infection

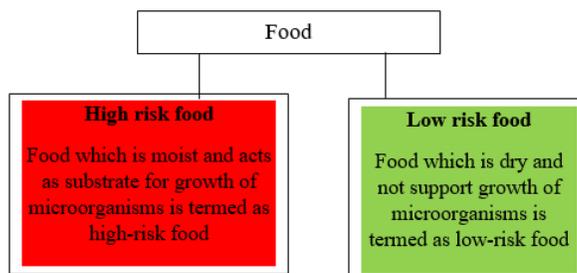


Fig. 2. Classification of food based on risk factor

Table 1. Persistence time of bacteria on common surfaces [7-16]

Bacteria name	Type of bacteria	Persistence rate on surfaces	Infection caused
Acinetobacter species	Gram negative	3 days -5 months	<ul style="list-style-type: none"> ● Urinary tract infection ● Open wound infection
<i>Bordetella pertussis</i>	Gram negative	3 days -5 days	<ul style="list-style-type: none"> ● Whooping cough
<i>Campylobacter jejuni</i>	Gram negative	2 days-6 days	<ul style="list-style-type: none"> ● Diarrhea ● Dysentery ● Fever ● Cramps
<i>Clostridium</i>	Gram positive	1month to 5 months	<ul style="list-style-type: none"> ● Gastroenteritis ● Fever ● Diarrhea
Vancomycin resistant enterococcus (VRE)	Gram positive	4 days to 4 months	<ul style="list-style-type: none"> ● Urinary tract infection ● Open wound infection
<i>E. coli</i>	Gram negative	1hr -16 months	<ul style="list-style-type: none"> ● Urinary tract infection ● Open wound infection ● Food poisoning ● Vomiting ● Nausea ● Fever
<i>Klebsiella pneumoniae</i>	Gram negative	1 hr -1 month	<ul style="list-style-type: none"> ● Urinary tract infection ● Open wound infection
<i>Pseudomonas aeruginosa</i>	Gram negative	5 hrs -5 months	<ul style="list-style-type: none"> ● Urinary tract infection ● Open wound infection ● Respiratory tract infection ● Dermatitis ● Systemic infection
<i>Mycobacterium tuberculosis</i>	Neither positive nor negative	2 days -2 months	<ul style="list-style-type: none"> ● Tuberculosis ● Whooping cough
MRSA	Gram positive	7 days -7 months	<ul style="list-style-type: none"> ● Staph infection

3.1.2 Foodborne illness

Foodborne diseases demand public health priority due to increase in the spread of infection caused by consumption of food containing pathogenic micro-organisms [17-18]. Sources of contamination present in the food can either be through contaminated raw materials or external sources such as air / water / food handlers etc. [19-20]. To prevent such contamination hygiene maintenance are in demand to maintain good standards of hygiene to deliver safe food. Improper cleaning and decontamination of kitchenware leads to the retention of microbes within the kitchen which may come in contact with food and reduce the quality of food leading to spread of foodborne diseases [21-23].

3.1.3 Standard operating protocol

Hazard analysis critical control point (HACCP) is a system that delivers set of

guidelines promulgated by European Union to protect lives of consumers & to deliver high quality food [24]. Sanitation standard operating procedure (SSOP) is a documented report comprising of series of instructions to be followed by trained staff to maintain hygiene in kitchen [25].

3.1.4 Food business operator

Institutes guide & train food handlers to follow guidelines to meet the standard expectations of Hazard analysis critical control point (HACCP). Inspection committee conducts internal audit (microbiology expert) & external audit (STS -Services of food safety consultancy) to constantly monitor hygiene quality, conduct survey by visual observation & surface sampling [26]. Table 2 gives a brief on role of food business operators in hospitals.

3.1.5 Cleaning practices in food operating section

Common surfaces which are suspected to have microbial contamination are frequently cleaned to prevent retention of pathogens which may come in contact with food. Food handlers are recommended to wear disposable mask, head caps, aprons and to wash hands on frequent interval to prevent spread of infection. Parallely Frequent pest control cleaning is also recommended to maintain good hygiene quality in raw material storage rooms & main kitchen to prevent spoilage of food components and to prevent cross contamination. Most common places suspected to contamination are vegetable washer, table, knife, large cookers, slicing machine, chopping boards & washbasin hence frequent cleaning is carried out using disinfectants as per guidelines formulated by HACCP given in Table 3.

4. HOSPITAL ACQUIRED INFECTION THROUGH EXTERNAL ENVIRONMENT

Spread of cross infection can be seen either exogenously through patients/hospital staff or

contaminated environment or endogenously from one's own flora. Table 4 Classification via source of infection.

4.1 High Infection Risk Areas in Hospital

High risk areas in the hospital having frequent occurrences of infection are intensive care unit (ICU), operation theater (OT), baby care unit, dialysis unit, patient waiting area & hospital pharmacy. Table 5 classifies mode of transmission of infection based on the source.

5. MICROBIAL CONTAMINATION DETECTION METHODS

Traditional microbiological techniques are time consuming and requires skilled man power to handle advanced techniques. However, these methods take long incubation time (2-7 days) to allow growth of viable colonies to detect contamination. These techniques would delay the identification of microbes leading to increase in the rate of infection in the hospitals.

Table 2. Role of food business operators in hospitals

Infection control team	<ul style="list-style-type: none"> • Conducts survey on reports submitted • Conducts direct interaction with patients to get feed back • Performs statistical analysis and future prediction
Inspection committee	<ul style="list-style-type: none"> • They conduct internal and external audit and maintain records • Internal audit: conducted once in a month • External audit: conducted once in year

Table 3. Composition of disinfectant solution for cleaning vessels [27]

Solution 1	Rinsing vessels and surfaces with 0.2-2% benzalkonium chloride for 10 mins & wash again with dish was surfactant with hot water
Solution 2	Rinsing vessel and surfaces with 0.85% alkyl dimethyl benzyl ammonium chloride + dodecyl dimethyl ammonium chloride and followed by wash with hot water and left air dry

Table 4. Classification via source of infection [28]

Exogenous self-infection	Endogenous cross infection
Microbes are present on skin, nose, mouth, intestine which may invade our body and cause opportunistic infection which is difficult to prevent	Patients and working staff contaminate the working environment by shedding large number of floras into the environment while talking, sneezing and other activities

5.1 Methods of Microbiological Sampling

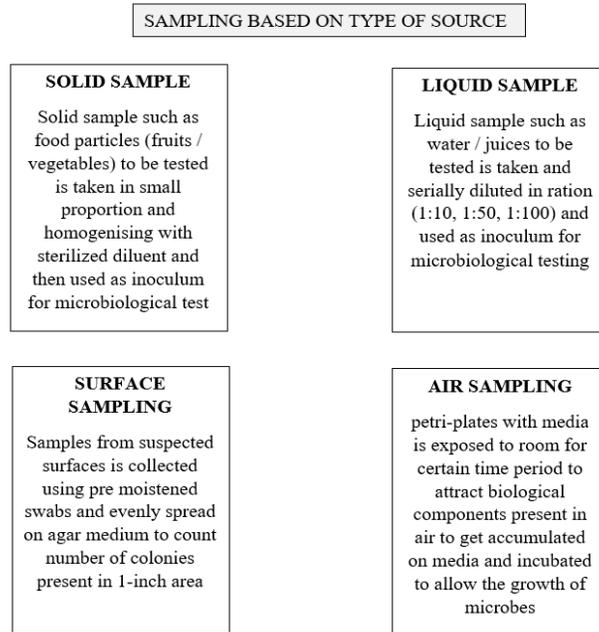


Fig. 3. Sample collection from different sources

Table 5. Mode of transmission of infection based on the source [29]

High risk area	Reason of infection	Infection caused	Preventive measures
Intensive care unit	Patients with poor health conditions / chronic illness may have poor immune system and they are highly prone to infection	Wound infection Pneumonia Viral infection Tuberculosis	Monitoring good hygiene level and cleaning practices
Operation theatre	Exposure of surgical sites and open wounds are prone to infection	Pneumonia Viral infection Tuberculosis	Constant check of surfaces which are highly prone to contamination
Burn unit	Exposure of burn sites may be a mode for air borne microbe to inter leading to infection	Superficial infection resulting in graft rejection	Frequent practice of disinfection of the locality
Baby care unit	Poor development of immune system	Skin infection, meningitis, septicaemia	Constant monitoring on hygiene levels of incubator
Dialysis unit	Presence of limited dialysis units demands proper sterilization when used from one patient to other, improper hygiene maintenance of device can be source of infection and cross contaminating the environment	Urinary tract infection, peritonitis, hepatitis	Sterilization of unit after every use and disinfecting the area in constant time interval Taking patients feedback on services provided to improve better services

High risk area	Reason of infection	Infection caused	Preventive measures
Outpatient Area	Area suspected with higher incidence of infection due to contamination of environment by patients (sneezing, coughing, talking etc.)	Whooping cough Fever Cold Skin infections Allergy Wound infection	Frequent cleaning & Maintaining distancing
Pharmacy	Area suspected with high number of people movement may lead to spread of contact-based infection	Whooping cough Fever Cold Skin infections Allergy Wound infection	Avoid crowding, maintain social distancing, clean surfaces which are in direct contact with people

Table 6. Types of luminometer [32]

Type of luminometer	Principle of working
First generation luminometer	Works on detecting radioactive emission – liquid scintillation counter
Second generation luminometer	Works on detecting photons in combination with photo multiplier tube

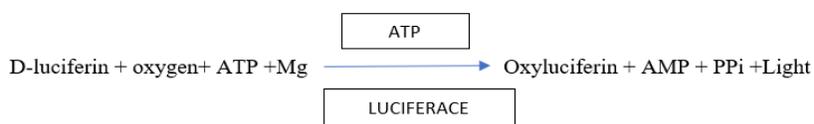


Fig. 4. Overall reaction involving conversion of substrate to product leading to emission of light

6. ADVANCED TECHNIQUE IN CONTAMINATION DETECTION

ATP bioluminescence test is rapid testing kit developed by biotechnologists which can be used as alternative approach to the conventional method due to its high sensitivity, specificity and real time detection. In 1940s research has proved requirement of ATP for catalysing reaction involving firefly luciferase enzyme. In this reaction luciferin is an organic substrate which undergoes oxidation in the presence of ATP, Magnesium ions & oxygen to form oxyluciferin and release of by-products such as pyrophosphate & Adenosine monophosphate (AMP), leading to emission of light termed as bioluminescence [30].

Instrument used for measuring bioluminescence is termed as luminometer. Based on its principle & application there are two types of luminometer explained in Table 1, apart from that luminometer can be further classified based on specificity, size & cost. Emitted light is measured in the form of RLU (relative light unit), and concentration of ATP is considered linear to light emitted during

biochemical reaction [31]. There is high demand and scope in market to initiate & develop portable luminometer which are cost effective.



Fig. 5. Handheld portable luminometer

Irrespective of few limitations of ATP bioluminescent assay can be a better alternative to conventional microbiological techniques to instantly monitor cleanliness & hygiene in the hospital environment. ATP bioluminescent method is considered better due to its ease on execution and immediate results ensure immediate actions and to maintain hygiene.

Table 7. Types of ATP assay

Type of test	Application
First generation ATP assay	To check the concentration of ATP present on surfaces free from interfering components Ex: surface contamination check
Second generation ATP assay	To check concentration of ATP present in liquid sample which may contain compounds interfering with reaction Ex: waste contamination, beverage & food industry

Table 8. Advantages and limitation of this assay

Advantages	Disadvantages
<ul style="list-style-type: none"> ● Easy to use Easy to store ● Very simple test ● Real time detection ● Fast process ● Less cost ● Less maintenance required ● High sensitivity 	<ul style="list-style-type: none"> ● Nonspecific test ● Cannot differentiate between organic matter and microbial contamination ● Presence of specific chemicals on surface during swab collection leads to interference in reaction leading to false positive and false negative results ● Cannot detect presence of microbial spores

7. CONCLUSION

Frequent hygiene monitoring and efficient cleaning practices in hospital vicinity and food operating section will reduce the incidences of hospital acquired infections. Even though ATP bioluminescence assay cannot replace conventional microbiology technique it can be used as alternative technique for rapid detection of microbial contamination.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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