Microbial Penetration Through Three Types of Double Wrappers for Sterile Packs

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Microbial penetration of sterile packs was studied by using double-wrap (two layers each) muslin, single-wrap (two layers) muslin inner covering with single-wrap (one layer) two-way crepe paper outer covering, and single-wrap (two layers) muslin inner covering with single-layer BAR-B-AC wrappers to wrap 20 gauze sponges (2 by 2 in.). These packs were stored on open shelves of a central sterile supply department of a hospital and processed for sterility at weekly intervals. Microorganisms penetrated the double-wrap muslin as early as 28 days, the single-wrap muslin and single-wrap two-way crepe paper combination in 77 days, and the single-wrap muslin and single-layer BAR-B-AC combination in 63 days.

A previous study on microbial penetration of sterile packs was conducted to determine, under actual hospital conditions of storage, safe times for sterile storage of four widely used single or double wrappers for packs (1). Viable microorganisms penetrated packs with single wrappers faster than packs with double wrappers, and the time for microbial penetration was less than half as long with open-shelf versus closed-cabinet storage. On the basis of this study, single wrappers were not recommended for sterile packs (1).

An extension of that study has been conducted to evaluate the safe time for storage of sterile packs with two additional types of double wrappers to compare them with the most effective wrapper previously studied, double-wrap (four layers) muslin. Because storage on open shelves is common in hospitals, and because such storage resulted in most rapid microbial penetration in the previous study, the comparison of the three types of wrappers was conducted only with open-shelf storage.

MATERIALS AND METHODS

Standard packs approximately 8 by 10 in. (20.4 by 25.5 cm) consisting of 20 by 2 in. (5.1 by 5.1 cm) 12-ply gauze sponges were prepared and sterilized as described by Standard, Mackel, and Mallison (1). These packs were covered with double muslin (each two layers), single-wrap (two layers) muslin inner covering with single-wrap (one layer) two-way crepe paper outer covering, and single-wrap (two layers) muslin inner covering with single-layer BAR-B-AC outer covering.

Muslin wrappers used for the standard packs were 140-thread-count material, unbleached, dyed green, laundered, and ironed 1 to 10 times before use. BAR-B-AC (Angelica Uniform Co.) wrappers were tightly woven cotton material, dyed green, laundered, and ironed at least one to three times before use. The paper wrappers used were commercially available two-way crepe paper (Dennison Wrap). All wrappers were approximately 24 by 24 in. (61 by 61 cm).

The sterile packs were transported in sealed, sterile plastic bags to a hospital central sterile supply department (CSSD). They were placed on open shelves in the same area used for hospital sterile supplies. Test packs were picked up at random in groups of two or four at weekly intervals, placed in sterile plastic bags, and returned to the laboratory for microbiological assay by procedures previously described (1). A total of 252 test packs were assayed.

Three series of 14-week evaluations were conducted. On the initial day of each series of evaluations, three packs wrapped in each type of wrapper used in that series were chosen at random, after placement on shelves of the hospital CSSD, and transported back to the laboratory in sterile plastic bags for an initial control assay to confirm that the packs were not contaminated during transportation. In addition, at the time of each weekly pick-up of study packs, two sterile double-muslin-wrapped (4 layers) packs were transported to the hospital and back to the laboratory in sterile plastic bags for assay as weekly transportation controls. A total of 108 initial control packs and weekly transportation control packs were assayed.

Temperature and relative humidity were monitored throughout the study by use of 7-day recording hygrothermographs. These instruments were calibrated at weekly intervals with a sling psychrometer.

Viable surface contamination settling on the outside of the packs was estimated by using stainless-steel strips placed open on the storage shelves used for the packs, as described previously (1).
RESULTS

Microbial contamination was determined for packs with three types of double wrapping: double-wrap (each two layers) muslin, single-wrap (two layers) muslin inner covering with single-wrap (one layer) two-way crepe paper outer covering, and single-wrap (two layers) muslin inner covering with single-layer BAR-BAC outer covering. Table 1 gives the time in days until the first contamination was found inside packs covered with each type of wrapping material. Contamination occurred as early as 28 days with double-wrap muslin, 63 days with the BAR-BAC and muslin combination, and 77 days with the two-way crepe paper and muslin combination. Tables 2 to 4 show the number of pack weeks of exposure and the number of positive test packs by week for the three series of evaluations.

Temperatures in the CSSD remained between 70 and 80 °F (21.1 to 26.7 °C) with few exceptions throughout the entire study, and weekly average relative humidities ranged from about 30 to 55%.

Table 5 shows the total microbial counts from stainless-steel strips exposed on open shelves to estimate the amount of viable fall-out on sterile packs on the shelves. The microbial counts were calculated on the basis of an area measuring 80 square inches, equal to the exposed surface area of the packs used in the study. About 65% of the settled microorganisms were aerobes grown without heat shocking, about 20% were anaerobes grown without heat shocking, over 5% each were molds and aerobes grown after heat shocking, and less than 5% were anaerobes grown after heat shocking.

Only one of the 108 control packs utilized during the study was found to be contaminated. Forty test packs were contaminated during the study.

Table 6 shows the type and frequency of organisms isolated from the 41 contaminated packs. The most frequently isolated organisms were Aspergillus spp, Streptomyces spp, and gram-positive sporeforming rods.

DISCUSSION

The earliest time required for contamination of the packs with double-wrap (four layers) muslin stored on open shelves was 28 days, as in the previous study (1). The amount of microbial contamination collected on stainless-steel strips

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**Table 1. Days required for first packs to become contaminated during open-shelf storage**

| Type of wrap | Time (days) |
|--------------|-------------|
|              | Series 1 | Series 2 | Series 3 |
| Double-wrap muslin | 49 | 35 | 28 |
| Single-wrap two-way crepe (outer) and single-wrap muslin (inner) | 98 | 98 | 77 |
| Single-wrap BAR-BAC (outer) and single-wrap muslin (inner) | — | 98 | 63 |

* Four test packs were assayed per week; 2 test packs were assayed per week for all other types of wrap and all other series.

**Table 2. Length of storage, number of pack weeks of exposure to contamination, number of positive packs found, and number tested, series 2**

| Length of storage by week | Double-wrap muslin packs | Crepe (outer)-muslin (inner) packs |
|----------------------------|--------------------------|-----------------------------------|
|                            | No. of pack weeks of exposure by week | No. of pack weeks of exposure by week | No. of positive | No. of positive |
| 1                          | 56                        | 112                               | 2               | 4               | 0               |
| 2                          | 104                       | 208                               | 2               | 4               | 0               |
| 3                          | 144                       | 288                               | 2               | 4               | 0               |
| 4                          | 176                       | 352                               | 2               | 4               | 0               |
| 5                          | 200                       | 400                               | 2               | 4               | 0               |
| 6                          | 216                       | 432                               | 0               | 4               | 0               |
| 7                          | 224                       | 448                               | 1               | 4               | 0               |
| 8                          | 224                       | 448                               | 0               | 4               | 0               |
| 9                          | 216                       | 432                               | 1               | 4               | 0               |
| 10                         | 200                       | 400                               | 1               | 4               | 0               |
| 11                         | 176                       | 352                               | 0               | 4               | 0               |
| 12                         | 144                       | 288                               | 1               | 4               | 0               |
| 13                         | 104                       | 208                               | 0               | 4               | 0               |
| 14                         | 56                        | 112                               | 0               | 4               | 0               |
TABLE 3. Length of storage, number of pack weeks of exposure to contamination, number of positive packs found, and number tested, series 2

| Length of storage by week | Number of pack weeks of exposure by week | Double-wrap muslin packs | Crepe (outer)-Muslin (inner) packs | BAR-BAC (outer)-muslin (inner) packs |
|---------------------------|----------------------------------------|--------------------------|------------------------------------|-------------------------------------|
|                           | No. tested | No. positive | No. tested | No. positive | No. tested | No. positive |
| 1                         | 56         | 2            | 0          | 2            | 0          | 2            |
| 2                         | 104        | 2            | 0          | 2            | 0          | 2            |
| 3                         | 144        | 2            | 0          | 2            | 0          | 2            |
| 4                         | 176        | 2            | 0          | 2            | 0          | 2            |
| 5                         | 200        | 2            | 1          | 2            | 0          | 2            |
| 6                         | 216        | 2            | 1          | 2            | 0          | 2            |
| 7                         | 224        | 2            | 2          | 2            | 0          | 2            |
| 8                         | 224        | 2            | 0          | 2            | 0          | 2            |
| 9                         | 216        | 2            | 2          | 2            | 0          | 2            |
| 10                        | 200        | 2            | 0          | 2            | 0          | 2            |
| 11                        | 176        | 2            | 1          | 2            | 0          | 2            |
| 12                        | 144        | 2            | 2          | 2            | 0          | 2            |
| 13                        | 104        | 2            | 0          | 2            | 0          | 2            |
| 14                        | 56         | 2            | 1          | 2            | 0          | 2            |

TABLE 4. Length of storage, number of pack weeks of exposure to contamination, number of positive packs found, and number tested, series 3

| Length of storage by week | Number of pack weeks of exposure by week | Double-wrap muslin packs | Crepe (outer)-muslin (inner) packs | BAR-BAC (outer)-muslin (inner) packs |
|---------------------------|----------------------------------------|--------------------------|------------------------------------|-------------------------------------|
|                           | No. tested | No. positive | No. tested | No. positive | No. tested | No. positive |
| 1                         | 56         | 2            | 0          | 2            | 0          | 2            |
| 2                         | 104        | 2            | 0          | 2            | 0          | 2            |
| 3                         | 144        | 2            | 0          | 2            | 0          | 2            |
| 4                         | 176        | 2            | 2          | 2            | 0          | 2            |
| 5                         | 200        | 2            | 2          | 2            | 0          | 2            |
| 6                         | 216        | 2            | 2          | 2            | 0          | 2            |
| 7                         | 224        | 2            | 1          | 2            | 0          | 2            |
| 8                         | 224        | 2            | 2          | 2            | 0          | 2            |
| 9                         | 216        | 2            | 2          | 2            | 0          | 2            |
| 10                        | 200        | 2            | 2          | 2            | 0          | 2            |
| 11                        | 176        | 2            | 2          | 2            | 0          | 2            |
| 12                        | 144        | 2            | 2          | 2            | 0          | 2            |
| 13                        | 104        | 2            | 0          | 2            | 0          | 2            |
| 14                        | 56         | 2            | 1          | 2            | 0          | 2            |

also was similar to the amount found in the previous study. Thus, a direct comparison of the results of the two studies was possible, and these results add to current knowledge on safe time of storage for sterile packs in hospital CSSD.

It is possible that manipulation of hospital linen packs larger than those used in this study might hasten microbial penetration, but this possibility was not evaluated.

In this study, packs wrapped with the BAR-BAC and muslin combination or the two-way crepe paper and muslin combination gave at least eight weeks of sterile storage on open shelves. Thus, more than twice the safe storage time is possible with these two combination wrappers than with double-wrap (four layers) muslin. Clearly, an evaluation of the economics of the extra wrapping cost with these combination wrappers versus the value of extra possible length of sterile storage would be necessary for an individual hospital to determine the preferable wrapping system for its use.

Longer sterile storage is possible if packs are sealed into sterile impervious plastic bags (1). Closed-cabinet storage will also offer improved
protection for sterile packs. Single wrappers are not recommended.

| Time strips exposed (days) | Counts of settled organisms per pack area |
|---------------------------|-------------------------------------------|
|                           | Series 1 | Series 2 | Series 3 |
| 7                         | 2,000    | 6,400    | 2,400    |
| 14                        | 5,200    | 4,500    | 5,300    |
| 21                        | 8,500    | 11,000   | 17,000   |
| 28                        | 11,000   | 9,900    | 7,100    |
| 35                        | 12,000   | 10,000   | 10,000   |
| 42                        | 13,000   | 12,000   | 14,000   |
| 49                        | 6,800    | 16,000   | 20,000   |
| 56                        | 11,000   | 15,000   | 39,000   |
| 63                        | 13,000   | 10,000   | 11,000   |
| 70                        | 10,000   | 8,800    | 10,000   |
| 77                        | 6,800    | 9,500    | 11,000   |
| 84                        | 16,000   | 11,000   | 22,000   |
| 91                        | 10,000   | 9,600    | 15,000   |
| 98                        | 18,000   | 10,000   | 17,000   |

*Expressed as number per 80 square inches, the area of the test packs used.

| Types of organisms*                        | Number of microorganisms isolated |
|--------------------------------------------|-----------------------------------|
| Micrococcus sp.                            | 1 0 2                             |
| Streptococcus sp.                          | 1 0 0                             |
| Gram-positive NSF rood                     | 0 1 0                             |
| Gram-positive SF rood                      | 0 5 5                             |
| Gram-negative NF rood                      | 0 1 0                             |
| Streptomyces spp.                          | 1 6 10                            |
| Aspergillus spp.                           | 3 4 11                            |
| Penicillium spp.                           | 0 2 0                             |
| Trichoderma sp.                            | 0 1 0                             |

*NSF, nonsporeforming rod; SF, sporeforming rod; NF, nonfermenting rod.

LITERATURE CITED

1. Standard, P. G., D. C. Mackel, and G. F. Mallison. 1971. Microbial penetration of muslin- and paper-wrapped sterile packs stored on open shelves and in closed cabinets. Appl. Microbiol. 22:432-437.