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Evaluations of a Patient Isolator System

II. Distribution Profiles of Patient Microflora During Prolonged Isolator Confinement

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A NEW APPROACH to prevention of secondary or nosocomial cross infections in the debilitated patient has been taken in the development of self-contained or unitized systems for total isolation of the individual patient.[1-3] Such systems, or isolators, have as their basic purpose the exclusion of all microbial contact between the patient and his external environment without interfering with his normal routine care and treatment. These systems consist basically of three integral components: the flexible plastic isolation enclosure or tent; a system of blowers and filters which provide a supply of sterile air within the isolator; and pass-through chambers, or locks, for introducing or removing items of patient care or treatment without breaching the isolation barrier. The feasibility as well as practicability of one such system * have been under examination. The effectiveness and reliability of the different systems and procedures involved in sterilization, concurrent sanitization, and continued maintenance of the microbial barrier have been described previously.[4] This report is concerned with an examination of the combined effects of prolonged isolation and intensive procedures for skin hygiene on the external microflora of the confined patient. In addition, bacteriological evidence was also sought as to any penetration of the isolator's barrier by microorganisms indigenous to the external hospital environment.

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* "Life Island" Hospital Isolator System, Matthews Research, Inc., Alexandria, Va.

Procedures

A. *The Isolator System.*—A detailed description of the isolator (Fig 1) has been presented elsewhere[2] and only limited specifications need be enumerated.

The isolation tent, which surrounds but does not encompass a standard mechanical hospital bed, is fabricated from clear flexible polyvinyl chloride plastic. Unlimited access to the patient is provided by two sets of paired gauntleted gloves. Clear, rigid plastic face plates set in the walls of the tent provide unrestricted visibility. Sterile air is provided by a combined blower and filtration system contained in the console unit which forms the foot of the bed. The filtration system utilizes two ultrahigh efficiency filter units † capable of retaining more than 99.99% of all particles over 0.3μ in diameter. The console also contains two double-door pass-through locks, controls for the adjustment of the mechanical bed, an alarm system, and other ancillary controls. The pass-through locks are each fitted with four G-8T5 ultraviolet lamps. Attachments for sphygmomanometers, electrodes, stethoscope, transfusion or venoclysis tubing, and other devices are made via special adapters set in the flexible walls of the tent.

† Cambridge Absolute Filter, Cambridge Filter Corp., Syracuse, NY.

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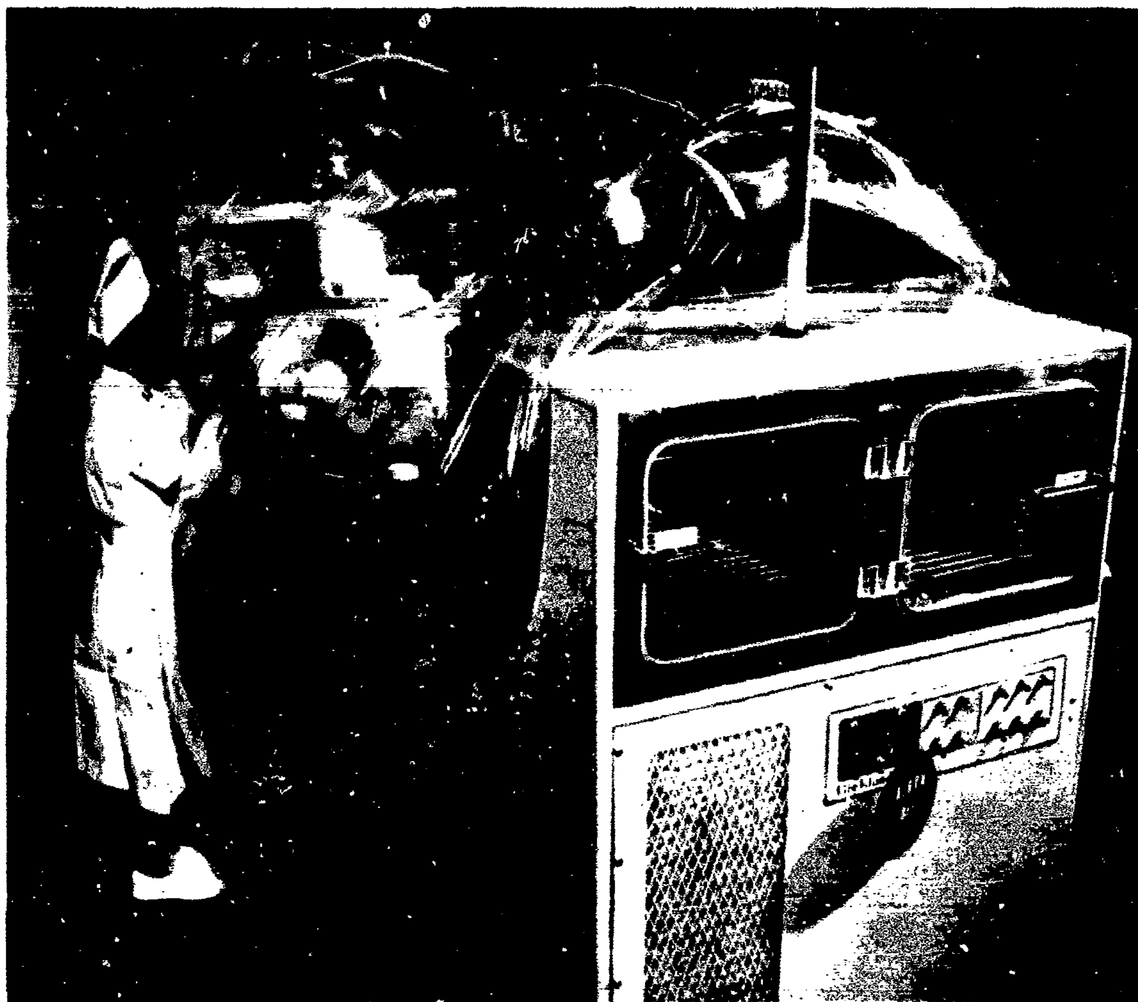

Fig 1.—Unitized patient isolator system ("Life Island, Mark V"). Shown are the control console (foreground) with pass-through locks, master controls, and inlet for the air filtration and supply system; the clear, flexible plastic patient enclosure with rigid plastic view plate, gauntlet-gloves, and overhead suspension system; also shown are the isolator interior with bed, bed rails and straps, and overbed tray. The mechanical components of the bed are contained within an inner plastic tunnel which sets them outside, topologically, from the isolator interior. (US Army photograph, Walter Reed Army Institute of Research.)

B. *Preparation and Sanitization of the Isolator Tent.*—Initial sterilization of the interior of the tent was achieved through surface treatment and aerosolization with a 3% solution of peracetic acid. A total of 24 hours was required for this procedure; exposure time to the sterilizing agent was one hour followed by a period of exhaust and ventilation for the remaining time. Efficiency of the sterilizing procedure had been previously verified using test strips impregnated with spores of *Bacillus subtilis* (variety *globigii*).‡ Similar strips exposed during the initial sterilization preparatory to this clinical trial and removed after ventilation were cultured and determined to be negative for growth at 48 hours and after seven days.

Concurrent sanitization of the interior of the tent was accomplished through periodic washings of the inner plastic surfaces and metal fittings with a 1:750 solution of benzalkonium chloride.§ Selection of benzalkonium chloride as the sanitizing agent of choice was based on data previously presented.[4] The schedule for tent sanitization (Table 1) was established when bacteriological evidence indicated the need for such a procedure.

The procedures for sanitization of the interior of the occupied isolator were as follows: Debris, waste, and similar materials were collected and either removed through one of the pass-through locks or flushed, under positive pressure, from the bottom of the tent through a plastic sleeve provided for such

‡ Sporodex Bacterial Spore Strips, American Sterilizer Co.

§ Benzalkonium chloride solution, USP, 10%, Certified Laboratories, Inc.

purposes. The solution of benzalkonium chloride, prepared with sterile water, was introduced into the tent together with a supply of sterile gauze and toweling. The solution was applied with the gauze to the entire inner surface of the tent and to all exposed fittings, shelving, etc. Extra sheeting was provided for protection of the patient. Following a minimum contact time of ten minutes, the treated surfaces were rinsed and then dried with sterile toweling. Excess or waste fluids which had been permitted to collect at the bottom of the tent were drained, under positive pressure, through the plastic sleeve into a collection basin.

C. *Clinical and Nursing Care Data.*—A man, convalescing from acute myocarditis, served as patient-volunteer for this clinical trial of the isolator. Selection of a test patient not necessarily prone to bacterial superinfection was based on the premise that the effects of prolonged isolation upon the ecology of the normal human microflora were as yet unknown.

Prior to his introduction into the isolator, the patient was bathed and shampooed with a commercial skin cleansing lotion containing 3% hexachlorophene,|| dressed in sterile pajamas, and wrapped in sterile sheets for transfer into the tent. Antibiotics or other antibacterial agents were not administered either before or during the period of isolation. The total period of confinement within the isolator was 12 days.

The procedures used in bathing the patient while confined within the isolator employed, initially, a commercial "antibacterial" bar soap¶ containing both 2% hexachlorophene and an unstated amount of 3,4,4-trichlorocarbinilide. This product was replaced after seven days by the 3% hexachlorophene lotion. The procedures were essentially the same as those employed in routine nursing care under normal conditions for bathing of the nonambulatory patient. They included both an intermittent washing of the face, hands, and upper portions of the body and a complete or total body bath, but no shampoo (Table 1).

D. *Preparation of Items for Patient Care.*—All items used for care, comfort, or feeding of the patient were introduced into the isolator through one of the ultraviolet irradiated pass-through locks. Used or discarded items, bedpans, and other expended materials were removed in a similar manner through the second lock. Most materials were introduced into the isolator after presterilization in double-wrapped packages by either gas or steam autoclave procedures.

Wherever possible all items were brought to the isolator in their double wrappings and introduced into the pass-through lock simultaneously with removal of the outer wrapping. Exposure time to the ultraviolet light within the lock was three to five minutes depending on the nature of the item being exposed. This procedure was intended primarily for the destruction of microorganisms present in the rather large volumes of air, which were displaced during manipulation of the doors of the pass-through locks. Surface decontamination of materials accidentally contaminated during their introduction into the lock was also accomplished during the irradiation period. Those items which required surface sterilization only, as, for example, commercially prepared sterile articles, were exposed for a minimum of ten minutes.

Items which were not presterilized included freshly prepared foods and therapeutic drugs. For this study, reliance was placed upon the pasteurization effect of normal cooking procedures for the provision of bacteriologically "safe" foods. Food trays were prepared aseptically using presterilized utensils and dishes. No ready solution to the requirement of providing sterile drug items was determined and only original pharmacy pack materials were used in an effort to avoid, as much as possible, any contamination of hospital or staff origin.

E. *Bacteriological Monitoring Schedule and Procedures.*—Specimens for bacteriological study were collected twice daily during the first eight days of isolation and once daily for the last four days. The specimens were collected, using moistened sterile swabs which were vigorously applied to a minimum surface area of 10 sq inches from the following cutaneous regions: forearm, including the volar and ulnar antebrachial surfaces; abdomen, including the upper pubic, umbilical and lateral surfaces; upper anterior and internal surfaces of the thigh; lower median, sacral and lumbar surfaces of the back; and rectal region including anal and perineal surfaces. Specimens were also collected from the patient's pharyngeal and nasopharyngeal orifices. Similar specimens were also taken from all of the professional and nonprofessional personnel associated with the project. Reference cultures of representative

TABLE 1.—*Schedule for Hygienic Patient Care and Plastic Isolator Enclosure Cleaning and Sanitization: 12-Day Period*

Day of Isolator Confinement *	Patient Hygienic Care Procedure †	Isolator Tent Cleaning & Sanitization ‡
2	Partial bath	None
3	Complete bath	None
4	Partial bath	None
5	Complete bath	None
6	Partial bath	None
7	Complete bath	None
8	Complete bath	Interior surfaces washed
9	Complete bath	Interior surfaces washed
10	Complete bath	Interior surfaces washed
11	Complete bath	Interior surfaces washed
12	Complete bath	None

* Patient introduced into isolator on afternoon of preceding day following complete bath and shampoo with hexachlorophene (pHisoHex) lotion.

† Patient bathing employed Dial bar soap for days 2-7; pHisoHex lotion was substituted in bathing procedures for days 8-12.

‡ Procedure included sponging of all interior plastic and metal surfaces with a 1:750 solution of benzalkonium chloride.

|| pHisoHex brand, Winthrop Laboratories, Division of Sterling Drug, Inc., New York.

¶ Dial soap, Armour and Co., Chicago.

TABLE 2.—*Effect of Isolator Confinement Care on Microflora of the Pharyngeal and Nasopharyngeal Regions*

Bacterial Isolations & Identifications	Pharyngeal Regions			Nasopharyngeal Regions		
	Average Rate of Recovery *	Frequency of Recovery †	Normal Values ‡	Average Rate of Recovery	Frequency of Recovery	Normal Values
α Streptococci	<300	100%	>100	>100	100%	<300
β Streptococci	<10	25%	>10	>10	75%	<10
γ Streptococci	10-100	100%	10-100	10-100	100%	10-100
S epidermis	<100	100%	10-100	>100	80%	<100
S aureus	<10	Single occurrence	<10	<10	Single occurrence	NR
Pneumococci	<10	Single occurrence	<10	—		NR
Diphtheroids	<100	75%	10-100	<10	50%	10-100
Neisseria	<10	50%	<10	<10	Single occurrence	NR
Hemophilus	<10	Single occurrence	NR §	—	—	NR
E coli	<10	Single occurrence	NR	—	—	NR
K pneumoniae, 3	<10	35%	<10	<10	90%	10-100
Totals	>300	100%	>300	>300	100%	>300

* Average recovery rate: approximate number of colonies recovered after primary dilution and plating.
† Frequency of recovery: number of individual specimens cultured from which positive isolations were reported.
‡ Normal recovery values: based on results of cultured specimens taken from same patient during hospitalization on open ward under conditions of normal environmental exposure.
§ NR: Not reported.

microorganisms were isolated from these latter specimens, identified and catalogued for future reference and comparison if required.

The individual specimens were prepared for plating on various media by elution, with agitation, in sterile peptone soy broth. A semiquantitative dilution and plating procedure[5] was used to inoculate the following selective and differential media; 5% sheep's blood agar (2 plates), MacConkey's agar, mannitol salt agar, "SF" # agar and Sabouraud's dextrose agar. Pharyngeal and nasopharyngeal specimens were also inoculated on chocolated blood agar and chocolated blood agar with 0.05% potassium tellurite. All plated media were incubated at 37 C for 48 hours; anaerobic cultures (on blood agar) were incubated under hydrogen in Torbal * jars and chocolated blood agar plates were incubated under CO_2.

The various media were examined following incubation, and data were recorded regarding presumptive identifications and relative numbers of the various microbial species which were recovered. Definitive identifications were made according to accepted taxonomic and diagnostic criteria and procedures.

Results

Four pertinent observations were made regarding the changes in the patient's external microflora during the 12 days of confinement within the isolator. First, and most significant, no transmigration of microorganisms indigenous to the external hospital environment or attendant to the patient could be detected.

Second, there was no detectable colonization of the patient by microorganisms which were not also recoverable at either the onset of the isolation period or under conditions of normal environmental exposure.

Third, although the bathing procedures which were employed were capable of reducing the indigenous microflora of some of the cutaneous surfaces to minimal levels, they did not prevent the rapid repopulation of these areas by organisms of predominantly fecal origin. Further, they did not prevent contamination of the patient or the interior of the isolator by several species of potential pathogens for which the patient was a carrier. These included a mannitol-positive strain of *Staphylococcus aureus* and a type III strain of *Klebsiella pneumoniae*. The isolation of such pathogens from an essentially normal individual was clinically unremarkable. However, their persistence during the period of isolation was considered to be significant in light of the probable high levels of susceptibility which would tend to characterize the type of patients for whom care within the isolator might be contemplated.

Fourth, information of value in the selection and mode of application of agents for use in personal hygienic and bathing procedures was also obtained from the bacteriological data. The extended period of the trial permitted a comparative study of the effectiveness of several agents.

Values for the composition of the normal microflora of the patient's skin and body

Difco Laboratories, Detroit, Mich.
* Torsion Balance Co., Clifton, NJ.

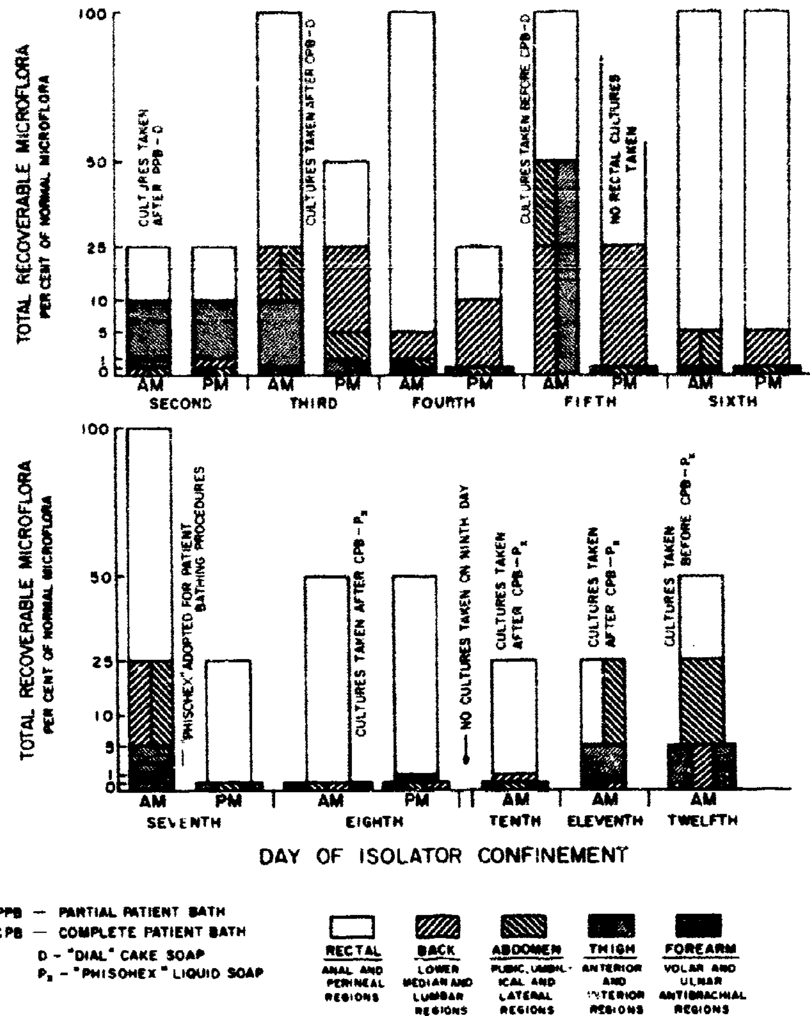

Fig 2.—Effects of prolonged isolator confinement on the microflora of selected regional skin surfaces during a 12-day period of confinement. The distribution profiles are derived from daily bacteriological examinations of the total microflora of the different sites and expressed in terms of recovery rates relative to normal qualitative and quantitative values obtained for the same patient under normal conditions of exposure. (US Army photograph, Walter Reed Army Institute of Research.)

orifices were determined in order to provide the basis for a comparative evaluation of the effects of isolator care and confinement upon his recoverable microflora. These control values were based upon a series of daily cultures taken during the patient's hospitalization on an open ward under conditions of normal environmental exposure and also upon available literature regarding the normal microflora of man.[8] Arbitrary values were assigned the various microorganisms according to their relative quantitative and qualitative contributions to the normal flora of the different surfaces and orifices. These values were then used as standards for determining, on a percentage basis, the rates of recovery for the various species isolated under the conditions of this study.

The microflora of the pharyngeal and nasopharyngeal orifices remained within the normal ranges as defined by the controls described above throughout the entire period of confinement. The only remarkable finding was the repeated isolation of the type III strain of *K pneumoniae* previously mentioned (Table 2). Various isolates identified as diphtheroids and species of *Neisseria* and *Hemophilus* were also obtained. These were regarded as being saprophytic normal flora and were not subjected to further study.

TABLE 3.—*Effect of Isolator Confinement Care on the Microflora of Selected Regional Patient Skin Surfaces*

Bacterial Isolations & Identifications	Average Recovery Rate (CFU range) *		Frequency of Recovery †		Normal Recovery Values ‡
	First Period	Second Period	First Period §	Second Period	
Abdominal Surfaces — Pubic, Umbilical & Lateral Regions					
α Streptococci	CRN ‖	CRN	—	—	10-100
β Streptococci	CRN	CRN	—	—	CRN
γ Streptococci	<10	CRN	1	—	10-100
S epidermidis	10-100	10-100	5	2	>100
S aureus	<10	<10	2	2	<10
S faecalis	<10	NR	1	—	10-100
E coli	<10	<10	3	1	10-100
Klebsiella-Aerobacter	CRN	CRN	—	—	<10
Others	NR ¶	NR	—	—	10-100
Totals (% positive cultures)	<100	10-100	6:11 (55%)	2:7 (29%)	>300
Rectal Surfaces — Anal & Perineal Regions					
α Streptococci	<10	<10	4	4	10-100
β Streptococci	CRN	CRN	—	—	CRN
γ Streptococci	10-100	<10	9	3	>100
S epidermidis	>100	<100	11	7	>100
S aureus	<10	<10	6	5	10-100
S faecalis	<10	<10	9	3	10-100
E coli	>100	10-100	10	7	>100
Klebsiella-Aerobacter	<10	<10	10	5	10-100
Others	10-100	NR	2	—	>100
Totals (% positive cultures)	>300	>100	11 (100%)	7 (100%)	>300
Back Surfaces — Lower Median, Sacral & Lumbar Regions					
α Streptococci	CRN	CRN	—	—	<10
β Streptococci	CRN	CRN	—	—	CRN
γ Streptococci	CRN	CRN	—	—	10-100
S epidermidis	10-100	<10	10	2	>300
S aureus	<10	<10	6	2	10-100
S faecalis	<10	CRN	2	—	10-100
E coli	<10	CRN	2	—	10-100
Klebsiella-Aerobacter	<10	CRN	2	—	<10
Others	NR	<10	—	1	10-100
Totals (% positive cultures)	<100	<10	10:11 (91%)	3:7 (43%)	>300
Forearm Surfaces — Volar & Ulnar Antibrachial Regions					
α Streptococci	<10	CRN	1	—	10-100
β Streptococci	CRN	CRN	—	—	<10
γ Streptococci	CRN	CRN	—	—	10-100
S epidermidis	<10	<10	6	—	10-100
S aureus	<10	<10		1	<10
S faecalis	NR	NR	—	1	NR
E coli	CRN	CRN	—	—	CRN
Klebsiella-Aerobacter	CR[illegible]	CRN	—	—	CRN
Others	NR	NR	—	—	NR
Totals (% positive cultures)	<100	<10	6:11 (55%)	1:7 (14%)	>300

TABLE 3—*Effect of Isolator Confinement Care on the Microflora of Selected Regional Patient Skin Surfaces*—Continued

	Thigh Surfaces Anterior & Interior Regions				
	Average Recovery Rate (CFU range) *		Frequency of Recovery †		
Bacterial Isolations & Identifications	First Period	Second Period	First Period §	Second Period	Normal Recovery Values ‡
α Streptococci	CRN	CRN	-	—	10-100
β Streptococci	CRN	CRN	—	-	CRN
γ Streptococci	<10	CRN	1	-	<10
S epidermidis	10-100	<10	4	3	>300
S aureus	<10	<10	2	2	<10
S faecalis	NR	NR		-	10-100
E coli	<10	CRN	1	-	10-100
Klebsiella-Aerobacter	CRN	CRN	-	-	<10
Others	<10	NR	1		10-100
Totals (% positive cultures)	<100	<10	5:11 (45%)	3:7 (43%)	>300

* Average recovery rate: approximate number of colony forming units (CFU) recovered on primary dilution and plating.
† Frequency of recovery: number of cultures examined in which positive isolations were reported.
‡ Normal recovery values: based on cultures taken from the same patient on an open ward in a normal hospital environment.
§ First period: through morning of seventh day, Dial soap used in patient bathing procedures, 11 cultures taken; second period: from afternoon of seventh day through last day of isolation, pHisoHex used in patient bathing procedures.
‖ CRN, culture reports negative.
¶ NR, not reported.
Average rates and frequencies of recovery are derived from bacteriological data obtained during two consecutive periods of seven to five days, respectively, during which two different skin cleansing agents were employed in the patient bathing procedures.

The microorganisms isolated most frequently from the various skin surfaces included *S aureus*, *E coli*, and several distinctive strains of *Staphylococcus epidermidis*. Isolations were also reported for both the type III strain of *K pneumoniae* and serologically nontypable strains of *Klebsiella-Aerobacter* (Table 3). A yeast-like organism identified as *Candida krusei*, recovered from the dorsal surfaces of the hand, was the only mycotic isolate.

Data accumulated during the first half of the study indicated that the procedures being employed for patient bathing and personal hygiene were having little effect on the recoverable microflora of the patient's skin. As noted in Section C above, the 3% hexachlorophene skin lotion was substituted after the seventh day of confinement for the original bar soap product used at the onset of the study. The change in skin cleansing agents was accompanied by a marked reduction in the total numbers of microorganisms recoverable from all of the monitored skin surfaces including those of the rectal surfaces (Fig 2).

The extent to which the change in cleansing agents affected the microflora which could be recovered from the various skin surfaces may be summarized as follows: The overall combined or average rate of microbial recovery for all of the monitored areas, excluding those of the rectal region and the small of the back, approximated 10% of the normal or control values during the first seven days of the study. On several occasions the daily total recovery rates for all of the monitored surfaces, again with the above exceptions, exceeded the normal 50% value. Following the change to the 3% hexachlorophene lotion, the total combined recovery rates for the same regions was reduced to a daily average of 3.2% for the final five-day period. The average recovery rates for the microflora of the rectal region and skin surfaces of the small of the back during the first seven days were found to be, respectively, 68% and 14% of the corresponding normal values. Following the change in cleansing agents, the comparable average values for the same regions were found to be 38% and 2%, respectively.

The recovery rates for the culturable microflora of the different skin regions were found to be directly proportional to the extent of exposure of the individual surfaces to fecal contamination. The nonrectal areas determined to be most sensitive in this respect were the abdomen and surfaces of the lower back. As

previously mentioned, several distinctive strains of *S epidermidis* were recovered from the patient. One such strain, which was predominant in the upper respiratory tract, was encountered only infrequently in the various skin surface cultures. In contrast, the strains of *S epidermidis* most frequently isolated from skin surfaces, particularly the areas of the lower trunk and extremities, were the same as those recovered from both rectal swabs and stool cultures. The frequent isolation of *E coli* from several nonrectal skin surfaces provided further evidence of the extent of colonization of such surfaces by microorganisms derived from the intestinal microflora. In all instances in which *E coli* was recovered from specimens taken from the various nonrectal skin surfaces, fecal strains of *S epidermidis* were also isolated from the same sites. *E coli* was never isolated from either throat or nasopharyngeal specimens.

Isolates presumptively identified as *Klebsiella-Aerobacter* were recovered from nearly all of the specimens taken from the rectal region and in over 50% of the specimens taken from the upper respiratory tract. All of the latter isolates proved to be typable as *K pneumoniae* type III. The former included both type III strains and nontypable strains which were subsequently reported as *A aerogenes*. Only two similar isolations were reported for the other monitored skin surfaces. Both of these were from the lower back region and were serologically nontypable.

Strains of mannitol-positive staphylococci were isolated on ten separate occasions from the rectal regions and nine times from one or more of the other monitored skin surfaces. On only one occasion were mannitol-positive staphylococci isolated from a specimen taken from a skin surface without also being recovered from rectal swabs. This recovery was fr n the lower back region and subsequent to a revious culture series in which elevated bact ial counts were obtained from nearly all of t e monitored regions. Mannitol-positive taphylococci were recovered on only one occasion from specimens taken from the upper respiratory tract. Isolates of this latter strain as well as those obtained for the mannitol-positive staphylococci recovered from the various skin surfaces were found to be coagulase positive. The two strains were biochemically identical in all respects.

Excluding the inconstant recovery of *C krusei* from the hands of the patient, no microbial isolates were recovered from any of the monitored regions which could not be clearly attributed to the normal endogenous microflora of the patient as described under either conditions of normal environmental exposure or at the onset of the period of isolation.

Comment

The feasibility and practicability of unitized patient isolators in protecting the debilitated or infection-prone patient have not been previously documented. Extensive examinations of the possible changes in patient microflora resulting from prolonged periods of continuous confinement within such an isolation system are essential to an effective assessment or evaluation of such equipment. Inasmuch as these systems are designed to sequester the patient from colonization by potentially pathogenic microbes indigenous to the hospital environment, the ultimate proof of their effectiveness and reliability must rest in the demonstrable exclusion of such opportunistic pathogens.

Three broad areas of clinical or experimental application are immediately concomitant upon the demonstration of the soundness of the unitized patient isolator. The most important of these is the provision of a reliable means of "reverse" isolation which is readily employable in any hospital area. The isolator should prove of critical value in preventing or controlling catastrophic secondary infections in those patients who have been debilitated by disease or extensive surgery or who have undergone intensive radiation therapy or treatment with immunosuppressive drugs or antimetabolic chemotherapeutics.

Second, the isolator may prove to be of value as a means of direct isolation in controlling the transmission of highly communicable disease agents from the infective patient to other susceptible hosts. However, such a capability is not the subject of this study and requires further evaluation.

Third, the isolator also appears to be of value as an experimental system in which, for the first time, man's responses to changes in

his microfloral environment could be examined under the strictest of experimentally manipulated and controlled conditions.

Results obtained from the bacteriological monitoring of the patient's external microflora during the period of confinement within the isolator permit several general conclusions regarding the behavior of the various microbial populations under the conditions employed in this study. First, it is apparent that while the cutaneous microflora of several of the skin regions were not drastically modified as a result of the combined procedures of total isolation and intensive skin hygiene, they were brought under a certain degree of control. Demonstration of such control is of merit to this study. Unfortunately the lack of comparative data, obtainable only from the same patient and under conditions identical to those employed here except for actual confinement within the isolator, prevents complete assessment of the extent and significance of this control.

It is obvious also that the cutaneous microflora of those areas which were not exposed to fecal contamination were not drastically affected by the combined procedures of isolation and skin cleansing. The gram-negative enteric components of the transient aerobic microflora of these areas persisted both on the surfaces immediately adjacent to the perineum and also on other surfaces which could have been reseeded or recolonized only through indirect contamination by contact with soiled clothes or similar vehicles.

In contrast, those surfaces which were topologically remote from either direct or indirect contamination of fecal origin remained bacteriologically clean for longer periods following bathing or cleansing. This finding was attributed to the cumulative inhibitory effects of hexachlorophene residues on the gram-positive components of the resident microflora of these latter surfaces. The persistence of a gram-negative microflora of enteric origin in the presence of hexachlorophene residues and the conclusive demonstration of the spread of bacterial contamination of fecal origin to other skin surfaces through contact with soiled clothing or similar items illustrate the need for further evaluation of skin cleansing agents intended for use in isolator care programs.

Information regarding the ultimate origins of various components of the cutaneous microflora was also developed from the bacteriological data. Those microorganisms which first prevailed on many of the bacteriologically denuded skin surfaces following bathing with the hexachlorophene lotion were clearly of enteric origin. This was the situation for nearly 60% of the total body skin surfaces; only those areas which were relatively remote from the rectal region demonstrated an initial recolonization by other microorganisms. In this latter situation, involving primarily skin surfaces of the forearm, lower thigh, and upper thorax, the recolonization was led by nonfecal strains of *S epidermidis*. In the absence of any demonstrable exogenous source for this recolonization, it could only be concluded that the reestablished microflora developed from encrypted foci in the deeper layers and emerged only after depletion of the hexachlorophene residues.

Dissemination to the various skin surfaces by microorganisms from the respiratory tract was not detected. However, this may have been a result of the fact that many of the organisms of respiratory origin normally associated with droplet or droplet nuclei contamination are in the so-called "hexachlorophene-sensitive" range. It is also apparent that prolonged periods of isolator confinement are without effect on the microflora of the pharyngeal and nasopharyngeal cavities. It is of particular interest in this respect that the type III strain of *K pneumoniae* for which the patient was a respiratory carrier was not lost during the 12 days of isolation.

In all instances where skin contamination or recolonization occurred, the responsible microbes were of demonstrable patient origin. None of the microbial isolates from either the patient or from the interior of the isolator could be equated with any of the bacterial strains recovered from either the immediately adjacent hospital environment or attending personnel. Thus, the basic premise upon which the unitized patient isolator is based—prevention of crossinfection or superinfection in the highly susceptible patient by excluding all possible microbial contact with exogenous environmental bacteria—appears to be defensible.

This study clearly demonstrates the limits to which the detectable levels of the cutaneous microflora can be reduced through combined isolator confinement techniques and effective hygienic procedures. The results are even more remarkable in light of the fact that they were obtained without manipulation of the patient's indigenous microflora by administration of antibiotics. The fact that isolation does not modify the flora of either the upper respiratory or lower intestinal tracts poses additional problems, particularly with patients such as the one involved in this study who are proved carriers of potential secondary pathogens. The hazards which may befall the debilitated patient in the contamination of wounds, burns, or incisions by organisms of enteric origin were demonstrated by the rapid and extensive topological migration in our patient of not only these organisms but also of *S aureus* for which he was an intestinal carrier.

The recovery of *E coli*, *A aerogenes*, and fecal strains of *S epidermidis* from the abdomen, small of the back, and other nonperineal skin surfaces provides the first absolute evidence of the transmigration of organisms of enteric origin into nonperineal regions. Hare has presented evidence which indicated the existence of such a route for the dispersal of staphylococci from the perineum to the skin and clothing of known carriers.[8,9] The pattern of dispersal suggested by Hare and demonstrated here includes initial transfer of the microorganisms from their site of multiplication or initial deposit in the perineum to the carrier's clothing with subsequent transfer to nonperineal skin surfaces. The mechanisms involved in this pattern would include friction and, as suggested by Hare, convection currents within the clothing.

Summary

A patient was bacteriologically monitored during a 12-day period of confinement within a patient isolator. The combined effects of isolation and antimicrobial skin cleansing agents upon the normal cutaneous microflora were examined.

Data derived from daily microbiological examination of selected cutaneous and body orifice microflora revealed the following: Use of a soap containing 2% hexachlorophene affected only a temporary reduction in the skin microflora; maximum reduction was obtained with a 3% hexachlorophene lotion. Repopulation of bacteriologically denuded skin surfaces was due primarily to recolonization by organisms of enteric origin; no repopulation by organisms of respiratory origin was detected. The indirect transmigration of enteric microorganisms to nonperineal surfaces was demonstrated.

At no time was there bacteriological evidence of a failure in the microbial barrier of the isolator.

Generic and Trade Names of Drug

Hexachlorophene—*Gamophen*, *Hexachlorophene*, *pHisoHex*, *Surgi-Cen*, *Surofene*.

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