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Microbiological Monitoring of Protected Environment Units

Effects of Antibiotic Prophylaxis and Type of Unit*

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Abstract—*One hundred and eighty-seven patients received chemotherapy for malignant diseases in protected environment units with oral or parenteral prophylactic antibiotics. Life Islands, permanent laminar air flow units (LAF) and portable LAF units were utilized. Microbiological monitoring was performed during patient occupancy of these units. A higher proportion of settling plate cultures was sterile when the units were occupied by patients receiving oral antibiotic prophylaxis (53 vs 46%). The highest proportions of sterile settling platelet cultures were obtained from Life Island units. Floor cultures were collected from LAF units and the proportion which was sterile was higher in the permanent LAF units both when the patients were receiving oral antibiotic prophylaxis (76 vs 68%) and when they were not receiving oral antibiotic prophylaxis (81 vs 56%). The type of protected environment unit and antibiotic prophylaxis affects the results of microbiological monitoring of these units.*

INTRODUCTION

THE PROPORTION of patients admitted to the hospital with impaired host defense mechanisms has been increasing in recent years. Infection has been identified as the major cause of morbidity and mortality in these compromised hosts. Usually, these infections are acquired during hospitalization and some are caused by organisms comprising the nosocomial flora. Recent reports have implicated Gram-negative bacilli, especially *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Serratia marcescens* as the etiologic agents in epidemics of hospital-acquired infections [1–5]. Hence, considerable interest has been manifested in methods for protecting highly susceptible patients from nosocomial organisms.

A variety of patient isolation units have been under investigation during the past decade. The first type of protected environment (PE) introduced for compromised hosts was the plastic tent isolator, known as the Life Island (LI). Subsequently, the concept of laminar air flow (LAF) which had been used for industrial clean rooms was applied to medical isolation facilities [6–8]. The first LAF rooms occupied by patients as isolation rooms were installed in our institution. Later, a semi-portable type of LAF room was introduced which could be installed in existing patient rooms [9]. All 3 types of PE units have been utilized at this institution for patients undergoing cancer chemotherapy.

Since compromised hosts are susceptible to infections caused by their own microbial flora, patients admitted to the PE units also received prophylactic antibiotics. The majority of these patients received oral non-absorbable antibiotics in an attempt to sterilize the gastrointestinal tract and oropharynx. However, during the past several years, we have also studied parenteral prophylactic antibiotic regimens in patients who were admitted to PE units. Microbiological monitoring of the PE units has revealed that the semi-portable LAF room produces the least reduction in microbial contamination of the environment. Also, oral antibiotic prophylaxis causes a greater reduction in microbial contamination of the patient's environment than parenteral antibiotic prophylaxis. However, the impact of environmental contamination on the acquisition of infection could not be adequately assessed during this study due to differences in

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patient populations occupying the different types of the PE units.

MATERIALS AND METHODS

The environmental studies of PE units were conducted between November 1969 and June 1977. Thirty-nine patients occupied LI units, 64 patients occupied the permanent LAF rooms and 84 patients occupied the portable LAF rooms. Nearly all of the patients who occupied LI and permanent LAF units had acute leukemia, whereas most of the patients who occupied portable LAF units had malignant lymphoma, soft tissue sarcomas and breast carcinoma. All patients were receiving cancer chemotherapy. The portable LAF units were located in a different building than the other PE units, but the same medical staff supervised the operation of the units and the same laboratory was responsible for the microbiological monitoring. The same nursing and housekeeping procedures were followed at both institutions.

Two LI units (T. M. Matthews Research, Alexandria, VA) were utilized during these studies. The LI consisted of a bed enclosed in a plastic tent [10]. Air circulating in the unit passed through high-efficiency particulate air filters capable of eliminating 99.97% of particles greater than 0.3 μm in diameter. There was sufficient space for the patient to sit or stand beside the bed when the unit was maximally inflated. The tent could be deflated to permit easier access to the patient. Procedures were performed through plastic sleeves on the sides of the tent. The LI unit was sprayed with a 2% peracetic acid solution before each patient's entry. Thirty minutes after spraying was completed, the unit was ventilated for 24 hr. The LI unit was cleaned once weekly with a 1:500 benzalkonium chloride solution during patient occupancy.

The permanent LAF unit consisted of 2 LAF rooms and was constructed by Envirco Co., Albuquerque, NM, following feasibility studies by Michaelson *et al.* [11]. A bank of high-efficiency particulate air filters comprised one entire wall of each room. Filtered air circulated through the room in a horizontal direction at a velocity of 90 ft/min and returned through prefilters in the ceiling for recirculation. A higher pressure was maintained within the room so that the flow of air was from the patient room to the access corridor to the hospital corridor. All furnishings in the room were constructed specially to provide minimum obstruction to the flow of air. Prior to each patient's entry, the walls and floor were cleaned with a solution containing an organic tin compound (Biomet 611). The unit was fogged for 30 min with a similar compound (Biomet 630), after which it was ventilated for 24 hr. The floors and furnishings were cleaned at least twice weekly with Biomet 611 during patient occupancy. Details of the design of the LAF rooms and preliminary environmental studies have been published elsewhere [12].

Five semi-portable LAF rooms constructed by Sci-Med Inc., Minneapolis, MN, were also utilized in these studies. These units were designed under contract with the National Cancer Institute [9]. The design and operation of these units were similar to that of the permanent LAF rooms. However, the velocity of air flow was maintained at 30 ft/min and there was no recirculation of air. The air intake was located at the side of the unit and the filtered air was exhausted through the door.

All items placed into either type of isolation unit were especially wrapped and either gas or steam autoclaved. Personnel entering a LAF room to care for patients wore a sterile cap, mask, gown, gloves and boots. It was not possible to enter a LI unit after the patient was admitted. The LI units were equipped with locks containing u.v. lights where all items entering the unit were placed for at least 90 sec.

All but 2 patients admitted to the PE units recovered prophylactic antibiotics. The majority received an oral non-absorbable antibiotic regimen consisting of vancomycin, gentamicin and nystatin, the details of which have already been published [13]. During a 3.5-yr period, we conducted a study of remission induction chemotherapy in patients with acute leukemia, which included a randomization between oral and parenteral antibiotic prophylaxis. The majority of these patients were treated in the LI units or permanent LAF rooms. This study created an opportunity to evaluate the PE units when occupied by patients whose gastrointestinal and oropharyngeal flora were not altered substantially by oral antibiotics. However, all patients applied topical antibiotics to body orifices and bathed with special soap preparations. The details of these prophylactic regimens have been published elsewhere [14]. Simultaneously, studies of the portable LAF rooms plus oral antibiotic prophylaxis were being conducted in patients with other malignancies.

Microbiological monitoring

Settling plates were placed in the LAF and LI units 5 days weekly. Two Petri dishes, 100 mm dia x 15 mm deep, containing sheep blood agar were set on the floor in areas of greatest activity for 8 hr daily and then were incubated aerobically at 37°C for 48 hr.

Squares 1 ft in length were marked on the floors of permanent LAF rooms (7 sites) and portable LAF room (6 sites) for surface sampling. Once weekly, before routine cleaning, these entire areas were swabbed with cotton balls (1 cm dia) moistened with approximately 1.5 ml of isotonic saline. The cotton balls were placed in tubes containing 5 ml of isotonic saline. No neutralizers were used in the isotonic saline. After shaking the tubes vigorously, a 0.1 ml sample was removed and inoculated onto a plate containing sheep blood agar. An additional 1.0 ml was inoculated into thioglycolate broth. The culture specimens were incubated aerobically at 37°C for 48 hr. Each colony-forming unit on the sheep blood agar plate represented 50 organisms. Organisms which grew only in the thioglycolate broth could not be quantitated.

Organisms were identified according to standard methods. Gram-negative bacilli were identified according to the methods of Weaver *et al.* (The Identification of Unusual Pathogenic Gram-Negative Bacteria, Center for Disease Control, U.S. Public Health Service, Atlanta, GA). Molds were not identified. For the purpose of this study, the following organisms were considered nonpathogens: *Staphylococcus epidermidis*, *Bacillus* sp., *Micrococcus* sp., diphtheroids, *Lactobacillus* sp., *Sarcina* sp., *Neisseria* sp., *Streptomyces* sp., non-enteric Gram-negative bacilli and molds. Statistical analyses were conducted using the Chi-square test.

Microbiological monitoring of regular hospital rooms was not included in this study. Our previous study demonstrated that microbial contamination in PE units was significantly less than in regular hospital rooms [15]. Air sampling was not conducted routinely during this study due to malfunctioning equipment. Our previous study indicated that the information obtained by air sampling was similar to that obtained by other sampling procedures [15].

RESULTS

Studies were conducted during occupancy of the PE units by 187 patients. Forty-five patients received no oral antibiotic prophylaxis (43 received parenteral antibiotic prophylaxis and 2 received no antibiotic prophylaxis) and 142 received oral prophylactic antibiotics (PA). Among those patients receiving PA, 17 occupied a LI unit, 51 a permanent LAF unit and 74 a portable LAF unit. Among those patients who received no PA, 22 occupied a LI unit, 13 a permanent LAF unit and 10 a portable LAF unit.

The results of settling plate cultures are presented in Table 1. Sterile samples were obtained most often from LI units ($P<0.001$). Also, a higher proportion of samples were sterile when patients occupying the PE units were receiving PA ($P<0.001$). Hence, 81% of samples collected from LI units occupied by patients receiving PA were sterile compared to only 25% of samples collected from portable LAF units occupied by patients receiving no PA ($P<0.001$). Potential pathogens were recovered consistently more often from settling plates when the patients were receiving no PA ($P<0.001$). The proportion of samples containing potential pathogens was the same in LI units and permanent LAF units and was less than in portable LAF units ($P<0.001$). Likewise, the number of organisms deposited upon settling plates per hour of sampling was highest in the portable LAF units ($P<0.001$). Although more organisms were deposited

Table 1. *Cultures of settling plates*

Protected environment	LI	Permanent LAF	Portable LAF	Total	LI	Permanent LAF	Portable LAF	Total
Oral antibiotic prophylaxis	Yes	Yes	Yes	Yes	No	No	No	No
No. of patients	17	51	74	143	22	13	10	45
Samples	1283	3634	5648	9043	1743	687	798	3228
Sterile samples (%)	81	57	46	53	55	46	25	46
With pathogens (%)	5	5	12	9	9	9	32	15
Total organisms	4386	8242	60,623	69,411	8056	2121	11,729	21,906
Organisms deposited/hr	0.4	0.3	1.3	1.0	0.6	0.4	1.8	0.8

when all units were occupied by patients not receiving PA, the difference was the greatest in the portable LAF units ($P<0.001$).

A wide variety of potentially pathogenic bacteria and fungi were recovered from settling plate cultures (Table 2). Gram-negative bacilli were recovered more often from the portable LAF units than from the other PE units ($P=0.01$). Included among these Gram-negative bacilli were *Enterobacter* spp., *Escherichia coli* and *Klebsiella* spp. However, most notable were *P. aeruginosa* and other *Pseudomonas* spp. which were recovered 5–10 times more frequently in the portable LAF units ($P<0.001$). Gram-negative bacilli and *Candida* spp. were recovered more frequently from all PE units when they were occupied by patients not receiving PA ($P=0.01$–$P<0.001$). The differences were especially striking for *E. coli*, *Klebsiella* spp. and *Candida* spp., but there were no major differences for *P. aeruginosa* and *Pseudomonas* spp. *Torulopsis glabrata* was only recovered from the PE units when they were occupied by patients receiving PA.

Floor cultures were obtained from the 2 types of LAF rooms during patient occupancy. Approximately 70% of all samples were sterile (Table 3). The proportions of sterile cultures were greater in the permanent than in the portable LAF rooms ($P<0.001$). There was a substantial difference in the proportion of sterile samples obtained from the portable LAF rooms dependent upon whether the patients

*Table 2. Potential pathogens isolated from settling plates**

Protected environment	LI	Permanent LAF	Portable LAF	LI	Permanent LAF	Portable LAF
Oral antibiotic prophylaxis	Yes	Yes	Yes	No	No	No
Achromobacter	0	0	0.1	0	0	0
Acinetobacter	0.1	0.2	0.3	0.1	0.1	0.3
Alcaligenes	0	0.1	0.1	0	0	0
Bordetella	0.1	0	0	0	0	0
Citrobacter	0.1	0	0.3	0.2	0	0
Enterobacter	0	0.2	0.6	0.2	0	0.9
E. coli	0.1	0.1	0.6	0.7	0.4	1.8
Flavobacterium	0	0.1	0.1	0	0.3	0.5
Klebsiella	0.3	0.5	1.5	1.4	1.7	4.3
Mima	0.2	0.1	0.1	0	0.1	0.1
Moraxella	0	0.1	0.1	0	0.6	0
Pneumococcus	0	0.1	0	0	0	0.1
Proteus	0	0.1	0.7	0	0.6	0.3
P. aeruginosa	0.9	0.7	4.3	0	0.3	5.6
Pseudomonas spp.	0.2	0.5	2.3	0.2	0.6	1.4
Serratia	0.1	0	0.1	0.2	0	0
Staph. aureus	0.1	0.2	0.1	0.1	0	7.1
Streptococcus	1.5	0.5	0.3	3.1	4.2	4.9
Vibrio	0	0	0.2	0	0	0
Aspergillus	0	0	0.1	0	0	0
Candida	2.3	1.4	2.0	3.5	1.9	7.4
Rhodotorula	0	0	0.1	0	0	0
Torulopsis	0.1	0.1	0.1	0	0	0

*Expressed as per cent of samples with organism.

Table 3. Floor culture samples

Protected environment	Permanent LAF	Portable LAF	Total	Permanent LAF	Portable LAF	Total
Oral antibiotic prophylaxis	Yes	Yes	Yes	No	No	No
Samples	2833	3652	6485	546	552	1098
Sterile samples (%)	76	68	71	81	56	68
With pathogens (%)	4	7	5	12	20	16
With positive broth cultures only* (%)	15	19	17	9	18	13
With cultures with >500 organisms/ft^2 (%)	2	6	4	4	14	9

*50 aerobes or anaerobes only.

were receiving PA ($P<0.001$). This was not true for the permanent LAF rooms. The proportion of samples containing potential pathogens was higher in the portable LAF rooms (9 vs 5%, $P<0.01$). Similarly, the proportion of samples containing potential pathogens in both types of LAF units was 3 times higher when they were occupied by patients not receiving PA ($P<0.001$).

The number of organisms recovered from floor samples also was determined. The proportion of samples which were heavily contaminated (>500 organisms ft^2) was greater in the portable LAF rooms (7 vs 2%, $P<0.01$). Also, a higher proportion of samples were heavily contaminated in both types of LAF units when they were occupied by patients not receiving PA ($P<0.01$). The proportion of samples containing only minimal contamination (organisms recovered from thioglycolate broth cultures only) was similar for both types of LAF units.

Potential pathogens recovered from floor cultures are listed in Table 4. Several organisms were cultured more often from the portable LAF rooms, including *Klebsiella* spp., *Staphylococcus aureus* and especially *P. aeruginosa* and *Pseudomonas* spp. ($P=0.05$–$P<0.01$). Among those organisms cultured more often when the LAF units were occupied by patients not receiving PA were included *E. coli*, *Staph. aureus*, *Streptococci* and *Candida* spp. ($P<0.001$). *P. aeruginosa* and *Pseudomonas* spp. were cultured from portable LAF units more often when they were occupied by patients not receiving PA ($P<0.01$), but this was not true for permanent LAF rooms. *Moraxella* sp. and *T. glabrata* were cultured only when the LAF rooms were occupied by patients who were receiving PA.

DISCUSSION

Previous studies have shown that the LI and permanent LAF units provide an environment with substantially less microbial contamination than a regular hospital room [15, 16]. This study expanded the observations in these PA units and also evaluated the newer portable LAF unit. The portable LAF unit is being utilized in many hospitals at the present time. Our studies provided the opportunity to compare the efficacy of these 3 types of PE units. Also, the role of prophylactic antibiotics on microbiological monitoring of PE units could be determined in these studies, during which some patients received prophylactic parenteral antibiotics which had minimal effect on the patients' gastrointestinal microbial flora.

The proportion of sterile samples were consistently higher in the permanent LAF rooms than in the portable LAF units. Also, the proportion of samples containing potential pathogens was usually higher in the portable LAF units. The differences were most striking for settling plate and floor cultures. Two factors that would affect contamination of

Table 4. Potential pathogens isolated from floor cultures

Protected environment	Permanent LAF	Portable LAF	Permanent LAF	Portable LAF
Oral antibiotic prophylaxis	Yes	Yes	No	No
Acinetobacter	0.2	0.2	0	0.4
Alcaligenes	0	0.2	0	0
Bacteroides	0.1	0	1.5	0.2
Citrobacter	0	0.8	0	0.4
Clostridium	0.1	0.4	0.4	0.2
Enterobacter	0.1	0.2	0	0.4
E. coli	0	0.2	1.0	1.1
Flavobacterium	0.1	0	0	0
Klebsiella	0.2	1.2	0.5	1.1
Mima	0	0.1	0.4	0.2
Moraxella	0.1	0.1	0	0
Proteus	0	0	0.2	0
P. aeruginosa	0.3	2.2	0.2	5.4
Pseudomonas spp.	0.1	1.8	0	2.5
Staph. aureus	0	0.1	0.2	3.6
Streptococcus	0.1	0.6	5.9	4.2
Aspergillus	0	0.1	0	0
Candida	0.8	0.5	2.0	3.4
Geotrichum	0	0.1	0	0
Torulopsis	1.7	0.2	0	0

settling plates are the number of organisms shed into the environment and the velocity of air flow. More organisms would be expected to be deposited at lower velocities and this most likely explains the greater contamination of settling plates in the portable LAF units. A possible explanation for the greater contamination of floor samples in the portable LAF units was the lack of a seal between the walls and the floor. Indeed, this presented a problem on several occasions when these units were contaminated by water from external sources. Another possible explanation for the greater amount of microbial contamination in the portable LAF rooms was their location in a different building with different nursing and housekeeping staff. However, the same housekeeping routines and disinfectants were utilized and the same medical staff supervised both programs.

Suppression of the patients' endogenous oropharyngeal and gastrointestinal flora is an important factor in maintaining minimum contamination within the PE unit. This was first demonstrated in the LI unit when it was observed that microbial contamination of air within the unit was greater during patient occupancy than in regular hospital rooms [17]. However, air flow in LI units is turbulent and there were less than 15 air exchanges per hr. It was anticipated that the lack of PA would have less of an impact in LAF rooms

Table 5. Cultures of water in laminar air flow units

Protected environment	Permanent LAF	Portable LAF	Permanent LAF	Portable LAF
Prophylactic oral antibiotics	Yes	Yes	No	No
Samples	409	584	73	67
Sterile samples (%)	76	71	67	61
With pathogens (%)	6	6	14	13

Table 6. Organisms cultured from water samples

Protected environment	Permanent LAF	Portable LAF	Permanent LAF	Portable LAF
Oral antibiotic prophylaxis	Yes	Yes	No	No
Acinetobacter	0.4	0.7	0	0
Alcaligenes	0.9	0	0	4.1
Bacillus	2.2	1.0	0	4.1
Cardiobacterium	0	1.5	2.7	1.4
Corynebacterium	2.7	6.3	0	13.5
Flavobacterium	4.5	0.2	1.4	6.8
Micrococcus	1.3	0.5	0	0
Mima	0.4	1.7	0	0
Moraxella	4.5	5.7	0	0
Propionobacterium	0.9	2.6	1.4	1.4
P. aeruginosa	0.4	0	0	1.4
Pseudomonas sp.	8.0	2.2	16.4	8.1
S. epidermidis	0.4	1.2	1.4	0
Vibrio	1.8	2.1	11.0	2.7
HB-1	0	1.7	0	0
BH-5	0.4	0.9	0	0
VE-2	0	0.3	1.4	0
TM-1	0	0.3	0	0
I-a	0.4	0	0	0
I-b	0.9	0	0	0
II-f	0	0.2	0	0
II-k	9.4	1.4	9.6	6.8
III-a	1.3	0.3	0	0
III-b	0.4	0	0	0
III-d	0.4	0	0	0
IV-a	0.4	0.5	0	0
IV-c	0.9	0	0	1.4
IV-d	0.4	0.2	0	0
IV-e	0.4	0	0	0
V-d	0.4	0	0	0

because of the minimal turbulence and the high rate of air exchange. The administration of PA to patients had a greater effect on microbial contamination of floor and settling plate cultures in the portable LAF units where air flow velocity was lower.

Only settling plates were used to monitor microbial contamination of LI units. The highest proportion of sterile samples were obtained from these PE units. This is not surprising, since personnel could not enter the LI units during patient occupancy. Furthermore, the patients remained confined to their beds during the majority of their stay in LI units. Personnel did enter the LAF units on a regular basis to clean the rooms and care for the patients. This occurred less frequently with the portable LAF units which had a plastic curtain and gauntlets on one side of the unit through which most patient care procedures could be performed. When personnel entered the LAF units, they wore sterile apparel but it is likely that organisms were deposited into the environment from their bodies. Also, it was necessary for patients to move about the LAF units to bathe, eat and perform other activities.

P. aeruginosa and other *Pseudomonas* spp. were some of the more common contaminants within the LAF units. *P. aeruginosa* was a major contaminant of the floors and sinks in our initial experience with the permanent LAF units and led to the design of special sinks and the installation of seamless flooring [15]. These modifications substantially reduced the frequency of contamination but did not eliminate it. Contamination of the sinks was a major problem since *Pseudomonas* spp. grow profusely in moist environments. *P. aeruginosa* is capable of proliferating in distilled water [18]. However, when contamination was detected, the sinks could be removed and

Table 7. Results of sink cultures

Protected environment	Permanent LAF	Portable LAF	Total	Permanent LAF	Portable LAF	Total
Oral antibiotic prophylaxis	Yes	Yes	Yes	No	No	No
Patients	51	77	104	13	10	23
Samples	1032	1858	2513	225	277	502
Sterile samples (%)	72	58	63	68	60	64
With pathogens (%)	13	17	15	22	18	20

Table 8. Potential pathogens isolated from sink cultures

Protected environment	Permanent LAF	Portable LAF	Permanent LAF	Portable LAF
Oral antibiotic prophylaxis	Yes	Yes	No	No
Acinetobacter	0.7	0.5	0	1.4
Alcaligenes	0	0.4	0	0.4
Bacteroides	0	0.4	0.9	0
Bordetella	0	0.1	0	0
Citrobacter	0	0.8	0	0.4
Clostridium	0	0.3	0.4	1.1
Enterobacter	0.7	0.8	0	0
E. coli	0.1	0.4	0.9	0.7
Flavobacterium	1.4	0.4	0.4	2.2
Klebsiella	0.6	0.7	0.2	4.3
Mima	0.1	0.9	1.3	0.7
Moraxella	1.6	0.8	0	0
Proteus	0	0	0.9	0
P. aeruginosa	2.5	7.4	3.6	4.7
Pseudomonas sp.	3.1	4.1	3.1	2.9
Serratia	0	0.1	0	0
Staph. aureus	0	0.1	0	0.1
Streptococcus	0.7	0.8	0.4	7.2
Vibrio	0	0	1.8	0
Candida	3.1	3.7	4.4	3.6
Geotrichum	0	0.1	0	0
Torulopsis	1.7	0.2	0	0.4

autoclaved, preventing this contamination from becoming a continuing threat to the patient. Neutropenic patients, burn patients and other compromised hosts are especially susceptible to *Pseudomonas* infections [19, 20]. Clinical studies of PE units have shown a reduction in the frequency of *Pseudomonas* infections as a major benefit of the use of this program [16].

Candida spp. were also common contaminants in these units. In previous studies, fungi were recovered more frequently from environmental cultures of PE units than from cultures of regular hospital rooms [15]. Since all of the patients had received PA, this was felt to reflect the alterations in the gastrointestinal flora by these medications and the difficulty in suppressing fungi growth by antifungal agents. In the present study, *Candida* spp. were isolated more often from settling plates and floor cultures when the PE units were occupied by patients who were not receiving PA. However, *Torulopsis glabrata* were seldom isolated from environmental cultures unless the patients were receiving PA.

Gram-negative bacilli were the major potential pathogens isolated from PE units. *Staph. aureus* was an infrequent contaminant. This differs from the experience in regular hospital rooms where *Staph. aureus* is a frequent contaminant [15]. Although special studies were not conducted, there was no evidence to suggest that organisms developed resistance to the cleansing solutions and persisted for this reason.

This study has demonstrated that the portable LAF room offers the least reduction in microbial contamination of the 3 types of PE units evaluated. Although the LI units had the lowest amount of microbial contamination as measured by settling plates, the units had many disadvantages which made them less acceptable to patients. The amount of microbial contamination detected in PE units is dependent upon the type of antibiotic prophylaxis utilized, which has not been appreciated in previous studies [15, 16]. The impact of the amount of microbial contamination in the PE units on the frequency of infectious complications could not be ascertained from this study. Only leukemic patients occupied the LI units and permanent LAF rooms, whereas the majority of patients occupying the portable LAF rooms had other malignancies. Our monitoring data indicates no differences in the efficacy of prophylactic antibiotic regimens related to the patients' underlying malignancy (Bodey, unpublished data). However, the frequency of infectious complications is dependent upon the patient's underlying malignancy and the degree and duration of neutropenia [21–23]. Hence, the differences in patient populations within the various types of units prevent an assessment of the importance of these observations. In our randomized study of patients undergoing treatment for acute leukemia, the frequency of infection was similar for patients receiving oral and parenteral antibiotic prophylaxis, even though the present data demonstrate that the former patients were exposed to less microbial contamination in their environment [14]. Although one would anticipate that the type of PE unit which afforded the largest reduction in microbial contamination would provide the greatest protection against infection, there are no data to support this conclusion at the present time.

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