

# Occlusion as an Active Agent

A brief review of the medical literature shows that occlusive dressings provide effective therapeutic intervention either as an adjunct to topical medications or as a monotherapy for certain skin diseases, especially psoriasis and dermatitis. Applications also are found in verruca vulgaris and possibly other dermatologic diseases involving disruption of the stratum corneum (SC) permeability barrier or abnormal epidermal differentiation. Although the physiologic and chemical changes that occur on occluded human skin are concisely summarized, the mechanism(s) of action remain incompletely explored and their therapeutic and cosmetic potential incompletely developed.

Occlusion occurs on a regular basis from diapers and feminine hygiene products to clothes, gloves and bandages. Originally felt to be a neutral intervention, occlusion has been found to be active on the skin. This article briefly reviews medical research on the effect of occlusion on human skin, both healthy and diseased, and illustrates the current knowledge regarding occlusion as an active agent. (A seminar on skin and wound care is described in **Symposium on Skin and Wound Care**.)

## Skin Physiology and Chemistry

**Plastic films:** Aly et al.<sup>1</sup> performed five days of occlusion with vinylidene polymer plastic film<sup>a</sup> on human forearm skin. During occlusion, pH increased from 4.3 pre-occlusion to 7.0 post-occlusion. Transepidermal water loss (TEWL) increased from 0.56 mg/cm<sup>2</sup>/h to 1.87 mg/cm<sup>2</sup>/h and carbon dioxide emission increased from 25 nL/cm<sup>2</sup>/min to 118 nL/cm<sup>2</sup>/min. Although *P* values were not provided, the commentary indicated that this data was statistically significant.

Faergemann et al.<sup>2</sup> provided statistical analysis confirming the findings of

Aly et al. After eight days of occlusion with vinylidene polymer plastic film<sup>a</sup>, the partial pressure of carbon dioxide (pCO<sub>2</sub>), pH, TEWL and skin water content (WC) were all significantly increased. pCO<sub>2</sub>, pH and WC remained elevated throughout the eight days of occlusion while TEWL peaked at three days and decreased thereafter. TEWL was significantly lower after eight days of occlusion than it was at its three-day peak. Significance of the increase was seen after 24 h for pCO<sub>2</sub> and WC.

**Tape:** Fisher and Maibach<sup>3</sup> studied the differences in cell kinetics in tape-stripped skin dressed with one of four agents: nonocclusive tape<sup>b</sup>, occlusive tape<sup>c</sup>, vinylidene plastic film<sup>a</sup> or the adhesive used in the occlusive tape<sup>c</sup> without the occlusive backing. These researchers found that the rate of mitosis and epidermal thickness was decreased with all four agents, thus questioning the belief that occlusivity of a dressing is the measure of its activity on the skin.

Hwang et al.<sup>4</sup> performed seven days of occlusion in psoriatic plaques and unaffected skin on the backs of five patients. The occlusion device used in this study had three layers: directly overlying the skin was water vapor-impermeable latex covered by a thin transparent dressing<sup>d</sup> itself having 7 g/m<sup>2</sup>/h vapor permeability followed by a layer of nonocclusive tape<sup>b</sup>. Occlusion by this vapor-impermeable device caused a nearly complete correction of the epidermal calcium gradient. The normal epidermal calcium gradient allows proper differentiation of keratinocytes. Occlusion of unaffected skin, however, did not alter the gradient. Earlier studies of occlusion following tape stripping as a means of disrupting the epidermal permeability barrier found that occlusion did not lead to restoration

<sup>b</sup> Micropore, 3M. Micropore is a trademark of 3M.

<sup>c</sup> Blenderm, 3M. Blenderm is a trademark of 3M.

<sup>d</sup> Tegaderm is a thin transparent dressing consisting of a polyurethane membrane coated with a layer of acrylic adhesive. Tegaderm is a trademark of 3M.

Howard I. Maibach, M.D., is professor of dermatology, University of California School of Medicine, San Francisco. His laboratory has been interested in and has published extensively on dermatopharmacology and dermatotoxicology.



Nicholas Golda, M.D., graduated from the University of Southern California Keck School of Medicine and presently is in residency training with the Department of Dermatology at the University of Missouri–Columbia.

of the calcium gradient. Hwang et al. hypothesized that their results differ from those of previous studies because psoriasis is a chronic disease resulting in long-standing disruption of the permeability barrier while tape stripping is a

## SYMPOSIUM ON SKIN AND WOUND CARE

A clinical symposium on advances in skin and wound care will be presented Sept. 28 through Oct. 1, 2006, at Disney's Coronado Springs Resort in Lake Buena Vista, Fla. The annual event draws more than 1,300 nurses, physicians and other professionals who manage skin and wound care patients. In the exhibit hall, more than 150 booths will display the latest in wound care technology and treatments. Breakout sessions will address topics such as skin and wound care issues in critical care, and benefits and precautions for bioengineered skin substitutes and skin replacements.

The symposium is organized by Lippincott Williams & Wilkins, a global publisher of medical, nursing and allied health information resources. For registration or other information, call 1-800-346-7844 ext. 7750 or e-mail [kcousart@lww.com](mailto:kcousart@lww.com).

—The Editors

<sup>a</sup> Saran Wrap. Saran is a trade name of Dow Chemical Company.

more acute perturbation of otherwise normal skin.

**Film and feminine hygiene product:** Schafer et al.<sup>5</sup> occluded forearm skin with vapor-permeable and vapor-impermeable films over an absorbent feminine hygiene product. Each participant had both forms of occlusion applied, one to each forearm, with 3 mL of normal saline used to premoisten the absorbent

pads before occlusion to simulate physiologic discharge. After six h of occlusion there was no significant difference between baseline and occlusion with a vapor-permeable film, whereas occlusion with a vapor-impermeable film caused a significant increase in SC hydration measured with an evaporimeter.

When ambient temperature and humidity are held relatively constant,

skin surface water loss and relative humidity below the dressing were significantly lower with the vapor-permeable dressing than with the vapor-impermeable dressing. The skin surface water loss and the relative humidity below the dressing were elevated under the impermeable dressing as compared with the permeable dressing at all studied levels of ambient temperature and humidity with one exception. That exception occurred when the temperature reached 30°C at 75% ambient humidity. At that point the difference in skin surface water loss between the two dressings lost significance, indicating that ambient humidity and temperature can negate the effects of a vapor-permeable dressing. Thus increased skin surface temperature may be the mechanism by which occlusion acts on the skin and may indicate that thermal treatments may be as effective as occlusion in occlusion-responsive dermatoses.

## Microbiology

Aly et al.<sup>1</sup> found that both the density and composition of the cutaneous bacterial flora changed on human forearm skin after five days of continuous occlusion with vinylidene polymer plastic film<sup>a</sup>. Bacterial counts, measured in organisms/cm<sup>2</sup>, increased significantly from a preocclusion value of  $1.8 \times 10^2$  to  $1.4 \times 10^6$  after only one day of occlusion and up to a maximum count of  $9.8 \times 10^7$  on day four of occlusion. After five days of occlusion the count decreased to  $7.5 \times 10^6$ . During occlusion, coagulate-negative staphylococci remained the predominant bacterial isolate, but the percent composition of lipophilic diptheroids, micrococci and Gram-negative rods increased while nonlipophilic diptheroids and bacillus decreased.

Faergemann et al.<sup>2</sup> confirmed findings of earlier studies of the effect of occlusion on bacterial counts in addition to examining the effect of occlusion on *Pityrosporum orbiculare* population and morphology. After eight days of occlusion with vinylidene polymer plastic film<sup>a</sup>, bacterial counts increased significantly. With respect to *P. orbiculare*,

the etiologic agent in tinea versicolor, the density increased significantly by a factor of 10 after three days of occlusion and remained significantly elevated through eight days of occlusion.

## Percutaneous Absorption

Bucks and Maibach<sup>6</sup> explained the varying penetration of topically applied steroids under occlusion. Under non-occluded conditions, there is normally a large contrast between the SC layer and the remainder of the epidermis in that the SC layer is hydrophobic while the remainder of the epidermis, the viable portion, is hydrophilic. Attraction by the hydrophobic SC as well as repulsion by the hydrophilic viable epidermis causes hydrophobic molecules such as steroids to collect in the SC despite a concentration gradient that would tend to push them into the viable epidermis. The more hydrophobic the steroid molecule, the greater this effect will be.

With occlusion, the SC becomes increasingly hydrated and therefore has

increased hydrophilicity. This reduces the contrast between these layers of the epidermis and increases the force that drives highly hydrophobic molecules from the SC into the lower layers of the epidermis. These two changes occur because the force of the concentration gradient plays more of a role in the transit of hydrophilic molecules through the epidermis under these occluded and hydrated conditions. Limiting the increased penetration of highly hydrophobic molecules is the fact that as the SC becomes maximally hydrated, hydrophobic molecules will experience some repulsion from the now hydrophilic SC and will be less able to enter the SC.

## Treatment of Disease

**Hydrocolloid dressings:** Friedman<sup>7</sup> studied psoriatic plaques exposed to one of the following treatments: weekly hydrocolloid occlusion; twice daily fluocinolone cream; and five erythrogenic UVB treatments per week. This was a

bilateral comparison study in which patients served as their own controls.

Both twice daily fluocinolone cream and weekly occlusion significantly improved psoriatic plaques, but after 10 weeks of treatment, occlusion alone was significantly more effective than the cream alone. In addition, 40.9% of plaques treated with occlusion alone completely resolved in 10 weeks, and in many cases they remained in remission for up to one year. When occlusion alone was compared with erythrogenic UVB, no significant difference was found between the two treatments.

Two forms of hydrocolloid dressings were used. One<sup>c</sup> was thicker than the other<sup>f</sup>. No difference in efficacy was detected between these dressings. Adverse reactions related to occlusive dressing treatment included Koebner phenomenon, Auspitz sign, and hyperpigmentation in some patients. Importantly, no infections or

<sup>c</sup> Duoderm, ConvaTec

<sup>f</sup> Surgihesive, E. R. Squibb & Sons, Inc.

purulence were associated with week-long occlusive therapy over the course of 10 weeks.

**Tapes:** Focht et al.<sup>8</sup> demonstrated that treatment of verruca vulgaris with repeated six-day-long occlusion with duct tape over two months was significantly more effective than liquid nitrogen cryotherapy every two-to-three weeks for a maximum of six treatments per lesion.

## Healing and Repair

Batra et al.<sup>9</sup> studied the effect of silicone occlusive dressings on wound care following laser skin resurfacing (LSR) of the face by comparing prospective use with matched historical controls using open wound care. They found that the severity of erythema and the time until complete resolution of erythema were significantly lower with silicone-occlusive dressing than with open wound management. The time to complete resolution of swelling and time to resolution of crusting

were significantly lower as well. These findings are consistent with an earlier study of the effect of occlusion on the speed of wound healing<sup>10</sup> and with other studies of occlusion following laser skin resurfacing<sup>11</sup> and split thickness skin graft harvesting.<sup>12</sup>

## Discussion

**Increased TEWL:** Occlusion by devices that are completely or almost completely vapor-impermeable has been clearly shown to disturb the SC permeability barrier as measured by increases in TEWL after varying lengths of occlusion.<sup>1,2</sup> TEWL is increased transiently after removal of the occlusive dressing because the occlusion prevents normal physiologic loss of water vapor, which then accumulates under the dressing and leads to increases in SC hydration.<sup>2</sup>

While these changes likely facilitate penetration of medications into the skin, they also may increase the penetration of allergens or irritants, and

excessive skin hydration itself can act as a primary skin irritant. Over hydration of the SC and subsequent maceration may account for at least part of the mechanism by which verruca vulgaris is treated effectively by occlusion.<sup>8</sup>

There now is interest in developing a dressing that avoids over hydration of the SC. It has been shown that when excess water is absorbed from the surface of the skin by the dressing or allowed to escape through a vapor-permeable dressing, the increases in TEWL and SC hydration can be avoided.<sup>5</sup> Studies also have shown that semi-occlusive dressings can have the same effect on human skin as totally occlusive dressings, so the degree of occlusivity may not be the only determinant of the function of a dressing.<sup>3</sup>

**Increased pH:** Vapor-impermeable nonabsorbent occlusion leads to significant increases in the pH below the dressing. On the other hand, absorbent occlusive devices cause no alteration in skin pH.<sup>1,2</sup>

**Increased bacterial counts:** Occlusion modifies the amount and types of bacteria on the skin surface and significantly increases the density of bacteria per square centimeter while also leading to the appearance of Gram-negative bacteria and an increase in the amount of *Pityrosporum orbiculare*.<sup>1,2</sup> Despite this increase in numbers of *Pityrosporum* and bacteria, an association

between occlusion and skin infection has yet to be demonstrated.<sup>2,7</sup>

**Increased drug penetration:** The increase in penetration of some steroids due to occlusion is well-proven. However, the magnitude of this enhanced penetration appears to depend on whether the steroid is hydrophilic or hydrophobic; hydrophobic steroids generally show greater enhancement of penetration.<sup>6</sup>

Different drugs will have different responses to occlusion depending on their physicochemical properties. Penetration and efficacy studies have not yet been conducted under occlusion with tacrolimus, pimecrolimus, retinoids and other classes of topical agents used in dermatology.

**Treatment possibilities:** Occlusion alone can lead to complete resolution of psoriatic plaques and possibly lasting remissions of individual plaques, with efficacy equivalent to topical corticosteroids.<sup>7</sup> Topical corticoid therapy under occlusion has increased efficacy due to enhanced penetration and a therapeutic effect of the occlusive device itself. Occlusion alone has thus been shown to affect both clinical and histologic change in psoriasis,<sup>4</sup> and can thus serve as yet another adjunct in the dermatologist's armamentarium when approaching a psoriasis that is difficult to treat. Occlusion, either alone or with topical corticoids, may be used to supplement outpatient UVB therapy,<sup>7</sup> or any other light or systemic therapy, for slowly responding or recalcitrant plaques such as are commonly found on the shins.

Occlusive dressings also have been studied in wound healing. Faster healing time, faster keratinocyte migration, reduction of eschar, faster resolution of erythema and swelling, and a decrease in pain associated with the wound have all been associated with the use of occlusive wound dressings.<sup>9</sup> Healing can be expedited and pain and morbidity reduced with occlusive dressing of superficial wounds such as those occurring after laser resurfacing or split thickness skin graft harvesting.

## Conclusions

Occlusive dressings are not simply inert devices used to cover the skin; like the medicines with which they often are used, occlusive dressings are biologically active.

Occlusive dressings hold significant promise as adjunctive therapy or monotherapy for psoriasis, verruca vulgaris and other skin diseases where the SC permeability barrier or normal epidermal differentiation is disrupted. Occlusive dressings can be used alone in mild psoriasis, or in addition to systemic treatment

for stubborn plaques. They enhance the efficacy of many corticosteroids and calcipotriene and have been shown to increase the penetration of lipophilic steroids into the skin by hydrating the lipid-filled intercellular spaces in the SC. They are not commonly associated with increased incidence of skin infection, even when used for up to one week without a dressing change, though they do increase the amount of bacteria present on the skin.

Occlusive dressings speed wound repair after superficial damage, and reduce pain and morbidity following these procedures. The only notable side effect of treatment is the possibility of enhanced irritation of normal skin if irritants or allergens are knowingly or unknowingly occluded between the dressing and the skin.

Much has been learned about the complex skin effects of occlusion, but more remains to be resolved. This is especially the case with occlusive cosmetic ingredients.

*Reproduction of all or part of this article is strictly prohibited.*

To get a copy of this article or others from a searchable database, visit the C&T magazine Article Archives at [www.CosmeticsandToiletries.com/articles](http://www.CosmeticsandToiletries.com/articles).

## References

Send e-mail to [goldan@health.missouri.edu](mailto:goldan@health.missouri.edu).

1. R Aly, C Shirley, B Cunico and HI Maibach, Effect of prolonged occlusion on the microbial flora, pH, carbon dioxide and transepidermal water loss on human skin, *J Invest Dermatol* 71(6) 378–381 (1978)
2. J Faergemann, R Aly, DR Wilson and HI Maibach, Skin occlusion: effect on *Pityrosporum orbiculare*, skin PCO, pH, transepidermal water loss and water content, *Arch Dermatol Res* 275(6) 383–387 (1983)
3. LB Fisher and HI Maibach, The effect of occlusive and semipermeable dressings on the cell kinetics of normal and wounded human epidermis, Chapter 5 in *Epidermal Wound Healing*, HI Maibach and DT Rovee, eds, Chicago: Year Book (1972) pp 113–122
4. SM Hwang, SK Ahn GK Menon, EH Choi and SH Lee, Basis of occlusive therapy in psoriasis: correcting defects in permeability barrier and calcium gradient, *Int J Dermatol* 40(3) 223–231 (2001)
5. P Schafer, C Bewick-Sonntag, MG Capri and E Berardesca, Physiological changes in skin barrier function in relation to occlusion level, exposure time and climactic conditions, *Skin Pharmacol Appl Skin Physiol* 15(1) 7–19 (2002)
6. D Bucks and HI Maibach, Occlusion does not uniformly enhance penetration in vivo, Chapter 4 in *Percutaneous Absorption Drugs-Cosmetics-Mechanisms-Methodology*, 3rd edition, RL Bronaugh and HI Maibach, eds, New York: Marcel Dekker (1999) pp 81–106
7. SJ Friedman, Management of psoriasis vulgaris with a hydrocolloid occlusive dressing, *Arch Dermatol* 123(8) 1046–1052 (1987)
8. DR Focht, C Spicer and MP Fairchok, The efficacy of duct tape vs cryotherapy in the treatment of verruca vulgaris (the common wart), *Arch Pediatr Adolesc Med* 156(10) 971–974 (2002)
9. RS Batra, RJ Ort, C Jacob, L Hobbs, KA Arndt and JS Dover, Evaluation of a silicone occlusive dressing after laser skin resurfacing, *Arch Dermatol* 137(10) 1317–1321 (2001)
10. CD Hinman and HI Maibach, Effect of air exposure and occlusion on experimental human skin wounds, *Nature* 200 377–378 (1963)
11. SS Collawn, Occlusion following laser resurfacing promotes reepithelialization and wound healing, *Plast Reconstr Surg* 105(6) 2180–2189 (2000)
12. JJ Disa, K Alizadeh, JW Smith, Q Hu and PG Cordeiro, Evaluation of a combined calcium sodium alginate and bio-occlusive membrane dressing in the management of split-thickness skin graft donor sites, *Ann Plast Surg* 46 405–408 (2001)

C&T