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Validation of hospital environmental disinfection efficiency of herbal fumigants

Research Article

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Abstract

Background: Healthcare associated infections includes infestation by bacteria, viruses and fungi. As per WHO estimates, approximately 15% of all hospitalized patients suffer from these nosocomial infections caused by these micro-organisms. Outbreaks of such infections increases the use of antibiotics, vitamins and immonomodulator medicines. During ancient times, to prevent spread of infections; fumigation with herbs was a practice and it is still seen continued. Material & methods: Good quality herbal fumigants like *Guggulu* gum-resin, turmeric powder, spikenard rhizome, white mustard fruits, caraway fruits, camphor resins and cow's ghee were used for fumigation of various hospital rooms like out-patient department room, dental clinic, gynecological procedure room, physiotherapy and operation theatre of Community Healthcare Center, Sarsa. Swabs from these units were tested for bacterial and fungal load before and after experiment by using culture media's like nutrient broth and potato dextrose agar respectively. Results: The bacteria culture reported organisms namely *Bacilus subtilis, Bacilus megaterium, Staphylococcus aureus, Micrococcus luteus* and fungi like *Aspergillus niger*, *mucor* and *rhizophus.* After 30 minutes of fumigation procedure, significant reduction in bacterial colonies was found in gynecological procedure room, dental clinic, OPD and physiotherapy room while statistically non-significant results were observed in operation theatre. Two hours after fumigation, statistically significant result was observed in bacterial count in all studied units except operation theatre while fungal colonies reduction was achieved in all studied units. Conclusion: Fumigation shall be encouraged in hospital units like out patients department, wards and minor procedure rooms but may not be perfectly suitable for operative theatres always. The study encourages daily herbal fumigation of home and surroundings for hygienic and pleasant environment.

Key Words: Ayurveda, COVID, Disinfection, Environment, Fumigation, Infections.

Introduction

Patients under medical care susceptible for nosocomial infections i.e., healthcare associated infections (HCAI). It includes infection by bacteria, viruses and fungal parasites. As per WHO estimates, approximately 15% of all hospitalized patients suffer from these nosocomial infections. It is considered as HCAI results in increased antibiotic resistance, financial burden, morbidity and mortality.(1) Prevention is one strategy to avoid transmission of these infections. In traditional science, fumigation technique is advised for controlling infections. Fumigation is easy to perform, cost effective when compared to operational and maintenance cost of these ventilation systems like plenum ventilation, laminar air-flow with HEPA filters which are presently used in hospitals for microbe free environment.(2,3).

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COVID-19 has alarmed to healthcare community on the danger and harm of nosocomial infection. A lot of awareness has come in disinfection practices after CVOID pandemic. Practically and economically, it is not feasible to put expensive technologies and chemical fumigation to homes especially in an underdeveloped or developing countries, small hospitals and clinic set-ups. Chemical fumigation itself associated with toxic side effects(4). Fumigation with herbal drugs ensures, disinfection of environment. Inhalation of fumigants helps to combat respiratory infections due to its anti-microbial action (5). This article delineates with herbs mentioned in Ayurveda for fumigation and validate it's antimicrobial potency.

Materials & methods

Good quality of herbal fumigants like *Guggulu* gum-resin, turmeric powder, spikenard rhizome, white mustard fruits, caraway fruits, camphor resin and cow's gheewere procured from medicine market. (Fig.1)

Procured drugs were studied organoleptically and confirmation of samples was done from Pharmacognosy department, Indukaka Ipcowala college of pharmacy (IICP), New Vallabhvidyanagar. For bacterial and fungal culture media's used were nutrient broth and potato dextrose agar respectively.

Fumigation was done by spreading 250g coarse powder of *Guggulu* gum resin by sprinkling few drops of cow's ghee and it was ignited first. Over it 200g camphor was added, followed by 200g spikenard, 200g of turmeric powder, 200g white mustard 200g and 200g of caraways.

The fumigation was kept for 20 minutes. The culture was done before fumigation, 30 minutes and 2 hours after completion of fumigation procedure. Experiment was planned to conduct in an area of 30-50 sq. m in an out-patient department room, dental clinic, gynecological procedure room, operation theatre and physiotherapy room of CHC, Sarsa dated 9th Jan 2022. (Figure 2) The plan of experiment is mentioned in table 1.

Table 1: Experimental procedure

Unit	Plate exposure before fumigation	Fumigation time	Plate exposure 30 minutes after fumigation	Plate exposure 2 hours after fumigation
Gynecology procedure room	10:45 am	11:08 am-11:30 am	12 pm	1:30 pm
Dental clinic	10:48 am	11:12am-11:35am	12:05 pm	1:35pm
OPD	11:15 am	11:37 am-11:57 am	12:27 pm	1:57 pm
Physiotherapy	11:25 am	11:50 am-12:10pm	12:40 pm	2:10 pm
Operation theatre	12:00 pm	12:30 pm-12:50 pm	1:20 pm	2:50pm

All the culture's plates were placed in incubator for 24 hours. Quantitative and qualitative analysis of culture was done in microbiology department, ARIBAS institute, New Vallabhvidyanagar, Anand.

Results

Raw drugs authenticity was confirmed from Pharmacognosy department, IICP, New Vidyananagar as *Guggulu* (*Commiphora wightii* Arn Bhandari) resin, turmeric powder (*Curcuma longa* L), spikernard (*Nardostachys jatamansi* DC) rhizome, white mustard fruits (*Brassica alba* L.), caraway fruits (*Trachyspermum ammi* L.), camphor resin (*Cinnamomum camphora* L.) and cow's ghee. The organoleptic characters are mentioned in table 2.

Table 2: Organoleptic observation of herbal fumigants

Drug	Colour	Odor	Touch	Taste
Guggulu gumresin	Black	Aromatic, pleasant	Rough	Pungent, bitter
Turmeric powder	Yellow	Turmeric	Fine, smooth	Bitter, astringent
Spikenard rhizome	Black	Aromatic, pleasant	Smooth	Bitter, pungent
White mustard fruits	Golden yellow	Non-significant	Smooth	Pungent
Caraway fruits	Yellow	Aromatic, pleasant	Rough	Pungent
Camphor resin	White	Aromatic, pleasant	Smooth	Not tested
Cow's ghee	Yellowish white	Pungent ghee smell	Slimy	Sweet

Quantitative analysis of bacterial and fungal culture before and after experiment is explained in table 3.

Table 3: Quantitative analysis of bacterial and fungal culture

Trial unit	Petri dish number	Bacterial culture count			Fungal culture count		
		BF	30 min	2 hr	BF	30 min	2 hr
Gynecology procedure room	1	110	21	13	10	5	0
	2	167	98	25	7	1	1
	3	90	31	29	8	2	1
	4	69	23	0	7	2	1
Dental clinic	1	95	30	2	17	3	5
	2	62	26	12	24	19	15
	3	78	56	26	39	17	11
	4	67	25	4	11	4	4
OPD	1	207	170	48	13	11	6
	2	176	117	64	43	21	16
	3	67	48	38	14	3	1
	4	166	72	23	17	6	5
Physio-therapy room	1	72	21	20	73	37	20
	2	54	12	25	28	9	5
	3	66	34	13	12	7	1
	4	77	37	29	13	2	1
Operation theatre	1	92	19	11	16	12	2
	2	36	8	9	12	5	3
	3	34	16	9	14	6	3
	4	158	57	27	10	6	1

BF: count done 15 minutes before start of procedure

Reduction in bacterial and fungal colonies have been analyzed statistically as presented in table 4.

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Table 4: Statistical significance of quantitative analysis of bacteria and fungi through culture

Trial unit	Bacterial culture count (*p* value)		Fungal culture count(*p* value)	
	After 30 min	After 2 hours	After 30 min	After 2 hours
Gynecology procedure room	0.005**	0.015**	<0.001@	0.005**
Dental clinic	0.019**	0.007**	0.053*	0.051*
OPD	0.048*	0.031*	0.067	0.041*
Physiotherapy	0.002**	0.004**	0.067	0.041*
Operation theatre	0.066	0.079	0.011**	0.003**

*P<0.05, **P<0.01, @P<0.001 when compared with initial value (Student's paired 't' test)

Qualitative analysis

In case of bacteria, mainly different species of bacillus were observed such as *Bacilus subtilis* (Gram+ve rod shaped), *Bacilusmegaterium* (Gram +ve rod shaped). Along with this some pigment producing bacteria were observed such as *Staphylococcus aureus* (Gram +ve round shaped) and *Micrococcus luteus* ((Gram +ve to Gram –ve, nonmotil). In case of fungi, many spore forming species were observed and most of them were *Aspergillus niger*, *mucor* and *rhizophus.*

Discussion

Airborne droplet, vectors, and vehicular transmission are common modes of bacterial infections(6). In hospital environment, fungi grows rapidly producing micro-colonies which circulate easily. Inhalation exposes respiratory tract to various pathogenic bacteria, fungi and viruses. This mainly affects people who works long hours in hospital environment and immune-compromised subjects who are under treatment leading to many respiratory infections, inflammation, allergic reactions etc. The survival of infectious agent like, bacteria, viruses or fungi partially depends on environmental factors like temperature and humidity. Fumigation makes environment warm and helps to reduce humidity.

The study results reports, after 30 minutes of fumigation procedure, a significant reduction of bacterial colonies in gynecological procedure room, dental clinic, OPD and physiotherapy room. Bacterial count was reduced in operation theatre but it was statistically non-significant. Statistically significant reduction in fungal colonies was found in gynecological procedures room, dental clinic and operation theatre Reduction in fungal colonies was observed in OPD and physiotherapy room however, it was statistically insignificant.

After two hours of fumigation, in all units' fungal and bacterial count (except in operation theatre) was significantly reduced statistically. The five different studied trial units possess almost same type of air flora. Reduction of bacteria's like *Bacillus subtilis, Bacillus megaterium, Staphylococcus aureus, Micrococcus luteus* and fungi like *Aspergillus niger*, *mucor* and *rhizophus.*

Though study reveals reduction in bacterial and fungal count in operation theatre, but it was statistically insignificant. In operation theatre, many infective diseases procedures are conducted, so it is continuously infected unit hence chemical fumigation shall be priority. Herbal fumigation can be practised for its other benefits like aroma, pleasantness etc.

Guggulu gum is reported to be effective against six gram-positive (*Bacillus cereus*, *Bacillus subtilis*, *Bacillus megaterium*, *Staphylococcus aureus*, *Micrococcus luteus*, *Enterococcus faecalis*) and four gram-negative (*Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa and Salmonella typhi*) bacterial strains.(7)

Curcuma longa is an effective anti-bacterial herb which has reported to be effective against 13 bacteria, namely, *Vibrio harveyi, V. alginolyticus, V. vulnificus, V. parahaemolyticus, V. cholerae, Bacillus subtilis, B. cereus, Aeromonas hydrophila, Streptococcus agalactiae, Staph. aureus, Staph. intermedius, Staph. Epidermidis, and Edwardsiella tarda* Curcuminoids elicited inhibitory activities against eight bacteria namely *Str. agalactiae, Staph. intermedius, Staph. epidermidis, Staph. aureus, A. hydrophila, B. subtilis, B. cereus,* and *Ed. tarda.*

Curcumin, a plant derivative of *Curcuma longa* possess a wide range of antiviral activity against different viruses. Methanol extract of turmeric is reported for its anti-fungal potential against *Cryptococcus neoformans* and *Candida albicans*, hexane extract is effective against *Rhizoctonia solani*, *Phytophthora infestans,* and *Erysiphe graminis* whereas ethyl acetate extract exhibits inhibitory effect against *R. Solani, P. infestans, Puccinia recondita* and *Botrytis cinera*. (8)

Essential oil of *Jatamansi* possess anti-microbial activity against large number of pathogenic bacteria and potent anti-fungal activity against different human and plant fungal pathogens(9,10). Essential oil derived from white mustard is more effective against gram negative than gram positive bacteria(11).

Essential oil procured from Caraway showed inhibitory effect on the growth of bacteria and fungi like *Staphylococcu saureus, Escherichia coli*, *Salmonella typhi*, *and Mycobacterium tuberculosis*. Carvon is the compound reported for antimicrobial action(12). Essential oil of *Cinnamomum camphora* (L.) possess broad range of antimicrobial, insecticidal, activities. Compounds, like linalool and camphor, possess potent antibacterial components against *Escherichia coli*, *Staphylococcus aureus*, and *Choanephora cucurbitarum*(13, 14).

Factors such as air circulation, moisture and temperature affect the extent of fungal contamination of indoor hospital units. (15) Fumigation helps in removal of moisture and increases warmth in environment; thus inhibit growth of fungus. Elimination of bacteria and fungi from the environment eventually reduces shelters of viruses and thus viral infections are also controlled. Respiratory viruses are transmitted in the hospital setting by various ways like with direct contact of infected visitors, families and healthcare workers, patient-to-patient spread, poor hygienic practices among healthcare providers etc. Fumigation helps to keep environment

hygienic. It is also reported during COVID-19 pandemic, for reopening, governments offices and other organizations; many countries have taken preventive initiatives of disinfecting public places by means of traditional and conventional fumigation techniques thus to make environments "safe" against virus.(16) Preventive measures have proven a dramatic impact on morbidity and mortality.(17)

Conclusion

Herbal fumigation technique has shown significant reduction in bacterial and fungal colonies observed through quantitative and qualitative analysis. Fumigation can be done for hospital units like out patients' department, wards and minor procedure rooms but for operative theatres the traditional fumigation may not be perfectly suitable. Study definitely encourages regular home fumigation for hygienic and pleasant environment.

Figure 1: Herbal fumigants

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