Microbiological Evaluation of Protected Environments During Patient Occupancy

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Microbiological monitoring has been conducted in two life island (LI) units and two laminar airflow (LAF) rooms while they were occupied by patients undergoing cancer chemotherapy. There were only 5 organisms per 1,000 ft³ of air sampled in LAF rooms, 31 organisms in LI units, and over 3,000 organisms in regular hospital rooms. None of the floor samples obtained from hospital rooms was sterile, compared to over 70% in LAF rooms. The rate of deposition of organisms onto settling plates was one organism per 4.5 hr in LAF rooms compared to one organism per 0.08 hr in hospital rooms. Potential pathogens were isolated much more frequently from environmental samples obtained from hospital rooms than from LI units or LAF rooms. Two sites of persistent contamination arose in the LAF rooms: the vinyl tile flooring and the water supply system. Over half of the potential pathogens cultured from the protected environment units were cultured initially from the patients who occupied the units.

The hospital is a notorious harbinger of organisms capable of causing serious infections, especially in patients with impaired host defense mechanisms. Penicillin G-resistant staphylococcal infections have been a major problem in hospitalized patients, and more recently hospital-acquired Klebsiella sp. and Serratia marcescens infections have become increasingly frequent (7, 10, 18, 19, 23). Acquisition of Pseudomonas aeruginosa from the hospital environment has been demonstrated among patients undergoing surgery, patients with leukemia, and patients with extensive burns (1, 15, 21).

In recent years, interest has been aroused in the use of various types of isolation units for those patients who have a high risk of acquiring infection from the hospital environment. Isolation units have been under investigation for the prophylaxis of infection in patients undergoing surgery, in patients recovering from bone marrow transplantation, in patients with burn wounds, and in patients receiving cancer chemotherapy (8, 12, 13, 16, 20, 22).

An effective program for the prophylaxis of infection would be especially beneficial to cancer patients undergoing chemotherapy. These patients are susceptible to infectious complications because their disease process or its treatment often caused neutropenia and immunological deficiencies. For example, the incidence and severity of infection in patients with acute leukemia is inversely related to their level of circulating neutrophils (2). Infections in neutropenic patients are often fatal despite adequate antibiotic therapy; therefore, the ability to prevent infections would be of considerable value to these patients.

A prophylactic program utilizing two types of patient isolation units to protect against nosocomial contamination and antibiotic regimens to reduce the endogenous microbial flora has been under investigation for patients undergoing cancer chemotherapy at the University of Texas M. D. Anderson Hospital. This report summarizes studies of microbiological monitoring of life island (LI) units and laminar airflow (LAF) rooms during patient occupancy. The results indicate that these units are effective in reducing the environmental microbial flora and that they provide a satisfactory barrier against most nosocomial contamination.

MATERIALS AND METHODS

The studies of protected environment units were conducted between October 1966 and April 1971. Microbiological monitoring of the environment was performed while 28 patients occupied the LAF rooms and 30 patients occupied the LI units. Forty-eight patients had acute leukemia, 9 had metastatic car-
cinoma, and 1 had aplastic anemia. Oral nonabsorbable, topical and systemic antibiotics were administered prophylactically to these patients to reduce their endogenous microbial flora. Details of these regimens have been published elsewhere (3, 6).

The LI unit consists of a bed enclosed in a plastic tent (5). Air circulating in the unit passes through high-efficiency particulate air filters capable of eliminating 99.97% of particles greater than 0.3 μm in diameter. There is sufficient space for the patient to sit or stand beside the bed when the tent is maximally inflated. The tent can be deflated to permit easier access to the patient. Procedures are performed through plastic sleeves on the sides of the tent. The LI unit is sprayed with a 2% peracetic acid solution before each patient's entry. Thirty minutes after the spraying is completed, the unit is ventilated for 24 hr. The LI unit is cleaned once weekly with a 1:500 benzalkonium chloride solution during patient occupancy.

Our LAF unit was the first such unit designed for patients undergoing cancer chemotherapy and was based on preliminary studies by Michaelson et al. (17). It consists of two patient isolation rooms, separated by a corridor. A bank of high-efficiency particulate air filters comprises one entire wall of each room. Filtered air circulates through the room in a horizontal direction at a velocity of 90 ft/min and returns through prefilter in the ceiling for recirculation. A higher pressure is maintained within the room so that the flow of air is from the patient room to the access corridor to the hospital corridor. All furnishings in the room have been constructed specially to provide minimum obstruction to the flow of air. Personnel entering the room to care for patients wear a sterile cap, mask, gown, gloves, and boots. Prior to each patient's entry, the walls and floor are cleaned with a solution containing an organic tin compound (Biomet 611). The unit is fogged twice for 30 min within a 24-hr period with a similar compound (Biomet 630), and the room is ventilated for 24 hr. The floors and furnishings are cleaned daily with Biomet 611 during patient occupancy. Details of the design of the LAF room and preliminary environmental studies have been published elsewhere (4).

All items placed into either type of isolation unit are specially wrapped and either gas or steam autoclaved. They are passed in and out of the unit through locks equipped with ultraviolet lights and remain exposed to the ultraviolet light for at least 90 sec.

Air samples were obtained from the LAF rooms with a Reynier slit sampler 5 days weekly during patient occupancy (11). Air was sampled for 2 hr at a flow rate of 1 ft³ per min. Samples were collected in the same manner from regular hospital rooms for comparison. Air samples were obtained from the LI units with a modified Dietrich slit sampler 5 days weekly (9). Air was sampled for 8 hr at a flow rate of 1 ft³ per min. The medium used was 4% human blood in Tryptcase soy agar, and the specimens were incubated aerobically at 37 C for 48 hr. The air samplers were placed on a shelf adjacent to the door at the downstream end of the LAF rooms. They were placed in the center of the regular hospital rooms. Air was collected through a port in the head board of the LI units. Gram-negative bacilli which were oxidase-negative and did not ferment lactose or sucrose were not identified further. Molds also were not identified. For the purposes of this study, the following organisms were considered nonpathogens: Staphylococcus epidermidis, Bacillus sp., Micrococcus sp., diphtheroids, Lactobacillus sp., Sarcina sp., Neisseria sp., Streptomyces sp., nonenteric gram-negative bacilli, and molds.

Squares 1 ft in length were marked on the floors (seven sites) and walls (three sites) for surface sampling in the LAF rooms. Once weekly, before routine cleaning, these entire areas were swabbed with cotton balls 1-cm in diameter 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 thioglycollate 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 thioglycollate broth could not be quantitated. Squares 1 ft in length were also marked on the floors of regular hospital rooms, and cultures were obtained sporadically before routine cleaning. Swab culture specimens of various sites within the LI units (plastic canopy, pass-through locks, gloves) were obtained once weekly before routine cleaning and inoculated onto sheep blood-agar and thioglycollate broth. Quantitative counts were not determined on culture specimens obtained from the LI units.

Mating plates were placed in the LAF rooms 5 days weekly. Two petri dishes, 100 mm diameter by 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. Quantitative cultures of the water and sink basin in the LAF rooms were obtained once weekly.

**RESULTS**

The procedures used for cleaning the LI units and LAF rooms between patient occupancy were very effective. Two hundred of the 208 specimens (96%) obtained from LI unit surfaces before new patients were admitted were sterile, and no potential pathogens were cultured from any of the specimens. Of the 168 specimens obtained from LAF room floor sites, 131 (78%) were sterile, as were 145 of the 152 specimens (95%) obtained from other LAF room surfaces. Potential pathogens (S. aureus, Candida albicans) were cultured from 1% of the floor specimens and from none of the surface specimens.

Air sampling was conducted while 31 patients occupied the LAF rooms and 15 patients occupied
the LI units (Table 1). The largest percent of sterile samples was obtained from the LAF rooms, and none of the air samples obtained from hospital rooms was sterile. Since air was sampled for 8 hr in the LI unit, but for only 2 hr in the LAF rooms, the percent sterile samples could not be compared. However, the LAF rooms provided cleaner air than the LI units (5 versus 31 organisms per 1,000 ft$^3$ of air), and this difference was statistically significant ($P < 0.01$).

Nearly 60% of the 53 air samples obtained from hospital rooms contained potential pathogens (Table 2). Potential pathogens were cultured from only 1.0% of the 1,168 LAF room air samples, compared to 21.4% of the 421 LI unit air samples, a statistically significant difference ($P < 0.01$). *S. aureus* was the most common potential pathogen cultured from air samples from hospital rooms and LI units but was never cultured from LAF room air samples. *Candida* spp. were common pathogens cultured from air samples from protected environment units but were never cultured from hospital room air samples. The majority of organisms cultured from hospital room and LAF room air samples were the nonpathogens, *S. epidermidis, Bacillus* sp., *Micrococcus* sp., and diphtheroids. Often more than one type of organism was cultured from the same contaminated specimen (several nonpathogens, two potential pathogens, or a nonpathogen with a potential pathogen).

Vinyl tiling, similar to that in our regular hospital rooms, was installed initially in the LAF rooms. Quantitative cultures were obtained weekly before routine cleaning while 21 patients occupied the LAF rooms (Table 3). Sixty-eight percent of the 1,418 culture specimens were sterile. The dirtiest floor sites were adjacent to the door (60%, sterile) and beneath the sink (64% sterile). The cleanest floor sites were the two sites near the filter wall (each 74% sterile). Only 4% of the LAF room floor samples contained more than 500 organisms per ft$^2$ compared to 99% of the hospital room floor samples.

Potential pathogens were cultured from 8.1% of LAF room floor specimens and from 46.6% of hospital room floor specimens (Table 4). The most common potential pathogen cultured from hospital room floors were *S. aureus, Escherichia coli*, enterococcus, and *Enterobacter* spp. *P. aeruginosa* and *Torulopsis glabrata* were the most common potential pathogens cultured from the floors of the LAF rooms. Nonpathogens were the organisms cultured most frequently from both the LAF room and hospital room floor sites.

Persistent contamination of the floors of both LAF rooms by *P. aeruginosa* arose 24 and 31 months after installation of the vinyl flooring. *P. aeruginosa* cells were cultured from the skin of a patient just before he entered the LAF room. One week later, the same pyocin type of *P. aeruginosa* was cultured from the sink basin and six of the seven floor sites. During the next 2 weeks, the organism was cultured from the floor near the sink despite intensive cleaning with Biomet 611. The site of persistent contamination was a
crack between several vinyl tiles underneath the sink. *P. aeruginosa* was no longer cultured from the floor after the crack was covered with heavy duty tape. Seven months later, *Pseudomonas* sp., *Enterobacter* sp., *Moraxella* sp., *Mima polymorpha*, *Citrobacter* sp. and a group IV gram-negative bacillus were cultured from the floor near the sink of the second room. These organisms were not cultured from the patient who occupied the room. Again, the site of persistent contamination was the crack between several vinyl tiles underneath the sink. Seventy per cent of all of the floor specimens which contained *P. aeruginosa* were obtained while these two patients occupied the rooms.

The vinyl tile flooring was replaced by a continuous polyurethane flooring. Subsequently, eight patients have occupied the rooms (Table 3). The per cent of sterile floor samples has increased from 68 to 80% (P < 0.01). The per cent of floor samples containing potential pathogens has decreased from 8.1 to 4.4% (P = 0.3), and *P. aeruginosa* has not been cultured from any floor site (Table 4).

Culture specimens of surfaces were obtained while 25 patients occupied the LAF rooms and 30 patients occupied the LI units. Ninety-two per cent of the 1,295 culture specimens obtained from the LAF room and 77% of the 2,421 culture specimens obtained from the LI units were sterile. Only 0.3% of the specimens obtained from LAF room surfaces contained more than 500 organisms per area, and the median number of organisms per positive sample was less than 50. Potential pathogens were cultured from 4.6% of surface specimens from the LI units and 1.2% of surface specimens from the LAF rooms (Table 5). *S. aureus*, *Clostridium* spp., and enterococcus were the potential pathogens cultured most often from LI unit surfaces, whereas *T. glabrata*, *P. aerugi-
nosa, and Clostridium spp. were the potential pathogens cultured most often from LAF room surfaces. The organisms cultured most frequently from surfaces in the protected environment units were the nonpathogens, S. epidermidis, Bacillus sp., Micrococcus sp., and diphtheroids.

Nearly 60% of the settling plates placed on the floors of the LAF rooms were sterile, compared to none of those placed on the floors of hospital rooms (Table 6). The rate of deposition of organisms was over 50 times lower in the LAF rooms than in hospital rooms ($P < 0.01$). Potential pathogens were cultured nearly five times more frequently from the settling plates placed in hospital rooms ($P < 0.01$). S. aureus and Enterobacter spp. were the most common potential pathogens cultured from hospital rooms, whereas P. aeruginosa and Candida spp. were the most common potential pathogens cultured from the LAF rooms (Table 7). Again, the majority of organisms cultured were nonpathogens.

Providing a sterile water supply for the LAF rooms was difficult. The original water supply system utilized cold water from the hospital supply which passed through a prefilter and membrane filter (Millipore Corp., Bedford, Mass.) to a storage tank. One line from the storage tank supplied cold water to each LAF room. A hot-water line passed from this storage tank through an electric coil heater to a second storage tank and thence to the LAF rooms. A steam-purging system, controlled by solenoid valves, was included to prevent retrograde contamination from the faucets. Bacillus sp. and a nonenteric, gram-negative bacilli were cultured from 10 of 12 water samples at concentrations up to 500 organisms per ml. Since this system failed to supply sterile water, it was replaced. In the new system, both hot- and cold-water lines from the hospital pass through prefilters and into the LAF rooms (Fig. 1). Valves are located at the sink to regulate the flow and temperature of the water. Hot- and cold-water lines join together and pass through a 293-mm sterilizing filter holder containing a 0.22 µm membrane filter (Millipore Corp.), located above the sink. Both the membrane filter holder and the stainless-steel pipe carrying water to the sink can be removed and autoclaved. Two hundred twenty-six of the 257 water samples (88%) from the new system have been sterile. Only 12 (5%) of the samples contained more than 500 organisms per ml and the median concentration per milliliter of positive samples was 20 (range: broth to 17,000 per ml). Organisms recovered from the water were nonenteric, gram-negative bacilli (5.5%), Moraxella (3.8%), Flavobacterium (1.3%), P. aeruginosa (0.8%), and S. epidermidis (0.4%).

Although 56% of the cultures obtained from the original porcelain sink basins in the LAF rooms were sterile, 21% contained more than 500 organisms per area and 17% contained Pseudomonas aeruginosa (Table 8). The third patient admitted to each LAF room contaminated the sink, one with T. glabrata and the other with P. aeruginosa. The organisms persisted in the sink basins at concentrations greater than 50,000 per area.

TABLE 6. Microbial contamination of settling plates

| Site of samplinga | No. of patients | No. of samples | Total time of sampling (hr) | Sterile samples (%) | Organisms | Median/positive sample | Range | Hr of sampling/organism |
|-------------------|----------------|----------------|-----------------------------|---------------------|-----------|-----------------------|-------|------------------------|
| LAF rooms         | 26             | 1,959          | 15,672                      | 58                  | 2         | 0-212                 | 22-568| 4.5                    |
| Hospital rooms    |                | 54            | 432                         | 0                   | 75        | 0.08                  |       |                        |

a LAF, laminar airflow; LI, life island.

TABLE 7. Potential pathogens recovered from settling plates

| Organism               | Per cent of samples containing organism |
|------------------------|-----------------------------------------|
|                        | LAF roomsa | Hospital rooms |
| Staphylococcus aureus. | 0.1       | 11.1          |
| Enterococcus.          | 0.2       | 1.9           |
| Enterobacter.          | 0.3       | 3.7           |
| Klebsiella.            | 0.7       | 1.9           |
| Escherichia coli.      | 0.1       | 0             |
| Pseudomonas aeruginosa.| 1.0       | 1.9           |
| Proteus.               | 0.2       | 1.9           |
| Serratia.              | 0.1       | 0             |
| Other gram-negative bacilli | 0.5 | 11.2        |
| Candida.               | 2.8       | 0             |
| Torulopsis.            | 0.2       | 0             |
| Other fungi.           | 0.5       | 0             |
| Potential pathogens.   | 5.5       | 25.9          |

a LAF, laminar airflow.

b Includes Mima polymorpha, Herellea, and Pseudomonas maltophilia.
even though the sinks were cleaned intensively with germicidal solutions. The porcelain sink basins were replaced by stainless-steel sink basins which rested in vinyl-covered wooden supports. They could be removed for autoclaving when they became contaminated. Traps were located outside of the LAF rooms with a break in the line to prevent backflow contamination. Sixty-two per cent of cultures from the sink basins were sterile and contamination was eliminated by autoclaving. However, 18 and 21 months later, the two sink basins became contaminated promptly after each autoclaving. Potential pathogens (Moraxella, P. aeruginosa and M. polymorpha) were cultured from 42% of the specimens during the next 6- and 3-month periods. These organisms also contaminated the wall and floor adjacent to the sinks and were not cultured from the patients occupying the LAF rooms. The sources of persistent contamination were defects in the vinyl covering of the wooden supports. The wooden supports have been replaced by stainless-steel supports which can be removed and autoclaved when they become contaminated. Since the new supports have been installed, 58% of specimens from the sink basins have been sterile (Table 8). The per cent of samples containing P. aeruginosa has decreased from 14% to 1%, a statistically significant difference (P = 0.01).

All species of organisms, except those considered to be nonpathogens, cultured from environmental specimens obtained during each patient’s occupancy of the LAF rooms and LI units were tabulated, and the source of contamination was determined (Table 9). Forty-one per cent of the 111 potential pathogens cultured from the environment of the LAF rooms had been cultured from the patients before they were isolated from the environment. The water supply system was the source of 36% of the organisms, and the surfaces were the source of 23%. The water supply system was the source of the majority of Pseudomonas sp., Moraxella sp., Flavobacterium sp., and nonenteric, gram-negative bacilli; the surfaces were the source of most of the Herellea sp. and S. aureus. In the LI units and LAF rooms, the patient was the major source of contamination. However, air was the source of all nonenteric, gram-negative bacilli in the LI units. In both types of protected environment units, the patient was usually the source of Enterobacteriaceae and fungi.

On six occasions, a potential pathogen which was first cultured from the environment was subsequently cultured from the patients. On five occasions, this occurred in the LAF room and once in a LI unit. Four patients acquired P. aeruginosa, one patient acquired a nonenteric, gram-negative bacillus, and one patient acquired both Clostridium sp. and C. albicans.

![Diagram of the new sterile water supply system for laminar airflow rooms.](http://aem.asm.org/)

**Table 8. Bathing facilities of laminar airflow rooms**

| Site of sampling      | No. of patients | No. of samples | Median organisms/positive sample | Per cent with 500 organisms/area | Per cent with potential pathogens | Per cent sterile | Per cent with Pseudomonas aeruginosa |
|-----------------------|-----------------|----------------|---------------------------------|---------------------------------|----------------------------------|-----------------|-------------------------------------|
| Porcelain sinks       | 6               | 99             | 300                             | 21                              | 28                               | 57              | 17                                  |
| Stainless steel sinks | 16              | 399            | <50                             | 8                               | 24                               | 62              | 14                                  |
| Wooden supports       | 8               | 92             | <50                             | 3                               | 20                               | 58              | 1                                  |
DISCUSSION

The LI units and LAF rooms are effective in providing an environment with a minimal amount of microbial contamination. The number of organisms cultured from air samples was 100-fold less in LI units and 600-fold less in LAF rooms than in regular hospital rooms. Other investigators have found a similar reduction in air contamination in LI units (3). Floor samples obtained from hospital rooms were never sterile, whereas the majority of floor samples from the LAF rooms were sterile. Likewise, the rate of deposition from organisms onto settling plates was 50-fold less in the LAF rooms than in hospital rooms. Most surface samples obtained from the LI units and LAF rooms were also sterile.

Air in the LAF rooms was significantly cleaner than in the LI units. This is largely due to the greater volume of air exchanged and, perhaps, to the laminar distribution of airflow in the LAF rooms. There are 385 air exchanges per hour in the LAF rooms compared to only 13 air exchanges per hour in the LI units. Furthermore, air exchange is incomplete in the LI units because the airflow is turbulent. Organisms which are shed from the patient may build up in the air of the LI unit. This has not been observed in the LAF room.

The LAF rooms provided a substantial reduction in exposure to potentially pathogenic organisms. Nearly 60% of air samples from regular hospital rooms contained potential pathogens compared to only 1% from LAF rooms. Over 45% of floor samples obtained from hospital rooms contained potential pathogens compared to only 4% of samples obtained from the new polyurethane flooring of the LAF rooms. The percent of settling plates containing potential pathogens was five times greater for hospital than for LAF rooms. S. aureus and enterococcus were the potential pathogens cultured most often from hospital rooms, and they were cultured infrequently from the LAF rooms. However, Entero-

| Organism                              | LAF rooms<sup>a</sup> | LI units<sup>a</sup> |
|---------------------------------------|------------------------|----------------------|
|                                       | Patient | Water and sink basins | Surfaces | Total | Patient | Air | Surfaces | Total |
| Klebsiella-Enterobacter-Serratia       | 11      | 1                    | 1       | 13    | 3       | 0  | 0       | 3     |
| Pseudomonas                           | 7       | 10                   | 2       | 19    | 1       | 1  | 0       | 2     |
| Herellea                              | 0       | 0                    | 6       | 6     | 0       | 2  | 0       | 2     |
| Mima polymorpha                       | 0       | 4                    | 1       | 5     | 0       |     |         | 0     |
| Moraxella                             | 0       | 6                    | 0       | 6     | 0       |     |         | 0     |
| Flavobacterium                        | 0       | 4                    | 0       | 4     | 0       | 1  | 0       | 1     |
| Nonenteric gram-negative bacilli      | 0       | 15                   | 5       | 20    | 0       | 6  | 0       | 6     |
| Clostridium                           | 1       | 0                    | 3       | 4     | 7       | 0  | 1       | 8     |
| Staphylococcus aureus                 | 1       | 0                    | 2       | 3     | 9       | 1  | 1       | 10    |
| Enterococcus                          | 15      | 0                    | 1       | 16    | 11      | 1  | 1       | 13    |
| Candida                               | 5       | 0                    | 1       | 6     | 1       | 0  | 0       | 1     |
| Torulopsis glabrata                   | 5       | 0                    | 4       | 9     | 4       | 1  | 1       | 6     |
| Miscellaneous<sup>b</sup>             | 45      | 40                   | 26      | 111   | 45      | 13 | 6       | 64    |

<sup>a</sup> LAF, laminar airflow; LI, life island.

<sup>b</sup> Includes Proteus (3), Bacteroides (2), Citrobacter (3), Escherichia coli (2), Achromobacter (1), Aspergillus (1), and Saccharomyces (1).
The sampling techniques available for microbiological monitoring were not entirely adequate. The Reynier slit air samplers collected only a very small proportion of air circulating in the LAF rooms. Since the Dietrich air samplers were in operation for 8 hr and the Reynier air samplers for only 2 hr, it was difficult to compare the results with the two instruments. The Dietrich air samplers were located outside of the LI units and were connected to the unit by a segment of tubing. This resulted in less accurate sampling and greater opportunity of external contamination. The organic tin compound used for cleaning the LAF room floors left a residue on the surface. This may have inhibited the growth of some organisms in the culture media, even though the samples were collected 24 hr after its application. No method has been available for neutralizing the antimicrobial effects of the organic tin compound, but any residue adherent to the swabs was greatly diluted by the culture medium. However, the substantial differences in microbial contamination between hospital rooms and the protected environment units could not be accounted for by the sampling difficulties.

The procedures used to clean the protected environment units before each patient's entry were quite effective. The LI units were easier to sterilize than the LAF rooms because they were completely self-enclosed. Consequently, a highly effective but toxic substance, peracetic acid, was sprayed into the LI units. Peracetic acid could not be used to sterilize the LAF rooms because the flow of air was from the room to the hospital corridor, and the air could not be vented outside of the hospital. The organic tin compound was less effective, and over 20% of floor samples collected after the initial cleaning procedure were contaminated. However, potential pathogens were cultured from only 1% of floor samples. Twenty-six of the 37 (70%) contaminated samples were obtained after five cleaning procedures. Presumably, the contamination was due to inadequate cleaning and was eliminated by a second cleaning.

The LI units possess several advantages over the LAF rooms. They are easier to sterilize and there is little opportunity for external contamination because personnel never enter the unit. However, the plastic does develop tears which reduce the effectiveness of the barrier. The LAF rooms are less confining, offer more privacy, and provide more patient care facilities, such as electrical outlets, hot and cold running water, and toilet facilities. Procedures can be performed more easily in the LAF rooms, but additional time is required for changing into sterile attire.

The type of floor construction was an important element in the design of the LAF room. After 2 years of use, the vinyl tiling served as a site of persistent contamination. The seal between tiles underneath the sink became defective because, as patients used the sink, water spilled on the floor and eventually seeped between the tiles, thus providing a haven for organisms. *P. aeruginosa*, which is a major threat to patients with impaired host defense mechanisms, is notorious for its ability to survive in moist environments. The replacement of the vinyl tiling with a continuous polyurethane flooring has resulted in a significant increase in the per cent of sterile samples and a significant reduction in the per cent of samples containing potential pathogens. Presumably the polyurethane flooring has eliminated the problems associated with the vinyl tiling, but it has not been in use sufficiently long to be completely certain.

Providing and maintaining a sterile water supply system in the LAF rooms proved to be exceedingly difficult. Contamination was virtually eliminated from the water when membrane filters (Millipore Corp.) were installed immediately adjacent to the sink basins. Persistent contamination of the sink basins has been a more serious problem, especially since *P. aeruginosa* frequently was cultured from these sites. The installation of stainless-steel sink basins and brackets which can be autoclaved apparently has eliminated this problem.

The LAF rooms are superior to the LI units as patient isolation units. Not only do they offer several important advantages for the comfort of the patient, but they provide an environment with significantly less microbial contamination. The most important advantage of the LAF rooms is the significant reduction in exposure to potentially pathogenic microorganisms. Experience with this prototype LAF unit has indicated those sites where microorganisms can become established. Methods for eliminating persistent contamination at these sites have been developed. The incorporation of these measures into future units should eliminate problems of persistent contamination.

Our studies indicate that protected environment units are effective in reducing exposure of the patients to potential pathogens from the hospital environment. Frequent monitoring of the microbial flora in these units is necessary to detect areas of persistent contamination. This approach to patient isolation should be useful in the management of patients with a variety of diseases which cause increased susceptibility to infection.

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