Comparison of Complete Barrier Isolation and Unidirectional Air Flow Isolation in the Treatment of Burn Wounds

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In the continuing attempt to limit bacterial contamination of burn wounds, a number of therapeutic procedures have been employed. These methods of therapy include topical and systemic antibiotic therapy, active and passive immunotherapy, aggressive local wound debridement and temporary wound coverage with homograft or xenograft, as well as, new and intensified methods of supportive therapy. An additional method of protecting burn patients from severe bacterial contamination and eventual invasive infection is to control the immediate environment during the period of burn therapy. Various approaches to this problem have been reported to range from the construction of an entire hospital facility to control the environment and all personnel within the facility, to the use of individual patient isolator systems of one type or another.1,2,3,5,6

For the past 5 years we have had experience with complete barrier isolation treatment of burn and other trauma patients, employing both the “Life Island Unit” and the Snyder Reverse Isolation Unit. More recently we have worked with a small unidirectional flow unit as an alternate method of less rigid reverse isolation. Some 25 burn patients have been studied in these various types of isolation units and our experiences will be reviewed in this report.

The objectives of reverse isolation therapy of any type is to attempt to eliminate exogenous sources of infection while preventing the emergence of resistant endogenous bacteria; to minimize endogenous bacterial spread; to deliver optimal patient care with minimal additional effort on the part of attending personnel; to create a pleasant treatment atmosphere and finally to reduce mortality secondary to infection.

Types of Isolators

The majority of patients treated in this study were housed in the Snyder Reverse Isolation Unit.* It is constructed of flexible plastic approximately 8 ft. long, 6 ft. wide, and 6 ft. high above the bed (Fig. 1). The rectangular shape is maintained by the frame of metal traction supports mounted on the bed. The mattress and side rails of the bed are external to the isolator. The patient is introduced into the isolator unit through an oval port at the head of the bed and there are many other ports and flares in the sides of the isolator for attachment of supporting isolators, waste disposal units, and numerous other items, such as electrical probes, oxygen and intravenous tubing, etc.

The air filtration system is individually controlled so that it is possible to create a positive or negative pressure within the isolator by regulating the volume of air produced by the inflow and outflow air blowers. The air that enters and leaves the unit first passes through a polyurethane prefilter and then through a HEPA (High Efficiency Particulate Air) type filter. The blowers are situated on the upper portion of the isolator to keep them away from the floor and reduce filter clogging due to dust. The air flow in the unit is cyclic and turbulent. There are approximately eight changes of air in the unit per hour.

An ultraviolet lock (UV) is attached at the foot of

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the isolator and has two chambers, one for passing the sterile items in and one for moving items from the isolator (Fig. 2). The UV lock is not intended to function as a sterilizing chamber but only to act as a convenient method of introducing and removing material from the isolator. The materials passed into the lock are doubly wrapped at the time of sterilization and the outer wrapping removed prior to introduction into the compartment. The UV lock furnishes a means of decontaminating any external air that may have entered when the package was introduced.

Built into the sides of the isolator are three personnel entry jackets, consisting of gloves, arms, helmets, and sufficient plastic to allow the attendant to move freely within the isolator and perform medical or technical duties. Each suit has its own individually controlled air supply.

A trap isolator has proved to be of great technical aid in supporting the patients within the isolator (Fig. 3). It consists of a double door, baffled, germicidal trap with a plastic isolator hood. A 12-inch entry port attaches the trap unit to the patient isolator. The trap unit has its own intake and its own exhaust filter air system. This unit has been valuable for passing food into the isolator and presterilized containers. Other items difficult to sterilize may be passed through the germicidal bath and left in the bath for 20 minutes to complete sterilization of the container.

The Life Island isolator * is another type of complete reverse isolation unit that has been employed to study a few burn patients. Although this isolator appears to be simpler than the Snyder Unit, we have found that caring for seriously burned patients requires frequent dressing, intravenous fluids, and many nursing procedures which are significantly more difficult in this unit. The isolator

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* Matthews Research, Inc., Alexandria, Virginia

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jackets built in the side of the Snyder Unit greatly facilitate nursing care. The Life Island unit also has cyclic air flow with approximately 14 changes per hour. There are full length gloves for personnel in the sides of the isolator and a UV lock in one end for supplies. A double zipper in the side of the unit is used to open the unit for the introduction of a patient.

The CRS (Contamination Reduction System) isolator* has been more recently employed in the study of environmental control in the therapy of burn patients (Fig. 4). This unit consists primarily of a unidirectional flow system with uniform turbulence-free air being delivered from a ceiling air plenum over the patient’s bed. The gentle flow of air (15–20 CFM per sq. ft.) minimizes patient discomfort and dehydration. The bed is surrounded by a flexible plastic canopy that is electrically operated as a draw curtain by a foot switch control (Fig. 5). The unit is easily assembled on a standard traction frame over any hospital bed. The air flow is controlled by a blower filter unit with a sealed HEPA filter assembly. The floor space required for the CRS isolator is only 40 sq. ft. as opposed to 122 sq. ft. for the Life Island and 129 sq. ft. for the Snyder Isolator Unit (Fig. 6). The initial cost and upkeep expenses are also much less for this type unit.

The unidirectional air flow unit, however, does remove the absolute barrier to cross-contamination from direct contact and unless strict isolation technics are employed by all personnel coming in contact with the patient, Breaks in technic will occur and direct contact cross-


contamination is unavoidable even if it is greatly diminished (Fig. 7).

Air-borne Bacterial Studies

In order to compare the bacterial contents of the air surrounding the burn patient in varying environments, periodic studies were performed with the TDL slit sampler which measured the number of organisms in 1 cu. ft./min. of air for 20-60 min. periods. The sampler was located in the Snyder complete barrier isolation unit, and in the hospital room in which these units were housed. Samples were taken over approximately one hour period of time both prior to placing patients in the isolator and after they had been in the isolator for various lengths of time. The number of colony producing agents was then plotted against time and activity inside the unit and in the hospital room.

It was immediately apparent that the bacterial counts in the room air were much higher than those inside the Snyder unit. The room air-borne bacterial counts varied directly with activity in the room and with the number and types of personnel present in the room. Prior to entry of a patient into the Snyder unit there was no bacterial air contamination. When the patient first entered there was only minimal increase in bacteria present in the air by the slit sample technic and this amount of contamination remained low during the first hour that the patient occupied the unit. After 2 days in the unit, however, the number of air-borne bacteria increased greatly, particularly with activity inside the unit. A bedding change inside the Snyder isolator unit would cause a marked elevation of air-borne bacteria almost at the levels of room air-borne bacteria and as the patient re-
remained in the isolator over a long period of time the patient’s own bacteria would accumulate inside the unit and be showered into the air with activity inside the unit.

All air samples taken with the CRS unidirectional flow unit were negative regardless of activity in the unit unless the activity was directly over the sampler. Although no bacterial isolates were detected above the bed level, a few colony producing agents were isolated when the slit sampler was placed on the floor of the CRS unit near the filter intake (Fig. 8a & 8b).

**Patient and Isolator Bacterial Studies**

In general it can be stated that all patients placed into the complete barrier isolator patient system (Snyder) developed no new bacterial flora after they were put in the unit. The bacteria brought with them upon entry into the unit remained and frequently spread from one area of the body to another and onto the isolator and isolator gloves despite precautions and sterile procedures performed within the isolator. The bacteria present in the isolator were usually first found on rectal cultures and then later on the wound, nose, throat, or tracheostomy area. As time progressed these various isolates were recovered from portions of the isolator particularly the gloves. Burn patients that were placed in the isolator early in their postburn treatment period usually did not have *Pseudomonas aeruginosa* cultured from their stool or wounds at the time of entry nor did

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**Fig. 7.** The nurse re-enacts a typical break in technic wearing no mask, apron or gloves. She contacts the side of the patient isolator and enters to give the patient an unsterilized object from another patient. Direct contact of this type cannot be prevented by the CRS unit without complete cooperation of the attending personnel.

**Fig. 8a.** Air cultures of the room in which the isolator was housed indicate relatively high levels of colony producing agents during the time sampled. Activity in the room caused a sharp rise of bacteria in the air. The Snyder Complete Barrier Isolation System showed no bacterial count prior to patient entry. Following patient entry there was only minimal increase in air-borne bacteria despite activity within the unit during the first hour of isolation. The unidirectional flow unit (CRS) showed no bacteria recovered from the air during the first hour of patient isolation.

**Fig. 8b.** After two days of isolation air cultures inside the Snyder Isolator revealed that activity caused a marked rise in colony producing agents almost to the level of the number of those recovered from the hospital room containing the patient isolator. The unidirectional flow unit continued to have no air bacteria recovered despite activity or length of time the patient was in the unit.
Table 1  Days Post-entry

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<th>Entry</th>
<th>3</th>
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<tr>
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<td>W</td>
<td>I*</td>
<td>I</td>
<td>R</td>
<td>TW</td>
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<td>W</td>
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<td>Strep. (Enter)</td>
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<td>R</td>
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<td>RWT</td>
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<tr>
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<td>W</td>
<td>W</td>
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<td>W</td>
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<td>W</td>
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<tr>
<td>C. albicans</td>
<td>W</td>
<td>RW</td>
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<td>RW</td>
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<tr>
<td>Yeast (not</td>
<td>C. alb.)</td>
<td>T</td>
<td>W</td>
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Ps. aeruginosa—not isolated from patients admitted early after burn.
R = Rectal  I = Isolator
W = Wound  * = Isolator gloves
T = Trachea

they develop Pseudomonas on their wounds during their period of isolation which in some cases lasted as long as 60 days. Table 1 indicates a composite of the bacterium recovered from several burn patients placed into the Snyder isolator early in the postburn period. The predominance of rectal organisms gradually spreading throughout the environment is apparent. Patients who were placed in the isolator system late in the postburn period frequently already had Pseudomonas on their burn wounds and this organism remained during the period of isolation. Although Pseudomonas would often be temporarily eliminated in one area or another of the burn by topical therapy it almost always recurred. Other patients who did not have Pseudomonas cultured during their stay in the Snyder isolator developed this organism on their burn wound after they were removed from the isolator system. In general, there was no evidence of cross-contamination occurring in any of the patients treated within the Snyder isolator system.

Bacterial surveys of patients treated within the CRS unidirectional unit compared to other patients in their immediate environment has revealed some cross-contamination by direct contact from personnel carriers. A typical study performed in the intensive care unit where four patients with severe burns were being treated simultaneously is demonstrated in Table 2. Patient A developed wound contamination and infection with Pseudomonas on 2/26 and had the organism again recovered on 2/27. Patient B in the Intensive Care Unit developed this same Pseudomonas on 2/28. It was also recovered from this patient’s wounds on 3/1, 3/4, and 3/5. Patient C developed the Pseudomonas contamination on the burn wound on 3/17, and patient D (housed in the CRS unit) was the last of the group to develop contamination of the burn wound from this Pseudomonas isolate on 3/5. The organisms appear to be transferred from one patient to another. The unidirectional flow unit seemed to delay this direct cross-contamination but did not prevent it. There was an eventual break in technic causing contamination and seeding of this Pseudomonas aeruginosa on the burn wound of patient in the CRS unit. This isolate was not recovered from the air environment of the CRS unit at any time but was found in the unit’s HEPA filter.

Discussion

Experience to date in comparing trauma patients treated in the complete barrier isolation system and the unidirectional flow CRS unit has led us to the following opinions and conclusions. The complete barrier isolation of the Snyder Unit affords total isolation from exogenous bacteria, but allows for the gradual rise in air contamination within the unit by the patient’s own endogenous bacteria. Activity within the unit causes a great particulate rise and after a period of time in the isolator this particulate rise is accompanied by a large number of bacteria. The longer the patient is in the isolator the greater this build up of bacteria of endogenous bacteria becomes. These bacterial isolates have consistently been those that have originated from the patient. It becomes immediately apparent to those caring for the burned or otherwise traumatized patient within the complete barrier isolation system that greatly increased support is necessary from the Nursing Service, Medical Service, Central Supply, and Dietary Service, Pharmacy, and other divisions and departments in the hospital. This increased demand on the time of so many personnel involved in caring for sick patients makes the complete barrier isolation impractical for widespread use, although it does afford clinical research tool. This type of isolator also places an obstacle between the patients and those caring for him and may in some cases hinder the care of the severely injured patient. Those patients better able to care for themselves, such as leukemia patients undergoing chemotherapy, do not present as great a care problem when they are treated in a complete barrier isolation unit.

The unidirectional air flow unit (CRS) prevents air cross-contamination of the patient from other patients or personnel. The air within the unit remains free of bacteria and keeps the patients’ environment free of exogenous and endogenous bacteria. Activity within the CRS unit did not increase the particulate count in the air. This type of unit is acceptable to the patient and to the personnel caring for him since only minimal increase in effort is necessary to care for these patients. However,
breaks in technic do occur and on occasion there will be personnel contact with the patient without proper precautions allowing for direct contact spread of exogenous bacteria to the traumatized patient. The establishment of specialized areas on the trauma ward for the care of patients in CRS units increases the awareness of the nursing and supporting personnel to the reverse isolation procedures and decreases the number of "breaks" in technic. Since the number of severely burned patients treated in the Isolation Units was small, no conclusions could be reached as to the effect of this form of therapy on mortality rates.

Summary

A 5-year experience with complete barrier isolation and a shorter experience with unidirectional flow isolators has been compared from several aspects. The basic objectives of patient isolators relating to burn and trauma patients as well as a description of the isolators that were used in this study has been presented.

Bacteriologic data from the patients and their environment within the isolator have shown that complete barrier isolation affords total exclusion of exogenous bacteria, but allows for a gradual rise in the air levels of the patient's own endogenous flora. The unidirectional air flow unit (CRS) prevents air cross-contamination and keeps the air within the unit free of bacteria, both exogenous and endogenous. Activity within the complete barrier isolation unit causes a great particulate rise. The longer the period of time a patient is in the isolator the more this particulate rise is accompanied by a large rise in the number of bacteria in the unit. Activity within the CRS unit causes no rise in air-borne bacteria. The unidirectional flow unit, however, is susceptible to breaks in isolation technic, and personnel contact does occur causing direct spread of exogenous bacteria from one traumatized patient to another.

Severely injured patients can be treated in the barrier isolation system but it requires a great increase in the amount of support necessary from medical personnel, nursing service, central supply, etc. and may result in deficiencies in patient care. The CRS unidirectional flow unit causes only minimal increase and effort compared to the barrier isolation system. A unidirectional flow system would seem to be of practical value in caring for burned patients whereas the value of the complete isolation unit seems limited to clinical research problems.

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