“It is the false shame of fools to try to conceal wounds that have not healed. “

Horace (BC 65-8) Latin Lyric Poet

OBJECTIVES

After completing this module, the participant should be able to:

1. Discuss dressing selection based on the 9 principles of wound healing.
2. Identify various advanced wound care dressings.
3. Select appropriate dressings, based on the wounds needs.

HISTORICAL ROLE OF DRESSINGS

The use of dressings in wound management can be traced back to the Egyptians. In 1862, a papyrus dating back to 3000–2500 BC was discovered by American Egyptologist Edwin Smith. When the papyrus was finally translated in 1930 a variety of dressings were recorded. The dressings included grease, resin, honey, lint, and fresh meat. Wounds were closed by the use of linen strips to which sticky gum had been applied. Antiseptics were made from green copper pigment and chyrsoedla were used in open wounds.
From 25 BC to 37 AD, Celsus wrote extensively on medicine. He was the first to describe rubor, tumor, calor, and dolor (redness, swelling, heat, and pain) as cardinal symptoms of infection. Celsus advocated the removal of foreign bodies before closure and expected the wound to become purulent.

Galen (129–200 AD) was a surgeon who tended gladiators in Pergamum. He is famous for his “laudable pus” theory. Galen advocated that wounds needed to become infected and form pus before healing would ensue. As a result, clean uninfected wounds were inoculated with a variety of substances to induce infection. This theory persisted for more than a thousand years.

Renaissance physician, Dr. Ambrose Paré followed the theory of his times and used boiling oils as cautery for amputation of limbs and wounds. During a great battle he ran out of boiling oils used to treat the soldiers. Dr. Pare began applying egg yolks, oil of roses, and turpentine. At the conclusion of the battle, he found the soldiers to whom the egg yolk mixture had been applied were making better progress than those soldiers that had boiling oil applied to their wounds. Dr. Pare began to question the theory of “laudable pus” and changed his practice.

During World War I, the use of topical antiseptics such as Dakin’s solution, iodine, carbolic acid and mercury was used to prevent infection in battlefield wounds. British soldiers were advised to carry iodine and immediately apply it to gunshot wounds. Unfortunately, many developed dermatitis as a result of indiscriminate use. It was also in this era a dressing called tulle gras was developed by Lumiere. This was gauze that had been impregnated with paraffin.

Through World War I, the task of changing dressings was in the realm of physicians and medical students. In the 1930s, the changing of dressings was given over to experienced nurses and became recognized as a nursing task. For the next 40–50 years the mainstay of wound coverings were gauze, cotton wool pads, impregnated gauze, absorbent cotton, and adhesive pads. The 1960s were the start of a change in dressings and the philosophy of their use.

**CHANGING PHILOSOPHY**

Early pre-clinical and clinical research in the 1960s started to define the idea of moist wound healing and the benefit in optimizing wound healing. The concept that a wound that is kept optimally moist will have better outcomes than one that is allowed to dry out.

The concept of moist wound care began to receive serious consideration in the late 1970s and 1980s. Prior to this time, drying of the wound was accomplished by several mechanisms: the use of povidone iodine as a drying agent, heat lamps, wet-to-dry dressings, and leaving the open wound exposed to air. Transparent film dressings and hydrocolloids were the first widely used dressings that addressed moisture retention. Throughout the 1980s and early 1990s there was an explosion in the realm of dressing products. Alginites, hydrogels, and foams appeared on the market in a wide variety of products. The concept of passive dressings began to change. Dressings were becoming active in their role to change the wound milieu in the healing process. The advent of growth factors and other biosynthetics such as collagen began the movement to an interactive dressing.

Today, research and development is being focused at the cellular level. Interactions of the cellular components
within the chronic wound environment and how interactive dressings can alter the wound milieu is putting dressing technology on the cutting edge. What is next may be limited only by our understanding of how the body changes from a normal healing environment to a chronic wound environment, our technological ability to create products and our imagination on how to get there.

**DRESSING CATEGORIES**

For more than two decades practitioners have been taught categories of dressings in order to understand how they work and when to use them (Table 1). The classic categories are gauze, films, alginates, foam, hydrogels, hydrocolloid, and composite dressings. Today, there is such an expanse of dressing products that the seven classic categories no longer are adequate. In order to embrace the new dressings, an eighth category was created called interactive dressings.

Hand in hand with dressing selection is the question of change frequency. The time interval for dressing change, will first and foremost, be based on sound clinical judgment. If the dressing is soiled, loose, slipping or curling at the edges it is obvious that it should be changed. If there is accumulation of fluid and debris that saturates the dressing it will need to be changed. If infection is present there may be a need for increased frequency of dressing change. All dressing products come from the manufacturer with recommendations for frequency of change or how long a particular dressing is expected to maintain its action. These recommendations should be used as guidelines with clinical judgment ruling supreme.

**Gauze Dressings (Figure 1)**

Dry woven or non-woven sponges and wraps with varying degrees of absorbency, based on design. Fabric composition may include cotton, polyester or rayon. They are available as sterile or non-sterile, in bulk, and with or without adhesive border. The gauze may be impregnated with other products such as hydrogel (to hydrate), sodium chloride (to absorb and draw).

**Transparent Films (Figure 2)**

Thought to be the very first advanced wound care dressing⁷, transparent films are polymer membranes of varying thickness with adhesive coatings on one side only to allow adherence to the skin. These dressings are impermeable to liquid and microbes but permeable to moisture vapor and atmospheric gases like oxygen. Visualization is easy since you can see the wound through the dressing. They are comfortable to wear because they can stay firmly on the skin for an extended period of time making them both an excellent secondary dressing for long wear time as well as a good primary dressing for lacerations, skin tears, and I.V. sites. Other varieties offer an island configuration with a soaker pad of non-adherent gauze, alginate pad or other component. Films have been shown to have a lower overall infection rates associated with their use than traditional gauze dressings⁸. It is important to select the correct dressing size to allow for approximately 1-inch of dressing to contact the intact periwound skin. To
remove, gently pull up just the edge of the dressing and pull/stretch the dressing at a parallel angle to the skin, breaking the seal and allowing. Do not pull straight up as this can cause damage to the epidermis.

**Figure 2**

### Alginates (Figure 3)

Calcium-alginate, calcium-sodium-alginate, and collagen alginate dressings are natural fiber dressings derived from processed seaweed. These dressings are highly absorbent and conform readily to wounds of various shapes and sizes. The chemical reaction between the dressings and the wound exudate creates a gel-like substance. The gel in turn assists in maintaining a moist wound-healing environment. An alginate can absorb up to 20 times its weight. Most alginates come in both sheet and rope form. Because alginate dressings are very porous and have no adhesive properties, secondary dressings must be used to secure them.

**Figure 3**

### Hydrogels (Figures 4 and 5)

By far one of the most versatile dressings on the market, hydrogels are primarily water and/or glycerin in composition. They are three-dimensional networks of hydrophilic polymers prepared from materials such as gelatin, polysaccharides, cross-linked polyacrylamide polymers, polyelectrolyte complexes and polymers or copolymers derived from methacrylate esters. Their function depends on their form, for instance amorphous (literally meaning “without form”) hydrogels donate moisture to the wound and offer gentle application and removal. This type also provides a good option for autolytic debridement and substitution for moist gauze. Some amorphous hydrogels additionally have the sophisticated capability to absorb and/or donate, depending on the wound’s needs. Other forms include impregnated dressings such as gauze and sheet, strand or semi occlusive varieties. The latter offers soothing, cooling relief and gentle healing to wounds such as skin tears. These dressings can and should be cut to fit the wound.

**Figure 4**

**Figure 5**
One of the initial advanced wound care dressings to come to market, hydrocolloids are occlusive and semi-occlusive dressings composed of carboxymethylcellulose, pectin, or gelatin and have different absorption capabilities depending on their thickness and composition. The original hydrocolloids were developed from the adhesive flanges used for the long term protection of skin surrounding stomas. The barrier produced when the dressing comes in contact with the tissue, prevents excretions and exudate from eroding or denuding the skin surrounding the wound. As exudate is absorbed by the dressing, it develops a thick colloidal gel in the wound bed that increases the moist healing environment necessary for granulation, epithelialization, and autolysis.

These wafers come in a variety of sizes and shapes such as the “butterfly” design or sacrum shape that are “hinged” to fit the gluteal fold of the buttocks. Look for tapered, low profile edges that decrease the chances of rolling up and a smooth satin-like outer coating to decrease friction and shear.

Although considered a low-tech option for chronic wound care, in many settings hydrocolloids remain the most heavily utilized moist dressing option for wound management.

Foams are non-adherent, absorbent dressings that vary in thickness and are obtainable in adhesive vs. non-adhesive varieties. They are composed of polymers like polyurethane with small open cells that trap moisture. They are appropriate for partial- and full-thickness wounds, provide for moist wound healing, thermoregulation and protection. Look for varieties that offer superior moisture management, micropores for low adherence to the wound bed, decreasing pain and disruption of healing and a water-proof backing to prevent strike-through bacterial penetration. Absorbency and moisture vapor permeability are varied either by a physical alteration or by uniting the foam with an added sheet element.

Composites combine two different types of dressings with several functions in one single dressing that can address different needs. They can be used as a primary and/or secondary dressing and feature an absorptive layer, an adhesive border and a strike-through barrier. These dressings are versatile and convenient offering options for both partial and full thickness wounds. Their water-proof nature makes them a popular choice for areas prone to moisture assault from incontinence. These versatile dressings provide a barrier to bioburden while offering a simple “Band-Aid” type application and removal.
Dressings that interact with the wound bed components to assist in producing an improved wound healing milieu. They can accomplish this via reducing colonization count, reducing the level of exudates, improving wound bed moisture retention, improving wound collagen matrix, removal of cellular products or providing protection for the epithelializing bed. Interactive dressings come in various forms.

Safe, broad spectrum antimicrobials or “biocides” (a general term describing a chemical agent, usually broad spectrum, that inactivates microorganisms)\(^1\) and wound dressing products containing these agents have been developed to address the needs of chronic wounds with the intent to minimize colonization and prevent local infection, thereby enhancing healing. Both in vitro as well as clinical observations support the utilization of various biocide and antimicrobial products\(^17\). Several of these products are outlined below.

**Silver**

Silver is more universally effective than antibiotics, more broadly powerful than chlorine and blocks the growth of gram negative and gram positive bacteria including resistant MRSA and VRE, fungi, viruses and yeast. An important feature of ionic silver is that it kills detrimental microbes but it is non-cytotoxic to proliferating granulation tissue, in the right concentrations\(^2\).

The use of silver has been documented for its broad-spectrum antimicrobial activity and compatibility with humans throughout history. The present recognized antimicrobial properties of silver have been empirically evident for more than 3000 years\(^3\). A plethora of literature has reviewed its historical use, antimicrobial properties and toxicity. In 1881, a German obstetrician named Dr. Crede used a 1% silver nitrate solution to eliminate congenital blindness (Ophthalmia neonatorum) in newborns caused by post-partum infection of *Neisseria gonorrhea*\(^4\). In 1887, von Behring used the same compound to treat

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\(^1\) Ovington LG. The truth about silver. *Ostomy Wound Management* 2004;50(9A) suppl, 1S-10S.


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**Interactive**

**Antimicrobials (Figure 9)**

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typhoid and anthrax. In 1964, Moyer\(^5\) first used silver for the care of burns. And in 1968, Fox\(^6\) introduced silver sulfadiazine (SSD), still used today despite the availability of more advanced and effective products.

As is true with all antimicrobials, too high a concentration of silver ions can prove to be cytotoxic\(^7\). Available in many different forms, ionic silver is safe and little or no evidence of associated clinical resistance\(^8\). This is because of silver's multifaceted mode of action on pathogenic metabolic pathways. Silver ions attack the cell membrane, the membrane transport system, the RNA and DNA function as well as the protein function rendering it nearly impossible for bacterial mutation to occur. With ease it can occur when antibiotics are used. Antibiotic resistant bacteria, for example MRSA and VRE are easily eliminated in dressings that have silver ions present. The longevity of silver ion presence in the dressings, through their controlled release mechanisms, ensures that the wound environment is hostile to bioburden for relatively long periods of time.

It is rare to observe allergic reactions or sensitization associated with silver. No other unfavorable side effects have been clinically observed despite the widespread use of silver containing dressings, especially in burn wound applications.

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5 Moyer CA, Brentono L, Gravens DL, Margrat HW, Monafo WW. Treatment of large human burns with 0.5% silver nitrate solution. *Arch Surg.* 1965;90:812.


Summary of the Key Differences between Ionic Silver and Silver Sulfadiazine

<table>
<thead>
<tr>
<th><strong>Silver Amorphous Hydrogel</strong></th>
<th><strong>Silver Sulfadiazine (Silvadene®)</strong></th>
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<tbody>
<tr>
<td>Silver-salt in a gel base, ionic silver, a device, not a drug</td>
<td>Silver salt of sulfa drug, requires a prescription</td>
</tr>
<tr>
<td>Effective broad-spectrum antimicrobial</td>
<td>Effective broad-spectrum antimicrobial</td>
</tr>
<tr>
<td>Effective for 3 days – self-regulating for controlled release of silver, reaches wound equilibrium of 1-2 parts per million in silver ions.</td>
<td>Applied a minimum of B.I.D. Silver ion release data reported variably. Clinicians seem to believe that all silver related activity is exhausted within the first 8-10 hours within the wound, necessitating removal of the product (pseudoeschar, see below), and reapplication twice daily at minimum.</td>
</tr>
<tr>
<td>Non-Cytotoxic to delicate wound tissue.</td>
<td>Toxic. Usually limited use to 2 weeks</td>
</tr>
<tr>
<td>Amorphous gel base is non-irritating, though “stinging” may be experienced in isolated cases.</td>
<td>Sulfa/petrolatum combination is a common skin irritant/allergen. Sulfa drug use, with its specific mutation susceptible method of “kill” may result in resistance buildup in micro-organisms. Adverse reaction of hematologic neutropenia in up to 5% of patients receiving.</td>
</tr>
</tbody>
</table>
Less painful and easy to apply and remove. Removal is not required as no pseudo-eschar is formed.  

More painful – Difficult to remove. Forms a pseudo-eschar that may need to be surgically removed (scraped), causing pain, wound bed disruption, and may initiate scarring responses (Glat PM, et al. Randomized clinical study of SilvaSorb Gel in Comparison to Silvadene silver sulfadiazine cream in the management of partial thickness burns, Journal of Burn Care & Research, 2009, 20(2):262-267.).

Non-staining to skin and tissue  

Stains wound bed and peri-wound skin (possibly permanently), causing disfigurement and potentially interfering with assessment

Less frequent dressing changes; staff time savings  

Time-consuming for staff to apply and remove; disruptive to patient and wound environment.

Does not “melt”, i.e. change viscosity significantly upon application, thus stays in place easily.  

Because product is based on petrolatum, it tends to liquefy at body temperature, and tends to “slip off” the wound. Cells do not proliferate well and tolerate an oil environment.

Anti-inflammatory action  

Pro-inflammatory action

Sophisticated microlattice delivery system that liberates silver into the tissue and is effective for three days.  

Unsophisticated delivery system, lower level of ionic silver, not stable in moisture.

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Researchers have tried to create transmittable mutations that will propagate in an environment without the antimicrobial (silver), just as antibiotic resistant organisms propagate in the clinic or an in vitro situation mimicking the clinic, in the presence or absence of antibiotics. Those experiments have shown that artificially created silver resistance in the laboratory is poorly transmitted in successive generations. In addition, silver in a low concentration is present in normal environment because silver ions are present in the environment. As precious metals go, silver is not a particularly rare element in nature, and thus the development of resistance to silver is rather unlikely. Finally, the mode of action of silver ions on the living pathogen is so multifarious in nature that it is difficult for pathogens to mutate to respond to all the mechanisms that exist to explain the lethality of silver ions. Antibiotics on the other hand, have a single mode of lethality, and it is easy for the pathogens to develop resistance, a single mutation can cause such resistance.20
It is true that at least two cases of isolation of silver resistance has been noted in clinical isolates (one in Hong Kong, one in London, UK). However, these isolates did not present any clinical challenges to healing, and more importantly, these isolates, which seem to have developed through a random genetic resistance development, did not respond to any commercial silver product, irrespective of the concentration of silver ion (release rate) that was associated with the product\textsuperscript{21,22}.

\textit{Silver Reservoirs}

Fundamentally speaking, as long as the silver reservoir (whether it be metallic silver which has to ionize to make the lethal agent Ag\textsuperscript{+}, or a compound of silver that instantly dissolves in a wound fluid) is not limiting, a natural law called the Le Chatelier's principle will determine the concentration of silver ions in the wound bed. According to this principle, in a chloride rich wound environment (all wound environments have a large amount of chloride ions present in them), ALL silver dressings will result in a concentration of 1-2 parts per million (ppm) in the wound bed, which roughly corresponds to the concentration of the silver ions when such dressings are tested in physiological saline. The fact is that the 60-70 ppm that is commonly referred to as the concentration emanating from a nanocrystalline silver is seen only when a medium such as distilled water is used for the testing. It is possible that such dressings provide a higher concentration (more than the equilibrium 1-2 ppm) of silver ions in a transient fashion. However, the only benefit of such a bolus effect is a high log rate kill in a wound when the dressing is first applied. The cost to such bolus effects seems to be the high cytotoxicity that is seen with these so called "high-silver" dressings, and there is some clinical evidence to show that such dressings may actually delay wound healing\textsuperscript{23,24}. Both nanocrystalline silver, as well as ionic silver showed similar antimicrobial efficacy in \textit{in vitro} testing.

There has been a lot of variation in the test methods used to determine silver concentration in numerous publications. There appears to be no standard technique\textsuperscript{25}. There is clearly a discrepancy between laws of nature (silver ion concentration in ANY environment is determined by immutable laws of nature) that "it is of interest to note that the MICs recorded by us and others are in excess of the reported maximum solubility of SSD, namely 1.32 microgram/ml" (which is 1.32 ppm, in the 1-2 ppm "law of nature" range that other authors have lately shown to be the only possible silver ion equilibrium concentration in the wound bed. Head to head testing, in a physiological medium (such as normal saline) seems to provide the best relative measurement of the silver release rates of the various products. It is also true that silver ions will indeed bind to organic matter. But the point is that in doing so, the silver concentration is transiently reduced from the "law of nature" concentration of 1-2 ppm, causing more of the silver reservoir (be it metallic silver, or an ionic salt of silver) to ionize, and the "law of nature" equilibrium concentration of 1-2 ppm is rapidly restored, irrespective of the type of silver dressing used\textsuperscript{26}. That is the Le Chatelier's principle at work.

Currently there is a plethora of silver products on the market with a wide range of silver delivery. Thomas and McCubbin, examined the silver content and antimicrobial activity of 10 common silver dressings on the market. They found significant differences in the activity of the products. There was a clear...
relationship between the silver content of the dressing and ability of the dressing to be bactericidal but other factors were also identified. Other factors included: was whether the silver was a surface coating or dispersed within the structure of the dressing; what form of silver (ionic, metallic or bound, and the dressings affinity for moisture. Dressings which had surface silver, silver in ionic form and those dressings that retained moisture performed the best. The challenge to clinicians is to critically examine the wide selections of silver products and choose those that will perform optimally.

**Polyhexamethylene biguanide (PHMB)**

Polyhexamethylene biguanide is a polymeric broad-spectrum cationic antimicrobial agent that is odorless, clear and colorless. PHMB is a membrane-active agent that also impairs the integrity of the outer membrane of gram-positive and gram-negative bacteria, although the membrane may also act as a permeability barrier. Recently this agent has been added to dressings as both barriers and active antimicrobials capable of impairing or preventing the growth and penetration from a barrier perspective and actively killing pathogens such as MRSA, vancomycin-resistant Enterococci (VRE), Escherichia coli, Pseudomonas aeruginosa, Bacteroides fragilis, Clostridium perfringens and yeasts such as Candida albicans from a sustained antimicrobial activity.

PHMB has been safely used in ophthalmic solutions, peri-operative cleansing solutions and other consumer products such as mouth wash.

The cytotoxicity and hemolysis profile of PHMB containing products is excellent. PHMB is neither a primary skin irritant nor a hypersensitizing agent, which make it particularly well-suited to chronic wound care. There is little or no evidence to suggest that the use of PHMB would lead to the emergence of resistant strains to the agent, or it many encourage development of cross resistance to antibiotics. The addition of this safe and effective versatile biocide is a positive development in wound management.

**Cadexomer Iodine**

Iodine is a potent broad-spectrum antiseptic agent with a controversial past since it has been shown to impair the function of cells involved in wound

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13 Data on file. Xylos Corporation, Longhorne, PA.


healing in vitro. Improved formulations of iodophors or "iodine carriers" provide a release of low levels of iodine over a longer period of time. These present the clinician with a viable iodine containing product for wound bioburden management. They have been available for several years in the form of cadexomer iodine. Cadexomer iodine is a slow-release antimicrobial capable of absorbing excess wound exudate while offering a sustained level of iodine in the wound bed. Appraisal of its benefits show that it is accepted topically and has demonstrated accelerated healing of chronic leg ulcers. Cadexomer iodine also has established effectiveness in vivo against Staphylococcus aureus and methicillin-resistant Staphylococcus aureus. Iodine needs moisture/hydration in order to be activated, similar to silver ion containing products. The clinical trend in recent years have been more favorable to silver and PHMB containing products compared to iodine containing products.

**Bacteriostatic Foam Dressing**

Bacteriostatic, absorptive moist wound healing PVA foam bound with two organic pigments (methylene blue and gentian violet) that inhibits the growth of bacteria that can lead to infection. Inhibits the growth of microorganisms. Indicated for the use of prevention of wound infection in local management of wounds such as pressure ulcers, venous stasis ulcers, arterial ulcers, donor sites, abrasions, laceration, radiation burns, post-surgical incisions, and other wounds caused by trauma.

Keep in mind that bacteriostatic dressings help prevent an overgrowth of bacteria and keep bacteria from growing in the dressing itself. Bacteriocidal dressings and broad spectrum antimicrobial dressings actually have the ability to kill pathogens such as bacteria.

**Honey Dressings**

Referenced as one of the oldest wound dressings in ancient medical writings of Egypt, Greece and parts of India, new honey-based dressings and products are now available and thought to have anti-inflammatory, antibacterial, debridement and odor control properties as well as possessing wound healing capabilities promoting fibroblast activity, angiogenesis and epithelialization. Honey based wound dressings have been used in a variety of chronic and acute wounds as well as burns and various dermatologic manifestations such as atopic dermatitis.

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recalcitrant wounds as compared to standard of care.\textsuperscript{29, 30}

Figure 10

Produced by fibroblasts, collagen represents the most abundant protein in the human body and the skin.\textsuperscript{31} It is a natural structural protein found in all three phases of the wound healing cascade and stimulates cellular migration and contributes to new tissue development and wound debridement.\textsuperscript{32} Collagen dressings in the form of sheets, gels, and particles encourage the deposition and organization of newly formed tissue, creating an environment that fosters healing. These materials are known to stimulate and recruit specific cells such as macrophages and fibroblasts to positively enhance and influence wound healing. They can be moisturizing or absorptive, depending on the delivery system, maintaining moist wound healing, are easy to apply and remove and tend to be conformable.

Collagen dressings are usually formulated with bovine (derived from cows) or avian collagen (derived from birds) or porcine collagen (derived from pigs). Two proteolytic enzymes, the matrix metalloproteases (MMPs) and elastase levels climb in chronic wounds, causing them to stagnate and disrupt the cycle of chronicity. Collagen derived dressing materials, especially native (non-denatured) dressings that have gone through gentler extraction and purification process have been shown to bring the detrimental enzymes into check and allowing fibroblasts to begin laying down more endogenous collagen to close wounds.\textsuperscript{33}

Figure 11

- Polyacrylates (Figure 12)

This activated absorbent polyacrylate polymer core dressing absorbs large protein molecules (necrotic tissue and bacteria) while irrigating with Ringer’s solution, a physiologic fluid, creating a “rinsing effect”. The interactive dressing supports both moist wound
healing and autolytic debridement, gently removing dead tissue from the wound bed while creating an ideal healing environment. Polyacrylates debride at a mean rate of 38%\textsuperscript{34}. New research shows that polyacrylate gel absorbents debride just as well as collagenase\textsuperscript{35}. Recent literature has also shown that the product may be effective in reducing wound bioburden by interfering with biofilm as well\textsuperscript{36}.

Most odors are lipophilic. Novel dressings that utilize cyclodextrins (same technology as in Febreze\textsuperscript{®}, Proctor and Gamble, Cincinnati, Ohio) use a bucket-shaped conformation of the hydrated cyclodextrin molecule to capture lipophilic odor molecules, which then neutralize the odor (see figure 13). Cyclodextrins occur naturally and are proven safe to use in modern wound care. How do these newer odor elimination dressings compare to the older technology of charcoal based dressings? Cyclodextrins work optimally in the presence of wound exudate and need humidity to work effectively\textsuperscript{42}. Charcoal activity decreases in the presence of wound exudate. Additionally, serum proteins inactivate charcoal dressings, while cyclodextrins' odor absorbing function is enhanced by it\textsuperscript{43}. In addition, cyclodextrins intrinsically have a longer active time of odor absorbing function by nature of their material\textsuperscript{44}.

Prudent wound bed preparation including debridement, thorough
cleansing, managing bioburden and exudates is a best practice, “first step” in eradicating malodor in wounds.\textsuperscript{45}

Figure 13. Molecular structure and bucket-shaped conformation of the cyclodextrin (starch) molecule capture lipophilic odor molecules, which neutralize the odor.

**MANAGING PAIN WITH DRESSINGS**

Dressing removal is considered to be the time of most pain.\textsuperscript{46} Dried dressing and adherent products are most likely to cause pain and trauma at dressing changes. Products designed to be non-traumatic should be used to prevent tissue trauma.

One of the most important things to consider in selecting a dressing to diminish pain in the wound is that the chosen dressing must minimize the degree of sensory stimulus to the sensitized wound area.\textsuperscript{47} Any dressing that sticks to the wound bed, such as gauze, or dries within the wound bed and is then pulled away sends more sensory information to receptors in the skin than one that is easily rinsed away or slides off the inflamed tissue.\textsuperscript{48} Dressings, such as sheet and amorphous hydrogels, hydrofibers, alginites, soft silicones,\textsuperscript{49} cellulose dressings\textsuperscript{50} provide beneficial wound healing environments and also offer a virtually pain-free dressing removal while curtailing the pain experience during wearing time.

Select dressings with absorbency that matches exudate levels.\textsuperscript{51} Choose dressings that can remain \emph{in situ} for longer periods of time,\textsuperscript{52} thus minimizing the chances of wound manipulation and a harmful aggravation of the pain cycle. Contact layers or dressings that remain in close proximity to the wound bed during dressing changes also have proven beneficial in the pain arena.\textsuperscript{53} Don’t neglect pain management during wound cleansing, either. Appropriate non-cytotoxic wound cleansers used at body temperature (~100°F) assist in keeping discomfort lower.\textsuperscript{54} Avoid cytotoxic solutions, such as povidone iodine or hydrogen peroxide, when cleaning the wound as these can cause discomfort as well as being lethal to fibroblasts and keratinocytes. Simple measures, such as the use of skin preparations (primarily the no-sting varieties), polymers that adhere and/or chemically bond to the skin to strengthen and prepare it for the adhesive application, provide less trauma to sensitive peri wound skin.\textsuperscript{55} Use them whenever you dress a wound. When removing a dressing, make every possible effort to avoid unnecessary manipulation of the wound and prevent further damage to the delicate granulation and healing tissue within the wound bed and peri wound skin. If the dressing has become dried out, moisten it with an isotonic solution before removing.\textsuperscript{56} Choose dressings that allow less frequent and therefore less painful dressing changes. Also, consider
contact layers that stay in place when the dressings are changed, thus staving off potential wound bed pain. Another area of concern with regard to the wound care patient and pain is how the dressing is attached. A study by Dykes and colleagues showed that some adhesive dressing caused skin stripping upon removal\textsuperscript{58}. One of the many myths surrounding wound pain is that, “paper tape is the least painful way to secure a dressing”. Heightened nerve sensation in a wide area around a wound can make any adhesive tape painful to remove\textsuperscript{59}. A thorough review of the dressings and tapes that you and your facility use is imperative. Are they gentle on thin, aging epidermis, young immature integument and skin that has endured critical illness, adhering with a low sensitivity adhesive, yet allowing easy removal and repositioning? Careful evaluation of your protocols is a necessary and important first step. State-of-the-art “tapeless” ways of securing a dressing have been around for centuries: Montgomery straps, Kling gauze, cohesive tape, elastic netting, “grip” elastic support bandages and tubular dressings that offer a bit of support and compression (7-8 mm Hg) not only provide support to the dressing but further protect from the injury and pain of removal and reapplication of tape\textsuperscript{60}.

CURRENT BEST PRACTICES

Until research proves otherwise, current guidelines for treatment and care of pressure ulcers have supported the use of clean dressings and clean dressing change technique over sterile methods\textsuperscript{61}. Bergstrom and her colleagues have shown that there is not sufficient evidence that using sterile technique has any significant effect on wound healing outcomes. Expert opinion advocates a no-touch technique that tries to guarantee that the procedure utilized to treat wounds will not increase the ulcer’s bioburden. In the case of patients with compromised immune systems (i.e., cancer, HIV, AIDS, organ transplant), sterile dressings and sterile technique is warranted.

Standardization of products and wound treatments generates benefits, primarily when protocols and clinical pathways are established collaboratively based on recent published guidelines, a review of the literature for available research and/or best practice\textsuperscript{62}.

DRESSING SELECTION

For the clinician today, the job of selecting a dressing can be daunting. The use of the traditional six categories of dressings is no longer adequate as most of the latest dressings do not fit easily in a category and actually manage the tasks of multiple categories. The first step in selection is understanding the four basic goals of wound healing.

Wound bed preparation, including debridement and bioburden control are mainstays for effective wound healing (Sibbald RG, Williamson D, Orsted HL, Campbell K, Keast D, Krasner D, Sibbald D. Preparing the wound bed – debridement, bacterial balance and moisture balance. O/WM. 2000;46(11):14-35. and Falanga V. Classification for wound bed preparation and stimulation of chronic wounds. Wound Rep Regn. 2000;8:347-352.). The savvy clinician need only remember the acronym D.I.M.E.S. to prompt prudent and methodical care. D = Debridement I = Infection and Inflammation M = Moisture balance E = Wound’s Edge and S = Supportive products, services and education. See diagram below in figure 14:
Figure 14. The D.I.M.E.S. model of wound bed preparation.

Goals include, maintaining a moist healing environment. Moist wound healing promotes epithelialization, enhances autolytic debridement, prevents wound desiccation and decreases pain. The second objective is to remove eschar and debris from the wound bed. This will decrease bioburden, improve epithelialization and decrease inflammation. The third goal is to control exudate. Increased exudate can cause periwound maceration and contributes to an increased bioburden in the wound. The fourth purpose is to prevent further wounding. Patients may unknowingly traumatize their wounds due to neuropathy or a dressing or product may be chosen which actually traumatizes the wound or surrounding skin.

In this article, two methods of dressing selection are covered.

The first methodology of dressing selection has been recently published by Fleck and focuses on nine simple questions.

1. Is the wound healing?

If the answer is “yes”, proceed with current best practice treatment. If the answer is “no”, consider other etiologies and care modalities, assess bioburden (bacterial or other microbial overload in the wound), look at intrinsic and extrinsic risk factors such as nutrition, pressure, shear, etiology, debris and devitalized material in the wound bed, temperature of the wound,
circulation, maceration, desiccation, chemical stress and medications as well as other co-morbidities. Confer and consult with colleagues if this is outside your scope of knowledge and/or practice. You should expect to see progress toward wound healing within 2-4 weeks of initiation of treatment.

2. **Is the tissue viable (living) or necrotic (dead)?**

The single most important parameter in reducing the level of bacterial contamination in the chronic wound is removal of all devitalized material. If it is viable, support it and keep it moist. Vital, healthy living tissue is usually red or pink. If it is necrotic, debride it. Necrotic tissue can be yellow, gray, black or some combination of these colors. It has no function, other than to slow healing, splint the wound open and provide a breeding ground for critical colonization. A dry cell is a dead cell so moist wound healing is the goal with all wounds. Dr. George Winter’s studies in the early 1960s proved that moist wound healing provided for better healing outcomes with less pain and scarring. The work of Hinman and Maibach further connected these findings in human models just a year later.

3. **Is the wound wet or dry?**

For most favorable outcomes, providing an optimal level of moisture is recommended. If the wound is “wet”, apply a product that donates or maintains moisture at optimal levels. One of the most important criteria for dressing selection is exudate amount.

Research and clinical experience have identified that in a moist environment, exudate provides the cells involved in wound repair with nutrients, controls infection and provides the best environment for healing. Moreover, revascularization occurs earlier in moist conditions. Studies have demonstrated that cells communicate and respond to growth factors and cytokines contained within wound exudate.

4. **Is there dead or open space in the wound?**

If so and it is deep, it is necessary to fill the space, loosely packing the open area when dressing the wound. If there is no dead space, covering the wound, if it is flat, is all that’s required. Covering the wound provides a physical barrier to microbes, a humid, moist and thermally insulated environment and protection from the outside environment.

5. **Is the wound or surrounding area edematous?**

Many wounds are accompanied by edema beyond the inflammatory phase. Furthermore, lower limb wounds are often secondary to poor venous return or venous hypertension. Without compression these wounds fail...
to progress\textsuperscript{84,85}. Evaluate lower limb wounds, ascertaining the patient’s ankle brachial index (ABI) and/or toe brachial index before applying compression wraps.

6. What is the condition of the peri-wound skin or the skin surrounding the wound (including the skin of a recently closed wound)?

If the skin surrounding the wound is compromised and/or painful, avoid adhesives or use great caution. Use of a polymer skin preparation, especially the no-sting varieties\textsuperscript{86}, before attaching any dressing is helpful. This will assist to strengthen and protect the skin without causing pain or discomfort. Also consider using protective products such as barrier creams and adhesive removers to treat this vulnerable skin with care. Soap-free, pH balanced non-cytotoxic cleansers should additionally be used to gently cleanse the area surrounding a wound\textsuperscript{87}. Remember, this is the skin that will eventually support the wound healing and from where the epithelial cells will migrate\textsuperscript{88}.

7. Is the wound painful?

Identify whether or not the wound is painful. Is the pain constant or only during procedures or dressing changes or manipulation. It is also important to assess when the pain began since pain can be an indicator of critical colonization. See Managing Pain with Dressings section for more information about pain management and dressings to diminish discomfort. Default is that all wound are painful. Simple measures such as selecting a dressing with absorbency that matches the exudates level of the wound, considering a contact layer that remains in contact with the wound bed during dressing change, helping to diminish pain, and avoiding gauze, the most painful dressing category, should be followed.

8. Does the wound have odor?

Odor can be associated with a variety of wounds including pressure ulcers, venous leg ulcers diabetic and neuropathic wounds, fungating cancerous ulcers, malignant lesions and wounds with necrotic tissue\textsuperscript{89}. The first step to eradicating odor is to identify the cause and eliminate it. Then prepare the wound bed, debride devitalized tissue, increase wound cleansing and consider the use of a safe antimicrobial cleansers with benzalkonium chloride (BZK) or benzethonium chloride (BC). Current treatment options include metronidazole (flagyl) to reduce anaerobic infection and ionic silver powder and gel, which is effective against both aerobes and anaerobes, gram positive and gram negative bacteria\textsuperscript{90}.

9. Is the wound stalled out?

Despite prudent care, has progress toward healing ceased? Wounds fail to thrive for a variety of reasons including: poor nutrition, lack of blood flow, unrelieved pressure, poor care, systemic disease with three local factors that can be alleviated with advanced dressings. Those
factors are: critical colonization and infection, senescence and increased proteolytic enzymes. Advanced ionic silver, PHMB, and cadexomer iodine dressings can help bring the bacteria and bioburden into check. Advanced collagen dressings can help to bind and soak up the proeolytic enzymes such as matrix metalloproteases (MMPs) and Elastase, in addition to providing a structure for fibroblasts to proliferate and offering a sacrificial substrate as a “food” source to the destructive enzymes.

The second is based upon Ovington’s methodology. Goals, form, and function is combined with a nursing assessment of the wound and the patient prior to dressing selection. The dressing must match the patient, the wound, and the setting. In Ovington’s article, she presents an all-purpose performance-based approach to using wound dressings by asking six basic assessment questions when deciding on a wound dressing:

- **What does the wound need?** Determined by a complete assessment of the wound and surrounding tissues. Assessment is performed at each dressing change, including the initial. Apply the goals. Anticipate that the needs of the wound will change as the tissue envelope normalizes and the healing process progresses.
- **What does the product do?** This is the function. Read the product literature and clinical data available.
- **How well does it do it?** Examine clinical studies and laboratory comparisons to other products in the same category. Talk with other clinicians. Evaluate it on your patients. Does the dressing perform how it is stated? Not all dressings are equal.
- **What does the patient need?** Comprehensive assessment of the patient, including psychosocial. Do they need a dressing that doesn’t require daily changes, do they need protection from trauma, or is there a large amount of exudate?
- **What is available?** Health insurance coverage, facility formulary and reimbursement?
- **What is practical?** Examine the goals of wound management. Does the dressing choice satisfy the goals? Is the dressing easy to apply (patient/family), easy to obtain and cost effective?

Cost effectiveness of the product should be considered during the selection process. This means understanding indirect costs as well as the direct cost involved in wound care. Direct cost examples include, but are not limited to the primary and secondary dressings, pharmacy, caregiver time, and diagnostic procedures. Indirect costs are similar to overhead costs, and include examples such as increased length of stays, treatment complications and litigation. The clinician should read published studies critically to take cost-per-unit outcome into account to determine if treatment measures are indeed cost effective. Sometimes the most expensive product can be less expensive in the long run because it leads to faster healing with a reduced amount of complications.

**WET-TO-DRY AND MOIST GAUZE**

In the United States, wet-to-dry and gauze dressings are still the most commonly used primary dressing substance. Many reasons for the persistence of gauze and saline used as wound management mainstays
include: lack of knowledge from physicians and nurses on advanced dressings and how they work, confusion due to the plethora of advanced products, incorrect view that advanced dressings come with a high price, and gauze is a "one size fits all" modality that is readily available, perceived as inexpensive and the dressings have been used throughout history since the practice is propagated in the medical school and surgical training. There is also evidence that they are used inappropriately. Recent journal articles, texts, as well as expert opinion support the principle of moist wound healing, but in practice the use of gauze, predominantly as a wet-to-dry dressing, does not guarantee a moist wound environment.

Wet-to-dry dressings are described in the literature as a means of mechanical debridement. Debridement is the mainstay of wound bed preparation since devitalized material harbors bacteria, delays healing and increases the risk of infection. However, it is the opinion of this author that wet-to-dry or moist gauze does not constitute advanced wound caring or advanced therapy. Granted, wet-to-dry gauze is a form of non-selective debridement, however, it is painful if the patient is sensate and can produce negative outcomes. Gauze dressings are not an optimal wound care choice for the patient, the caregiver or the healthcare system and facility. They do not support optimal granulation and healing and are more labor intensive to use than advanced dressings such as polyacrylates, transparent films, hydrocolloids, alginates, hydrogels and foams. Therefore, these archaic regimes should be abandoned since they are not considered standard of care despite The Agency for Healthcare Research and Quality (AHRQ), formerly the Agency for Health Care Policy and Research (AHCPR), Clinical Practice Guidelines for Treatment of Pressure Ulcers have supported the use of wet-to-dry dressing for debridement by maintaining that its use is backed by expert opinion (rated as C on their scale of hierarchy of evidence).

Ovington describes gauze as the most widely used wound care dressing and may be erroneously considered a standard of care. Her article comments that 'wet-to-dry' and 'wet-to-moist' are frequently used in clinical practice in a fashion that makes them interchangeable. She describes hampered healing due to local tissue cooling, disruption of angiogenesis by dressing removal, and increased infection risk from frequent dressing changes, strike through, and prolonged inflammation as good reason to abandon this 'traditional' dressing technique. Ovington also offers a cost-effectiveness argument for change. She illustrates the costs of saline and gauze compared with an advanced dressing (Tielle, Johnson & Johnson Wound Management, Somerville, New Jersey), over a four-week period, performed by a home health nurse. The largest contribution to cost is nursing time; even with the patient and/or family doing some of his or her care, the cost is decreased with the advanced dressing secondary to fewer dressing changes and better outcomes (less time to closure).

Another investigator, Coyne, examined the cost-benefit of wet-to-dry compared to another advanced dressing, polyacrylate moist wound dressing (TenderWet, Medline Industries, Inc. Advanced Skin and Wound Care, Mundelein, IL) in a nationwide 65 location home care agency (TLC/Staff Builders) realizing a 26% cost-savings alone annually, pointing out that wet-to-dry treatments additionally cause pain, slower healing and an increased
There are other important considerations when choosing a dressing, such as clinical outcome, quality of life issues, discomfort, disruption of daily routines, and coping with daily activities that can all be addressed by modern products\textsuperscript{103}. A comparison of wet-to-dry gauze and polyacrylate moist wound and debriding dressing is summarized in the table below:

<table>
<thead>
<tr>
<th><strong>Polyacrylate Debriding Wound Dressing</strong> (TenderWet\textsuperscript{®} Active)</th>
<th><strong>Wet-to-dry</strong> (saline and gauze)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absorbs planktonic bacteria and disrupts biofilm (Bruggisser, 2005)\textsuperscript{104} as well as MMPs (Eming, et al, 2008)\textsuperscript{105}</td>
<td>Increases the chances of external contamination and infection as well as cross-contamination. Bacteria can travel through 64 layers of gauze (Lawrence, 1994)\textsuperscript{106}.</td>
</tr>
<tr>
<td>Maintains wound temperature for 24 hour period</td>
<td>Frequent (T.I.D. and Q.I.D) dressing changes lead to a drop in wound temperature, causing vasoconstriction and decrease in blood perfusion, further drastically impairing the ability of oxygen to clear bacteria from the wound leading to an increase in tissue infectability.</td>
</tr>
<tr>
<td>Preserves wound moisture and promotes moist wound healing (Fleck and Chakravarthy, 2009)\textsuperscript{107}</td>
<td>Does little to impede fluid evaporation and does not provide moist wound healing unless kept continuously wet</td>
</tr>
<tr>
<td>Multiple literature and research sources to prove efficacy</td>
<td>“Traditional” dressing, despite evidence to the contrary</td>
</tr>
<tr>
<td>Cost-effective (Coyne, 2003\textsuperscript{108} and Murano, 2004)</td>
<td>Cost prohibitive secondary to caregiver time and frequency of change, etc.</td>
</tr>
<tr>
<td>Pain-free advanced dressing modality (Konig, et al, 2005)\textsuperscript{109}</td>
<td>Painful and barbaric dressing causing substantial patient discomfort and wound bed disturbance.</td>
</tr>
<tr>
<td>Effective selective mechanical debridement (mean rate of 38%) (Paustian and Stegman, 2003)\textsuperscript{110}</td>
<td>Non-selective mechanical debridement, causing tissue destruction and injury at each dressing change, delaying healing</td>
</tr>
<tr>
<td>Contains wound debris and bacteria</td>
<td>Dried dressing removal disperses significant amount of bacteria into the air (Lawrence, Lilly &amp; Kidson, 1992)\textsuperscript{111}</td>
</tr>
<tr>
<td>Anti-inflammatory dressing action</td>
<td>Prolonged inflammatory phase of wound healing (Ovington, 2000)\textsuperscript{112}</td>
</tr>
<tr>
<td>Ease of patient compliance/adherence to routine (Flemister, 2000)</td>
<td>Poor patient compliance/adherence (Sibbald et al, 2000)</td>
</tr>
<tr>
<td>--------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Isotonic (Ringer’s solution) homeostatic dressing from application to removal, promoting moist wound healing throughout.</td>
<td>As saline evaporates, becomes hypertonic and fluid from the wound is then drawn into the dressing promoting desiccation of the tissue. As the wound dries, cell migration and proliferation are impeded (Kim, et al, 2000).</td>
</tr>
</tbody>
</table>

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