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COMPARATIVE ANALYSIS OF QUATERNARY AMMONIUM AND HYDROGEN PEROXIDE-BASED OPERATION THEATRE DISINFECTION

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Abstract

Introduction and Objectives: *Operation theater associated surgical sites infections have become a major concern globally diverting the attention of the health authorities towards the importance of disinfection in operation theatres. This study was carried out to compare the efficacy of Quaternary based compound and hydrogen peroxide containing compound in operation theater disinfection.*

Material and Methodology: *A total of 288 Pre-fumigation and post fumigation samples comprising of swabs and agar plates were collected for both chemicals from General and Gynaecology operation theatres of District Headquarter Sheikhupura Hospital in a study duration of four months July-November 2024. Samples were then processed for microbiological analysis using standard microbiological guidelines.*

Results: *In first pre-fumigation, only (n=30) 41.6% of 72 samples were positive with Staphylococcus aureus 64.5% being predominant isolate from general in comparison to Coagulase Negative Staphylococci 48.5% from gynaecology operation theaters. Growth was reduced to (n=13) 18% post fogging using quaternary compound-based disinfectant with less than 10% growth observed for all microorganism collectively. During the 2nd cycle, less growth (n=28) 38.8% was observed pre-fumigation in comparison to 1st cycle with Staphylococcus aureus 48.3% and Staphylococcus epidermidis 54.7% being predominant isolates from the general and gynaecology operation theaters respectively. A reduction in positive samples (n=16)20.8% was observed following Hydrogen peroxide based disinfectant fogging with reduction below 13% in growth for all the isolates collectively.*

Conclusion: *It was concluded that although, Quaternary compound-based disinfectant provided more promising outcomes as compared to hydrogen peroxide-based chemical. Both reagents used were effective in reducing the microbial population to an extent no longer able to cause infection.*

INTRODUCTION

Surgical site infections caused by microbes present in the vicinity of operation theaters are one of the most prevalent post-operative complications accountings for 40% of all nosocomial infections which can

manifest in the patient who have undergone a surgery without an implant for up to a month, for patient who have undergone transplantation it may take up to one year [1–3]. Many endogenous and exogenous sources comprising from surgical patient to operating environment with all its belonging from intimate surfaces to air, even the surgical staff can contribute to the surgical site infections which not only delay the wound healing, and cost expensive treatment but also increase the duration of hospital stay for additional seven to ten days [4–6]. A variable spectrum of organisms including Gram positive and Gram-negative bacteria, fungi and viruses has been isolated from the operation theaters so far to look for potential microorganisms contributing to the third most common healthcare associated infection [7–9]. Several strategies from general cleaning to disinfection of the operation theater environment with suitable disinfectants strong enough to kill the microbial agents are useful in the breaking this chain of transmission. Efficacy of various chemicals of different chemical compositions like aldehydes, alcohol hydrogen peroxide, picrate acids and quartneary ammonium compounds have been studied to search for the suitable disinfectant with less toxicity and maximum antimicrobial activity within minimum time frame [10,11]. This study would be meaningful addition to the existing knowledge regarding the efficacy of these compounds for operation theater disinfection.

Objectives:

This study was carried out to

- To check the microbial profile of two different operation theatres setting.
- Compare the efficacy of Quartneary ammonium compound-based disinfectant with hydrogen peroxide-based disinfectant fogging in disinfection of in these settings.

Material and Method:

This comparative prospective study was carried out in the general and gynecology operation theaters of secondary care hospital Sheikhupura from July-November 2024. A total of 288 samples including swabs and plates for air sampling were collected including 72 pre-fumigation and 72 post-fumigation samples for both chemical disinfectants in two cycles from the same theaters within a gap interval of three months with 144 samples during each cycle. Following pre-fogging sample collection, fogging was carried out with each solution, for quaternary ammonium compound a dilution of 1.5% of solution was made in water as per guidelines and room was sealed and exposed to fogger spray for a time period of 15 minutes and post fogging samples were collected after contact time of one hour, for 2nd cycle accelerated Hydrogen peroxide-based solution was used as such as per guidelines for fogging and samples were collected 1 hour post fogging. Swabs were cultured in blood and MacConkey agar and plates were incubated as such. Further identification was carried out using standard microbiological techniques and biochemical testing. Data analysis was done using SPSS 20 and results were evaluated.

Results:

First cycle pre-fogging results revealed 41.6% positive growth in samples which was reduced to 18% post fogging. In 2nd Cycle, pre-fogging samples were less samples positive as compare to 1st cycle with a positivity of 38.8% which was reduced to 20.8% post-fogging with hydrogen peroxide-based disinfectant as shown in **Table 1**.

Table 1: Frequency of Growth in Samples

Growth Analysis of Sample	1st Cycle		2nd Cycle	
	Pre-Fogging	Post-Fogging	Pre-Fogging	Post-Fogging
No of Positive Samples	30(41.6%)	13(18%)	28(38.8%)	16(20.8%)
No of Negative Samples	42(58.3%)	59(81.9%)	44(61.1%)	56(77.7%)

A variable spectrum of microorganism was observed in both general and gynaecology operation theaters with Gram positive bacteria being predominant isolates during 1st cycle the growth of which was significantly reduced to below 10% collectively for all the contaminants with maximum growth of 8%

Staphylococcus aureus from general operation theaters as shown in **Fig 1**.

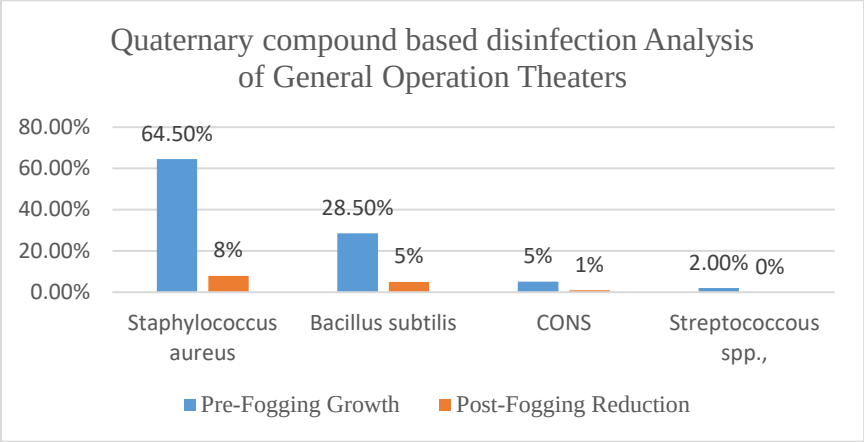

Fig 1: Quaternary Compound based Microbial Reduction in General Operation Theaters

While maximum growth of 3% was reported post - fogging for Coagulase Negative Staphylococci from gynaecology operation theaters as shown in **Fig 2**.

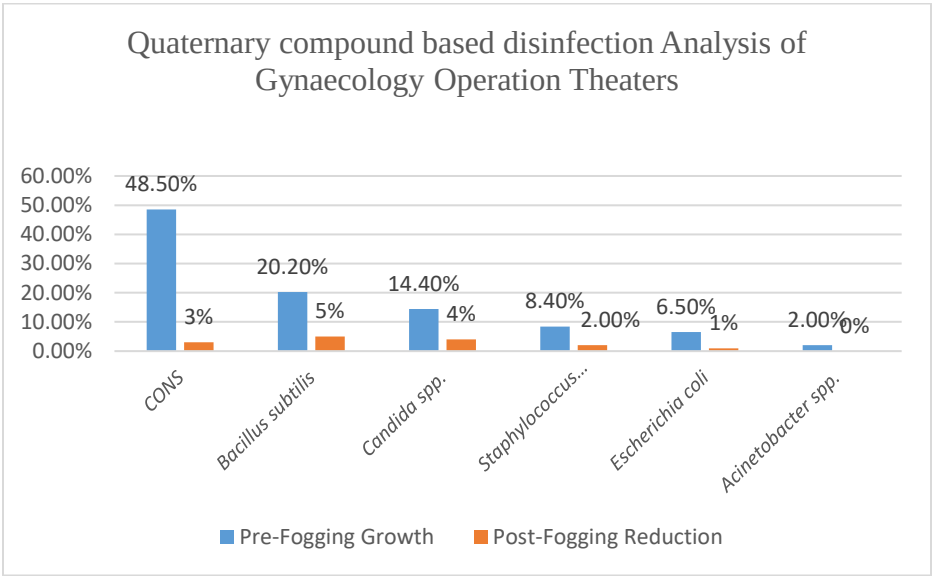

Fig 2: Quaternary Compound based Microbial Reduction in Gynaecology Operation Theaters

During 2nd cycle although less positive samples were retrieved in comparison to 1st cycle. However, a variable spectrum of microbes with the same predominance of Gram-positive bacteria with in both settings was observed. Following fogging with accelerated hydrogen peroxide-based disinfectant the growth of all the microorganisms was significantly reduced as shown in **Fig 3** with maximum growth of 10% for Staphylococcus aureus from general operation theaters.

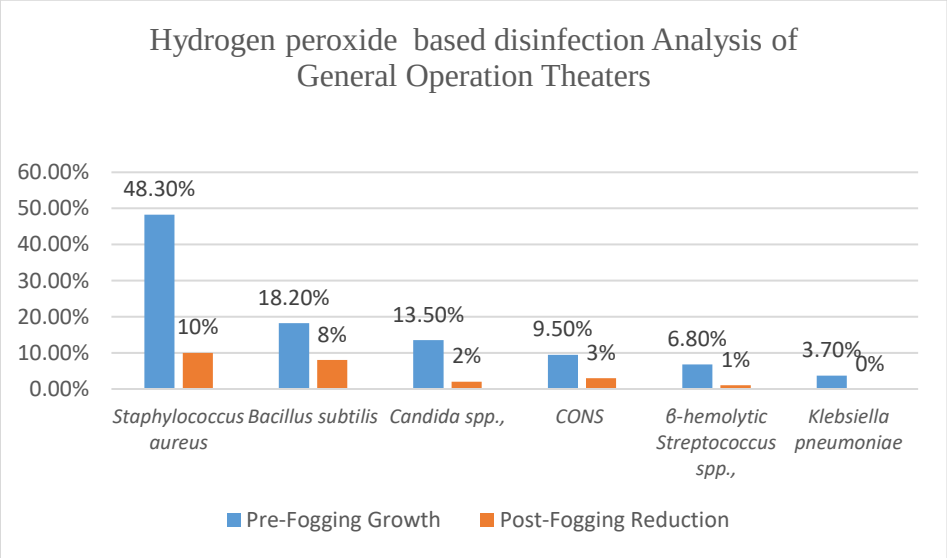

Fig 3: Hydrogen peroxide based Microbial Reduction in General Operation Theaters

While maximum growth of 12% for Staphylococcus epidermidis was obtained in response to fogging with hydrogen-peroxide based disinfectant from gynaecology operation theaters as shown in **Fig 4**.

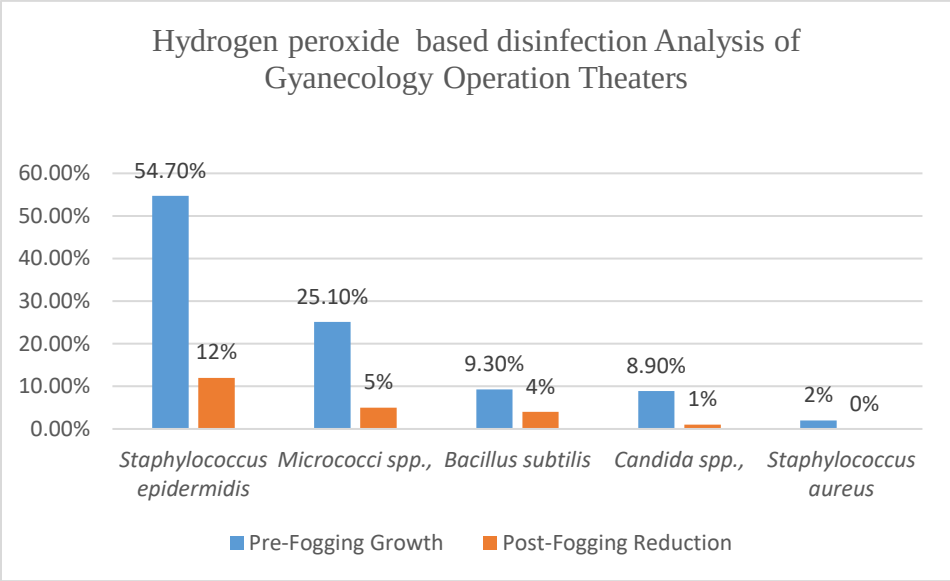

Fig 4: Hydrogen peroxide based Microbial Reduction in Gynaecology Operation Theaters

Discussion:

Disinfection of operation theaters has been one of the major concerns for the health authorities all around the globe ever since its crucial role in the surgical site infections. Many chemicals have been studied in this regard to check for their efficacy in the disinfection of this hub for surgical procedures to ensure the patient safety [12]. This study was carried out to compare the efficacy of two disinfectant with different chemical composition against the microbial population residing in those operation theaters in same setting to ensure the clear reflection of the disinfectant for microbial entities growing in same environment. During 1st cycle, only 41.6% samples were positive with Staphyloccocus aureus (64.5%), Bacillus subtilis (28.5%), CONS (5%) and Streptococcus spp. (2%)

among the most common isolates in the pr-fogging samples collected from the General operation theatre. while CONS (48.5%), Bacillus subtilis (20.2%), Candida spp. (14.4%), Staphylococcus aureus (8.40%) and Enterobacteriaceae like Escherichia coli (6.5%) and Acinetobacter spp. (2%), were common isolates from Gynaecology operation theatres indicating the dominance of Gram-Positive bacteria over Gram negative ones. Similar pattern was observed in many studies where Gram positive bacteria including Staphylococcus spp. and Bacillus spp., were most common isolates although Gram negative bacteria like Escherichia coli, Pseudomonas spp., and Acinetobacter spp., were also found in these studies still the growth of Gram-positive bacteria was more prevalent in comparison to Gram- negative ones which might be contributed to the prevalence of this bacteria as a part of normal flora [13–16].

Post-fogging with Quaternary ammonium-based compounds revealed a promising decline in the growth of these microbes below 10% with maximum resistance observed by Staphylococcus aureus (8%) isolated from General operation theater which was negligible to cause any infection. Furthermore, no growth in air sample was detected with growth observed in 13(18%) surface samples only which might be observed because of uneven distribution of chemicals to the hidden surface. A study carried out in Children hospital Lahore Operation theaters with the objective to compare of efficacy of Formaldehyde and Quaternary compounds using the similar fogging techniques also observed its remarkable antimicrobial activity in comparison to toxic formaldehyde in less time with the reduction in growth from 47% to 18% in post fogging samples. A similar study in India reported its promising results in the operation theater disinfection [17,18].

During 2nd cycle, pre-fogging samples revealed the same microbial pattern with less positive samples 28(38.8%). However, new contaminants like Candida spp and Klebsiella pneumoniae and Staphylococcus epidermidis and Micrococci species were isolated from general and gynaecology operation theatres respectively these findings were aligned with a study conducted in the operation theatres of India reported CONS and Micrococci of the normal flora among common isolates in samples taken gynaecology operation theatres following contaminants like Bacillus spp. Same study also reported the isolation of Klebsiella from the general operation theatres [19] . Similar profile was observed in Jinnah Hospital, Lahore where Staphylococcus epidermidis were prominently isolated from labour rooms while Klebsiella pneumoniae and Candida spp. were reported in the samples from theatres carrying out minor and major surgeries [20].

Fogging with hydrogen peroxide-based disinfectant containing 1% active solution also showed strong antimicrobial activity against these microorganisms comparable to Quaternary compound as indicated by less positive samples 16(20.8%), no growth in air samples and significant reduction in growth below 13% for all isolates. Hydrogen peroxide has been used widely for disinfection in multiple healthcare settings for its effective antimicrobial activity as a study using 12% aerosolized hydrogen peroxide fogging revealed its outstanding antimicrobial activity in comparison to 70% isopropanol in a dental health care setup [21]. Another study from regional hospital of United States also observed the efficacy of 7% hybrid hydrogen peroxide fogging with a reduction rate of 98% from pre-fogging sampling in comparison to conventional cleaning and UV treatment. [22]. A study also reported the considerable efficiency of hydrogen peroxide fogging in reduction of surgical site infection from a level 3.38% to 0.68% [23]. A reduction in efficacy in our case in comparison to other disinfectant might be due to the less concentration and different composition of hydrogen peroxide in comparison to other studies. Although the efficacy of first disinfectant was more in comparison to latter one as observed from both post fogging results, however both the disinfectants utilized were effective enough to lower the microbial index a level safe for surgical patient.

Conclusion:

This study proves that both disinfectants are effective in killing microbes to a level no longer potent enough to cause any infection. However, concentration, contact time and surface exposure all can contribute towards the efficacy of antimicrobial activity of these chemicals to obtain ideal outcome.

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Author Contribution:
T. T: (Investigation) acquisition of data, (Writing – Original Draft) Drafting the manuscript
H. J: (Conceptualization) Conception and design of study, (Formal analysis) analysis and/or interpretation of data,
Z.A. (Formal analysis) analysis and/or interpretation of data
S.N (Writing - Review & Editing) revising the manuscript critically for important intellectual content.

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