HOSPITAL TECHNIQUES

Bacterial control of the indoor air pollution

Disinfection and sterilization

We evaluated the capacity of disinfection of the indoor air by a portable device for decontamination based upon his recycling after a microbicidial action of the ultraviolet rays (UV-C).
The study has been done in rooms of two day hospitals of the hospital "L. Sacco" of Milan, evaluating the bacterial air contamination not only in absence of patient but also during the normal assistance activity.

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BACTERIAL CONTROL

The importance of the air as carrier of hospital infections is already known since a long time (2, 3, 8, 19, 23, 25, 27, 30, 53, 49, 62) but, even if several methods of prevention have been taken, the air-diffused microrganism are still the frequent cause of morbidity and mortality in recovered patients, especially in those areas called "high risk" for extremely vulnerable patients, like those of intensive therapy, reanimation, transplant surgery etc. (4, 18, 52, 53, 57, 64). Another category of patients particularly sensible to air infections are AIDS patients, of whom the immune-deficiency makes them more vulnerable to various infections of in first place the breathing apparatus (29, 35).
Furthermore, during the last years has been verified, in the developing countries, in the U.S.A. and in many European countries, included Italy, a return of the tuberculosis (7, 13, 41, 61, 65, 66) mainly correlated to the diffusion of the HIV-1 infection (5, 9, 22, 24, 32, 36, 55), and numerous hospital epidemics of this decease are indicated (6, 11, 12, 15, 16, 17, 25, 40), as the tuberculosis bacilli, dispersed by the cough of patients with laringea tuberculosis or contagious lung tuberculosis not diagnosed or who is not proper isolated, may remain for a long time in the air like nucleus of drops (1-5 mm Ø), being inhaled and entering the lungs of other patients or medical assistance (31, 48, 63). The frequent periods of hospital epidemics, often caused by colonies of Mycobacterium tuberculosis multiresistant to normal antituberculosis medicines, and the high lethality of HIV-1 patients have evidenced the need and urge of a more efficient prevention

of tuberculosis in medical structures, which has become a great interested to the researchers of this argument (21, 26, 34, 38, 39, 50, 54, 60) and the publication in 1990 by Centers for Disease Control (CDC) of "Guidelines for preventing the transmission of tuberculosis in healthcare settings, with special focus on HIV-related issues" (10).

The updated version of the a.m. guideline, published in 1994 (15), says that the program of control of the tuberculosis infection has to be based upon a ladder of measures made of:

1) a first level of administrative measures, mainly intended to assure a quick identification , isolation and treatment of patients with contagious tuberculosis;
2) a second level of ingenious or ambience measures in order to prevent the spreading out and to reduce the concentration of air-diffused tuberculosis bacilli with the nucleus of drops;
3) a third level of personal protection measures (protective inhaling devices) in order to protect the doctors and the other medical assistance from the risk of infection still present in some areas (for example, in the isolating rooms of patients with contagious tuberculosis and in rooms in which those patients are being treated which causes coughs or generates aerosol).

In order to reduce the concentration of air-diffused tuberculosis bacilli with the nucleus of drops and, in that way, the risk of their transmission to vulnerable patients it is recommended to change the air at least 6 times/hr to increase to at least 12 times/hr "where possible" in rooms of isolation and of treatment of patients with contagious tuberculosis.

The a.m. air changes may be done by regulating or modifying the ventilation or air conditioning system or by using auxiliary devices, like the recycling of the air in the room in "portable units for the decontamination of the air".

The aim of this research is to evaluate the efficiency of a portable device for the air decontamination based on its recycling after having it subjected to a microbicide action of ultraviolet C-type rays (UV-C).

Methods and materials

The research has been carried out in two Day Hospitals of the Division of infective deceases of the hospital "L. Sacco" of Milan, in two rectangular rooms, one of 50 m^3 (room "A") and one of 80 m^3 (room "B"), connected to a conditioner which assures two air changes per hour.

For the disinfection of the air has been used a device called "Sterilite Arianne 250" of the company Sterilite S.r.l. (Milan), equipped with 4 germicide UV-C lamps of 55 W. each and functioning as recycling: the ambience air is being aspirated by three fans through an opening on the bottom, irradiated and then re-emitted in the room through the opening on the top of the device.

The two optic labyrinths on the inlet and on the outlet of the air avoid the flowing out of the ultraviolet rays in the device.

In the two rooms the Sterilite device has been installed to the wall at the right of the entrance door and orientated in diagonal. The device has been activated when doors and windows were closed, regulated on a medium speed of aspiration (280 m^3/hr) during the day and at maximum speed (360 m^3/hr) at night, as by the Producers instructions.

In order to determine the total bacterial charge of the air the sampler "Surface Air System" (SAS) of P.B.I. International (Milan) has been used, by means of "Agar-Contact" plates of the same company.

The air drawings have been carried out on a height of 1,5 m. in two positions corresponding to the two angles of the wall at the left of the entrance.

In each rooms have been carried out two determinations in absence of patients and medical assistance (Day Hospital "Not active") and three during the normal assistance activity (Day Hospital "Active" with the germicide device not activated ("off") and the same determinations with the germicide device activated ("on").

For each determination has been carried out in each position a series of 4 drawings with interruptions of 30 minutes (beginning at 09:30hr) on Saturday and Sunday for the evaluation of the bacterial charge at Day Hospital not activated and during Monday, Tuesday and Wednesday for the evaluation of Day Hospital activated.
Prior to and after the series of drawings the temperature and the relative humidity of the air have been revealed at a height of 1,5mt. and at the centre of the rooms by means of a psycrometer by aspiration.
For the total bacterial charge, the number of the formed colonies ("UFC") counted on the surface of the plates after incubation at 37°C for 24 hours, has been corrected for the statistic probability and then reported at 1 m^3 of air as to the indications of the SAS supplier.
Finally, in order to indicate "the recycles of air per hour" (42, 50, 63) as the reduction of the bacterial air charge provoked by the UV-C irradiation in the Sterilite device, the following formula has been used (28):

$$Kuv = K1 (C1/C2) – 1$$

in which K1 are the air changes per hours assured by the conditioning system and C1 and C2 the medium of the bacterial charges revealed in each room, with the germicide device off and with the germicide device on.

Results

As shown in tab. 1, the presence of patients and staff meant a big increase of air-diffused bacteria not only in Day Hospital A (increase of the medium and of the median of total bacterial charge, from 107,3 to 278,6 and from 107,0 to 249,0 UFC per m^3) as well as in Day Hospital B (increase of the medium and of the median of total bacterial charge, from 136,9 to 347,5 and from 126,0 to 335,5 UFC per m^3). When the Sterilite device was activated in the same rooms you may notice a significant reduction ($p<0,01$) of the bacterial charge of the air which results mainly in Day Hospital off condition.
The difference in percent between the medians, in fact is reduced from 58,9% to 36,9% in room A and from 38,1% to 29,8% in room B, with Day Hospital off and on.
This reduction of the bacterial charge corresponds to 2,38 and 1,24 air changes equivalent per the hour in room A and to 1,58 and 0,90 air changes equivalent per the hour in room B, in the conditions of Day Hospital off and on.
Therefor, in the same conditions each air change per hour, assured by the conditioning system, increased, by effect of the UV-C irradiation of the Sterilite device, to 4,38 and 3,24 air changes equivalent per hour in Day Hospital A and 3,58 and 2,90 air changes equivalent per hour in Days Hospital B.
As far as the temperature and the relative air humidity are concerned, the medium of the values revealed (tab. 2) have been respectively between 22,8°C and 29,0 °C (variation field, 21,8 – 29,2%) and between 41,0% and 63,0°C (variation field 36 – 69%); the relative humidity values higher than 65% were only revealed in a determination with the Sterilite device off.

Discussion

The importance of the reduction of the microbic charge of the air in the prevention of the infections transmitted by air has recently be reconfirmed in "Guidelines for preventing the transmission of Myco-bacterium tuberculosis in health-care facilities, 1994" (15), which includes such providing in the second level of the ladder of measures of control which is based upon an efficient program of preventing tuberculosis infection.
The use to this aim of the UV-C germicide lamps, which admit radiation with a wavelength of approx. 253,7 nm (15, 51) is based on their efficient documentation with fixed systems (in tubes, in the conditioning or ventilation systems) or by irradiation of the highest part of the rooms (33, 37, 43, 44, 45, 46, 49, 50, 60).
As far as the efficiency of the UV-C radiations is concerned in the bacterial decontamination of the air with mobile units,

the results of our research indicate that the Sterilite device has reduced significantly ($p<0,01$) the bacterial charge in the two Day Hospitals.

The reduction which was more in room A than in room B (58,9% to 38,1% and 36,9% to 29,8%, with Day Hospital off and on) was due to a minor volume of the first room (50m³ to 80m³) which permitted a mayor number of air passages per hour (5,6 to 3,5) in the room of irradiation of the device.

However, we have to point out that the device which was used, has been able to increase the number of air changes equivalent per hour only from 2 to 4,38 and to 3,24 in room A and from 2,0 to 3,58 and to 2,90 in room B, both in Day Hospital off and on.

As already known the efficiency of the microbicide of the UV-C radiations depends on the intensity of the irradiation, on the lasting of exposition of the microrganism and on the relative humidity of the air, which may not exceed 65% (45, 48).

As the microclimatic revelations have evidenced that during the determination with Sterilite device on, the relative humidity of the air was always lower than 65%, we believe that the structural characteristics of the device may further being improved in order to increase the efficiency, so that the ventilation can by integrated in the room assured by the conditioning system to have a minimum of 6 air changes per hour as requested by the guidelines of CDC (14).

TAB. 1 efficiency of the Sterilite in bacterial decontamination of the air in two Day Hospitals of the infective deceases area of the Hospital "L. Sacco" of Milan.

Day Hospital	Activity	N. Persons Present *	Sterilite	N. Samples	Total bacterial charge (UFC/m³)				
					Medium + e.s.	Median	Variation Field	Difference° (P$)	KUV^
A	No	-	Off	16	107,3+11,0	107,0	28-179	58,9%	-
A	No	-	On	16	48,8+5,4	44,0	19-104	(0,0015)	2,38
A	Yes	5,3	Off	24	278,6+22,8	249,0	91-548	36,9%	-
A	Yes	3,3	On	24	171,5+14,3	157,0	67-333	(0,0007)	1,24
B	No	-	Off	16	136,9+18,2	126,0	39-329	38,1%	-
B	No	-	On	16	76,4+5,6	78,0	48-123	(0,0097)	1,58
B	Yes	5,7	Off	24	347,5+19,9	335,5	206-581	29,8%	-
B	Yes	6,0	On	24	238,3+14,5	235,5	90-378	(0,0003)	0,90

* Number media of people present, excluded the two researchers.

° Percent difference between mediane, 100 (Off-On)/Off

$ Wilkoxon's signed-rank test (not parametric test; dated indicated per area, hour and day of the week) (58)

^ Air changes equivalent per hour determined by the UV-C irradiation of the air in the Sterilite

Tab. 2 – Values of the temperature and of the relative humidity of the air revealed in two Day Hospitals of the infective deceases area of the Hospital "L. Sacco" of Milan during the determinations of the bacterial air charges.

Day Hospital	Activity	Sterilite	N. Determinations	Temperature (°C)		Relative Humidity (%)	
				Medium	Variation Field	Medium	Variation Field
A	No	Off	4	25,3	23,8-26,4	53,0	48-61
A	No	On	4	29,0	28,8-29,2	41,2	38-47
A	Yes	Off	6	24,7	23,4-25,8	58,1	51-65
A	Yes	On	6	27,6	26,1-28,0	50,1	46-53
B	No	Off	4	24,1	21,8-26,2	58,5	49-50
B	No	On	4	22,8	21,8-23,8	41,0	36-46
B	Yes	Off	6	23,9	23,0-25,0	63,0	55-69
B	Yes	On	6	27,2	24,2-28,6	47,8	43-57