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SHORT REPORT

Hospital use of decontaminating mats

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Summary Decontaminating mats made of several layers of adhesive sheets (water-based acrylic 6 g/m^2) supplemented with a bactericidal agent (3-1 benzoisothiazolin) at a concentration of 25% were placed in the passages providing access to the operating rooms of an orthopaedic service. Contact plates containing tryptone soy agar were used to assess bacterial concentration at specific points in front of and beyond the mats. For trolley passageways two areas were defined: central and lateral paths, corresponding to the areas walked upon by the personnel pushing the trolleys and to the paths covered by the trolley wheels, respectively. In order to exclude a simple mechanical effect, a comparison of bacterial loads at defined sites beyond the mats was carried out in the presence and in the absence of decontaminating mats. Bacterial colony counts in the presence of decontaminating mats were substantially and statistically significantly reduced compared with the absence of mats. The lower mean number of colony-forming units detected at points located beyond the mats parallels this finding; this difference is also statistically significant. We thus conclude that decontaminating mats are potentially useful in decreasing micro-organism carry-over due to personnel or the passage of trolleys into areas at high risk of infection such as operating rooms.

Introduction

The potential importance of microbial carry-over by personnel or trolley passage into sterile areas is rarely considered.[1-4] Micro-organisms resistant to air-drying can be carried to sterile areas and may become a source of infection.

To reduce carry-over, polyethylene adhesive mats coated with disinfectant agents have been developed. One such is manufactured by STERYLAB S.R.L. (Rho, Milan, Italy). The surface of this mat is coated with an adhesive substance (water-based acrylic 6 g/m^2) supplemented with a bactericidal agent [3-1 benzoisothiazolin (BIT)] at a concentration of 25%.

The bactericidal activity of BIT and its mechanism of action have been well documented.[5] BIT interacts with organic compounds containing thiol moieties and inhibits the oxidation of a number of

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carbohydrate substrates that are transported across the cell membrane by a process involving thiol-dependent enzymes. BIT inhibits the oxidation of glycerol entering the cell by diffusion and impairs the electron transport chain by acting on dehydrogenase enzymes.

In a previous study we reported data[6] comparing mats containing BIT with those using adhesive alone or adhesive associated with other disinfectants (diiodometyl-*p*-tolysulfone, thiazolone). Substantial broad-spectrum antibacterial activity of BIT was demonstrated with fragments of CBS mats consistently inhibiting all micro-organisms tested. In contrast, fragments of mats containing only adhesive substances or disinfectants, which were either poorly active or at inadequate concentrations, resulted in minimal growth inhibition. In addition, fragments of adhesive mats experimentally contaminated with 10^6 micro-organisms yielded no growth when subsequently applied to agar plates. In contrast, microbial growth was consistently observed when testing in the same way other types of mats containing only adhesive or other disinfectants.

Contact with BIT-impregnated decontaminating mats was also shown to result in a substantial reduction of bacterial contamination on shoe soles and trolley wheels, which was not observed with other mats containing the other disinfectants or adhesive only. Reduction was inversely related to the number of personnel or trolley passages.

Our initial laboratory study led us to the conclusion that BIT-containing CBS mats are not simply a 'dust-capturing' device but are actively biocidal.[6] In order to obtain in-use confirmation of this activity we therefore undertook the following study, by placing decontaminating mats in passages providing access to sterile areas and assessing whether this effectively reduced bacterial contamination due to personnel and stretcher passage.

Materials and methods

This study was performed in the orthopaedic ward of the S. Orsola-Malpighi Hospital in Bologna, Italy.

The passageway used by personnel to gain access to the operating room is 600 cm long and 150 cm wide, while the atrium for trolley passage is 440 cm long and 430 cm wide. However, the right side of the trolley access area, a surface approximately 440 cm long and 200 cm wide, may be considered a trolley storage area and consequently is not used for the passage of personnel pushing trolleys. The access areas to the operating rooms, both used overlying polyethylene sheets of 90 × 115 cm. Each sheet was coated with an adhesive substance (water-based acrylic 6 g/m^2) and supplemented with the bactericidal agent (BIT) at a concentration of 25%. Every sheet has a label, which indicates the number of remaining layers. The bottom layer is bi-adhesive and anchors the mat to the floor, this anchoring layer can be removed entirely without leaving behind fragments and can be used on all types of floor surfaces. The first and last sheets are protected by a transparent polyethylene wrapping.

The mats were positioned to cover almost the entire surface of the operating room access, and it was thus almost impossible for any operator or trolley entering the operating room area to avoid them. In the nursing and medical staff access area only one mat of 90 × 115 cm was placed, while in the larger area used for patient transportation, four 90 × 115 cm mats were placed covering an area of 180 × 230 cm. All personnel were instructed to step on the mats at least three times for each sole and all trolley wheels were to pass over the mats when trolleys entered through the operating room access. Adhesive sheets were removed after the passage of 10 people or 10 stretchers to avoid loss of efficacy.

During the first phase of the study, to monitor the surface bacteria loads, a fixed number of points were examined on the floor, beyond the mats. The control bacterial loads were measured at the same distance beyond the mat placement points when no mat was present. This was done in order to rule out a reduction of contamination due to a simple mechanical cleaning effect of soles or wheels passing through the areas immediately in front of the operating rooms. In a later phase of the study, monitoring was extended to corresponding points lying in front of and beyond the mats. Trolley area testing points were chosen where there was maximum likelihood of wheel passage (lateral paths) or of foot contact by personnel (central paths).

Monitoring was performed with contact culture plates Maxi Contact (PBI, Milan, Italy), containing 4% tryptone soy agar (OXOID, Basingstoke, UK). Plates were incubated at 36.5 ± 1 °C, and colonies developing after 24–48 h were counted. Contamination analysis was quantitative only as micro-organism identification was impossible due to the wide variety of microbial species present.

Contact plates were taken at 8:30 am and 12:30 pm, in the early phase of the study and for control. In the later phase of the study they were taken at 12:30 pm only. Every phase lasted one working week.

At the end of the incubation period, for each plate the number of colony-forming units was scored. For each phase and at each different time point the mean number of colony-forming units and standard deviations was calculated. A comprehensive statistical analysis was done using analysis of variance (ANOVA).

Results

The data from the various experimental series were examined by calculation of the chi square for adaptation to normal distribution. This showed that the number of colony-forming units for each point followed a Gaussian distribution. Thus it was possible to apply the ANOVA statistical pair test for repeated measurements. The contamination level at different points in both the personnel and trolley access areas were assessed with and without decontaminating mats. Standard deviation values were large as the degree of contamination was quite variable, both comparing different sampling points and within the same point at different times (Tables I and II).

It is noteworthy that the assessments performed at 12:30 pm generally showed much higher contamination compared with those performed at 8:30 am (Table I). This was particularly evident for the personnel access area, in which the mean number of colony-forming units doubled from 8:30 am to 12:30 pm. After decontaminating mat placement the degree of contamination of the sampling sites was substantially less than without mats (Table I). The reduction in microbial contamination in the trolley access area was 39.60% at 8:30 am and 31.5% at 12:30 pm in the lateral paths corresponding to areas of wheels passage, and 43.0% at 8.30 am and 40.9% at 12:30 pm in the central paths corresponding to the area of passage of personnel pushing stretchers (Table I). In the personnel passage area the mean reduction was 76.6% at 8:30 am and 66.1% at 12:30 pm (Table I).

ANOVA for degrees of freedom proved statistically highly significant ($P < 0.01$) when the data obtained in the personnel access hallway in the presence of the mats were compared with the data obtained in their absence; this was true for both sampling times. Likewise as regards the trolley passageway, the difference between the data obtained in the presence or in the absence of the decontamination mats appeared statistically significant for the side passageways at 8:30 am and for the central passageways at 12:30 pm ($P < 0.01$); conversely, for the central passageways at 8:30 am

Table I Micro-organism contamination mean values (and standard deviations) expressed as cfu per plate (55.39 cm^2) in the presence or absence of decontaminating carpets

		No. of scored plates	Decontaminating carpets absent (cfu)	No. of scored plates	Decontaminating carpets present (cfu)	*R*%	*F*
Stretcher access area							
Lateral paths (trolley wheel passage)	8:30 am	35	392.43 (202.27)	30	241.00 (151.00)	39.59	8.23 $P < 0.01$
	12:30 pm	29	547.17 (289.97)	24	359.04 (238.86)	31.53	7.20 $P < 0.05$
Central paths (trolley personnel passage)	8:30 am	22	408.15 (201.63)	19	230.42 (158.44)	43.04	7.30 $P < 0.05$
	12:30 am	23	468.31 (187.00)	16	276.87 (184.84)	40.88	11.5 $P < 0.01$
Personnel access area							
	8:30 am	35	505.88 (348.39)	30	138.36 (93.47)	76.56	31.5 $P < 0.01$
	12:30 pm	33	1084.42 (117.95)	30	343.53 (279.46)	66.06	13.2 $P < 0.01$

These values were obtained at several fixed sampling points in the trolley access areas and in the personnel access areas. The mean percent reduction (*R*%) and statistical significance by ANOVA test (*F*) have been calculated for mean colony-forming units values before and after decontaminating carpet placement.

Table II Micro-organism contamination mean values (and standard deviation) expressed as cfu/55.39 cm^2 before and after passage over decontaminating carpets

		No. of scored plates	Prior to carpet passage (cfu)	No. of scored plates	After carpet passage (cfu)	R%	F
Stretcher access area							
Lateral paths (trolley wheel passage)	12:30 am	30	344.60 (230.14)	30	147.86 (71.49)	57.1	20.01 $P < 0.01$
Central paths (trolley personnel passage)	12:30 am	20	268.19 (191.02)	20	153.00 (94.02)	42.94	7.14 $P < 0.05$
Personnel access area							
	12:30 pm	30	420.33 (236.53)	30	255.16 (182.86)	39.30	9.55 $P < 0.01$

These values were obtained at several fixed sampling points in the trolley access areas and in the personnel access areas. The mean percent reduction (R%) and statistical significance by ANOVA test (F) have been calculated for mean colony-forming units values before and after passage over decontaminating carpets.

and the side passageways at 12:30 pm, a reduction was also evident ($P < 0.05$).

Examining the results from the sampling points in front of the decontaminating mats with the corresponding results beyond them (Table II), it can be seen that at 12:30 pm, i.e. at the end of the morning operating room session, the colony-forming units per plate are substantially lower in points beyond the mats compared with those in front of them. The mean reduction was 57.1% for the lateral paths and 42.9% for the central paths in the trolley passage area, and 39.3% in the area of personnel passage (Table II). These differences were statistically significant for both personnel and trolley access areas.

The ANOVA test for the personnel access a *P*-value lower than 0.01, while in the trolley passage area it is <0.05 in the central paths and <0.01 for the lateral paths.

Discussion

Our data demonstrate that the use of decontaminating mats result in substantial reduction of microbial load due to personnel foot steps or trolley wheel passage. This activity seems to be specific and not simply due to a mechanical decontamination or a 'dilution effect' related to the distance from the entrance, as control values obtained without decontaminating mats were substantially higher.

The decontamination results of the trolley access area are essentially similar to those obtained at the personnel entrance. Overall these on-site data confirm and extend the experimental observations obtained in the laboratory and emphasize the efficacy of decontaminating mats in reducing substantially the microbial carry-over of footsteps and trolley wheels beyond the mats. The use of decontaminating mats may thus be considered a potentially very useful tool in areas at increased infectious risk such as operating rooms and wards caring for immunosuppressed patients.

It should be noted that the efficacy of decontaminating mats depends on their appropriate use. Nurses and medical staff should walk through the mats in small steps and all trolley wheels should cross the mats. Moreover, every 60 steps or 10 wheels passages an adhesive layer should be removed. When these limits are exceeded the decontaminating efficacy may decrease as the likelihood of overlapping with a previous passage area increases, resulting in reduced antimicrobial activity.

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