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FEATURED

Wound Dressing Agents

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Introduction

In preceding articles we discussed four of the five strategies that are necessary for optimal management of problem wounds.[1-6] This article discusses the fifth strategy, namely selection of the wound dressing agent. Of the five strategies, the wound dressing agent selection strategy has the most superlatives (**Table 1**). First, it has by far the largest number of selection choices. It is estimated that over 2,400 agents are available for covering the wound base.[7] Second, with the proliferation of facilities devoted to wound treatment, the dressing selection option is, in our observations, the strategy that gives the treatment centers the distinction of being the "experts" on wound management. Third, the most tangible evidence of wound improvement is through serial inspections of the wound base, and credit (whether justifiable or not) is often ascribed to the selection of the wound dressing agent. Fourth, the wound dressing agent selection has the widest number of choices with the least number of complications, side-effects, and/or potential hazards of any of the four other treatment strategies (**Table 1**). That is, wound dressing agents can almost be selected with impunity; if they do not work it is a fault of the wound and the solution is selection of another dressing agent. Fifth, the costs of wound dressing agents can vary from a few cents per application for moist gauze dressings to hundreds of dollars for agents with growth factors in them and thousands of dollars for bioengineered wound covering agents. The following

Table 1

STRATEGIES FOR MANAGING PROBLEM WOUNDS

Strategy	Comment	Source Information
Management of the Wound Base	**Primary:** Superficial Debridements **Secondary:** In-office Procedures Tertiary: In-OR procedures	***MMW*** — Chapter 7 ***WCHM*** — *2011 June; 2(2): 14-30*
Protection and Stabilization	**Hierarchy:** Padded dressings → Splints → Removable boots → Casts → External fixation → Internal fixation	***MMW*** — Chapter 8 ***WCHM*** — *2011 July; 3(2): 33-53*
Medical Management	**Hierarchy:** Wound Care Provider→ Primary Care Provider → Specialist →	***MMW*** — Chapter 6 ***WCHM*** — *2011 October; 2(4): 13-32*
Selection of the Wound Dressing Agent	**"Lumper's" approach to over 2,000 choices; the theme of this article**	***MMW*** — Chapter 9
Wound Oxygenation	**Secondary Mechanisms:** 1) Vasoconstriction, 2) Host cellular, 3) Microbiological effects, 4) Reperfusion injury, 5) Washout/counter diffusion, 6) RBC deformability, 7) Blood-brain barrier effects	***MMW*** — Chapter 10 ***WCHM*** — *2012; 3(2): 36-51* (Wound oxygenation) ***WCHM*** — *2012; 3(3): 27-42* (Primary mechanisms)

Notes: Five strategies are essential for managing all problem wounds. This is the last article in this series describing the strategic management of these wounds; it discusses wound dressing agents.

MMW: MasterMinding Wounds, Strauss, M.B, et al., 2010, Best Publishing Company, Palm Beach Gardens, FL 33410
WCHM: Wound Care & Hyperbaric Medicine [Journal], Best Publishing Company

information considers each of these superlatives. This information provides an introduction to the thesis of this article, the categorization of the wound dressing agents, their special features, and generic examples of each.

Number of Choices

With so many choices of wound dressing agents, is there any way to make sense out of them and provide an approach to logical decision-making in their use? It is more than fanciful thinking to expect any wound care provider to be familiar with over 2,000 wound dressing agents? To resolve this "splitters" problem, the answer is to "lump" agents with similar effects into categories. Familiarity with a category will provide sufficient information for the provider to make appropriate decisions about any particular agent in that category and provide a logical approach to the selection process. By using a "lumper's" approach, wound dressing agents can be categorized into four distinct types (**Table 2**). They include: **1) gauze dressings with or without moisturizing agents, 2) permeable and semi-permeable membranes or skin substitutes, 3) agents primarily directed at absorbing secretions, and 4) gels, ointments, and salves with or without additives. To somewhat complicate the decision making process, mechanisms from two categories may be used such as combining an additive to an absorptive agent.**

Wound Treatment Centers

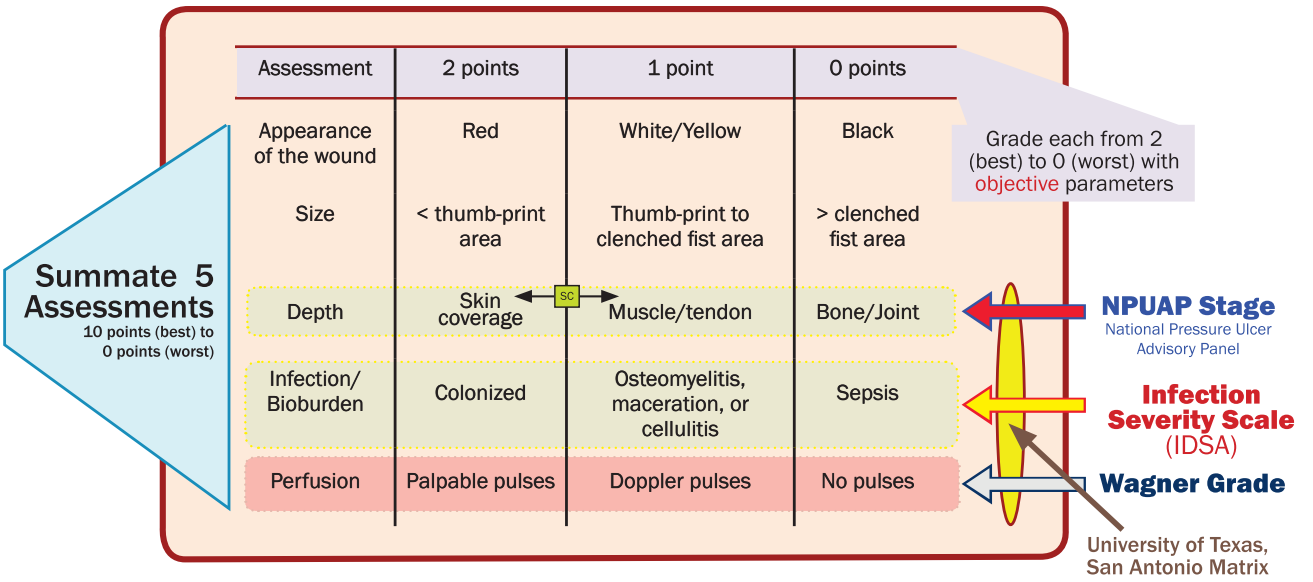
Since the proliferation of wound treatment centers, it is assumed that the providers in these centers are the "experts" in selection of wound dressing agents. However, it behooves anyone who manages wounds to be familiar with three cardinal principles regarding managing difficult wounds. First, there must be an accurate appraisal of the seriousness of the wound. Our **Wound Score** serves this role well (**Table 3**).[8] This user-friendly tool provides a speedy way to quantify the seriousness of a wound into "healthy," "problem," or "futile" types. From this information decisions become apparent for what the optimal wound dressing agent is for each wound type. Second, chronic wounds evolve through four clearly defined states, namely **1) initial presentation/deterioration stage, 2) latency/resting stage, 3) angiogenesis stage, and 4) epithelialization stage (Table 4).**[9] Just as for each **Wound Score**, there are optimal wound dressing

Table 2

CATEGORIES OF WOUND DRESSING AGENTS; A "LUMPER'S APPROACH

Strategy	Comment	Source Information
Gauze Dressing	Applicable to almost any wound type	Usually moistened (except for the very exudative wound) with normal saline with or without an antimicrobial agent
Membranes & Bioengineered Skin Coverings	Healthy, vascular based superficial wounds	Minimizes frequency of dressing changes; maintains a moist environment; may introduce growth factors (bioengineered agents)
Absorption Agents	For very exudative and transudative wounds	Typically sponges and foams; negative pressure wound therapy fits into this category
Gels, Ointments, & Salves with/ without additives	Typically for the most healthy, usually closest to being healed wounds	Enormous number of choices; options range from antibiotic ointments to drying agent and everything in between
Combinations	Often combines the best features of two different categories	Now combinations of absorption agents with antimicrobials (often silver) are very popular

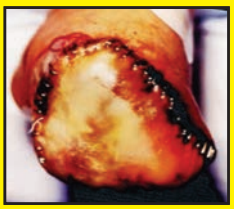
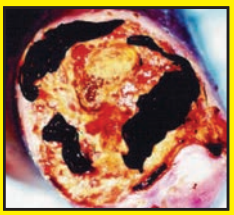
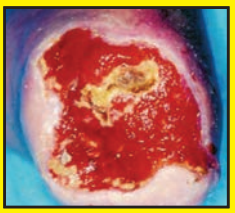
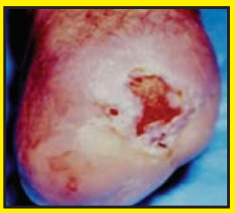
Table 3
THE FIVE ASSESSMENTS USED TO GENERATE THE WOUND SCORE



Notes: Five assessments are each graded from 2 (best) to 0 (worst) to generate a 0 to 10 score analogous to the methodology of the Apgar Score. "Healthy" wounds score in the 8 to 10 range, "Problem" wounds in the 4 to 7 range and "Futile" wounds in the 0 to 3 range. By using the Wound Score, direction is provided for wound management; especially wound dressing agent selection and debridements. In addition, like the Apgar Score, it quantifies progress.

A special feature of the Wound Score is that integrates the criteria the four other most utilized wound scoring systems (i.e. Wagner, NPUAP, IDSA and UTSA/Lavery) use for making their determinations. The other two assessments are the next most important for evaluating a wound and were added to give the five assessment a 0 to 10 scoring range.

Table 4
STAGES IN THE HEALING OF A CHRONIC WOUND

Stage	1	2	3	4
Findings	**Deterioration** 	**Latency** 	**Angiogenesis** 	**Epithelialization** 
Goals	**Demarcation**	**Healthy Margins**	**Angiogenesis**	**Epithelialization**
Management	**Protect, Hyperbaric O_2**	**Debride, Bioburden Management**	**Moist Dressings**	**Gels, Ointments**
Activity	**Bed Rest**	**Household Ambulation**	**Community Ambulation**	**Unrestricted for Ambulation & Travel**
Duration (Weeks)	**1 - 4**	**2 - 16**	**3 - 32**	**4 - 64**

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agents for each wound stage. Third, when selecting optimal wound dressing agents, the care provider must be cognizant of the resources available to the patient for wound care during the vast majority of time when the patient is not at the wound treatment center. This decision is influenced by economics, family/nursing facility support, the patient's health status, and the patient's goals. The latter two considerations can be easily quantified by using our **Health Status Score** and **Goal Score** tools (**Tables 5, 6**). As categories of wound covering agents are discussed in detail, each will be appraised with respect to wound seriousness, wound stage, and economics.

The importance of support mechanisms for managing patients' wounds at times other than when they are at a wound treatment center cannot be overemphasized. For example, if a patient spends 15 minutes every two weeks being evaluated and managed at a wound treatment center, it is almost an infinitesimal amount of time as compared to the time the patient is not at the facility. It represents 0.074% (15 minutes of 336 hours) of the total time in the two-week period. What happens in the other 99.926% of the time largely determines the success or failure of healing of the wound.

Unfortunately, resources such as home health services, skilled nursing facilities (SNF), and long-term acute care centers (LTAC) are becoming increasingly limited in their ability to provide sustained wound care for chronic wounds. Often, home health visits are limited to several times a week even though optimal wound care dictates more frequent visits. For SNF and LTAC, durations of stay are often shortened to a couple weeks' time even though the wound may take months to heal (Table 4).

Our most resounding successes in treating serious wounds occur when the patient and/or family become the home wound care providers. They are taught the techniques of applying the wound dressing agents and when motivated as confirmed by the Goal Score tool (Table 6), provide the prescribed dressing change routines. It has been particularly rewarding to us when family members assume such roles and become highly proficient in providing wound care for their loved one as well as observe the wound improvement under their care. We have even observed after such experiences that family care providers decide to enter the nursing field because of their experiences with providing wound care to their family member.

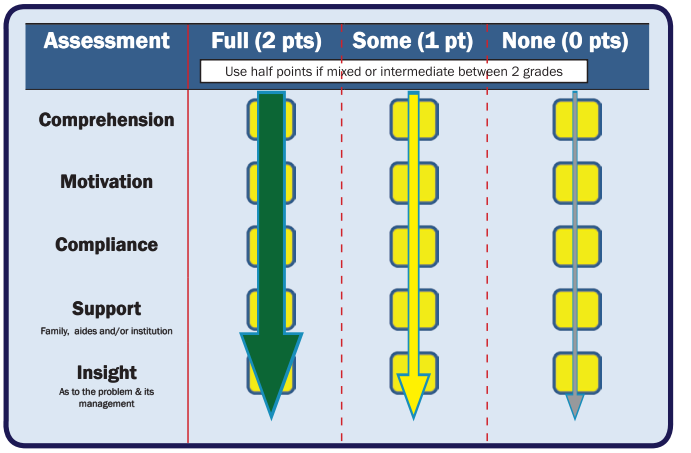
Table 5
THE HEALTH STATUS SCORE QUANTIFYING HEALTH & FUNCTION

Assessment	2-Points	1-Point	0-Points
	Use half points if finding are intermediate		
Activities of Daily Living	Full	Some	None
Ambulation	Community	Household	None
	Subtract ½ point if aids are used		
Co-Morbidities	Not Significant	Impaired	Decompensated
Smoke/Steroid Whichever gives the lower score	None	Past	Current
Neurological Deficits	None	Some	Severe

Notes: As in the Wound Score, the five assessments (considered to be the most important to determine how healthy and functional the patient is) are each graded from 2 points (best) to 0 points (worst) and summated to generate a 0 to 10 score. Healthy hosts generate scores in the 8-10 range; impaired hosts in the 4-7 range and decompensated hosts in the 0-3 range.

Scores greater than 4 support the decision for continuing wound care and not advising amputation.

Table 6
THE GOAL SCORE



Notes: As in the Wound Score, the 5 assessments (considered to be the most important to determine how serious the patient (& family) are about healing the wound and avoiding a lower limb amputation are also graded from 2 (best) to 0 (worst) to generate a 0 to 10 score. Scores greater than 4 support the decision for continuing wound care and not advising amputation.

A secondary benefit of scores greater than 4 indicate that the patient understands the treatment options, can make decisions regarding the option and can aid in their own care. A tertiary benefit of this score is that it provides criteria for how often the patient needs to be followed at a wound clinic after the wound heals. For example, 8 to 10 scores justify yearly visits to assess risk factors and quality of footwear; 4 to 7 scores justify quarterly visits focusing on compliance issues such as skin care, nail care and using protective footwear. Finally, scores of 0-3 indicate that the patient needs to be seen every other week to avoid new wounds, reiterate compliance measures, do proactive surgeries, etc.

Gauging Progress of the Healing Wound

The healing of a serious wound represents a continuum of responses ranging from control of systemic sepsis from the wound, to infection (cellulitis) resolution around the wound margins, to elimination of necrotic material in the wound base, to generation of granulation tissue in the wound, and finally to epithelialization confirming final healing of the wound. None of the commonly used wound scores (e.g. Wagner, Lavery/University of Texas San Antonio Diabetic Wound Classification, National Pressure Ulcer Advisory Panel, and Infections Disease of America Diabetic Foot Infection) are designed to measure progress (**Table 3**). They all provide a wound assessment at an instantaneous period of time. As wounds improve, it is possible to re-grade the wounds using the wound scores, but none of the initiators of these scores, to our knowledge, suggested using their scores for this purpose. In addition, most of these scores only consider one parameter as either being present or absent of the overall wound condition such as presence or absence of infection, presence or absence of ischemia, viable or non-viable tissue in the wound base, etc. Qualitative observations as just described above in the continuum of responses are commonly used to describe improvement. To quantify improvement of the healing wound, the **Wound Score** tool (**Table 3**) serves this purpose. As the wound improves the **Wound Score** increases and is as easy to quantify by the improving scores. This justifies continuing the present management and if improvement is not observed switching to other wound dressing agents and perhaps surgical interventions.

Making Sense of the Plethora of Wound Dressing Agents

As mentioned above, there are almost unlimited choices for wound dressing agents. Even with a prodigious memory and a lifetime of experiences, it is not reasonable to know the specific details about every wound dressing agent. To further complicate the matter, many companies that generate wound care products offer an array of products that have identical or very similar counterparts that can be found in competing companies. To mitigate these challenges, we have lumped wound care dressing agents, as mentioned previously, into four major categories based on the action of the agent paired with the characteristics of the wound base (**Table 2**). Many of the products, however, have secondary benefits and/or are combined with ingredients that result in their mechanisms fitting into two or more categories.

The four categories which will be described in detail in the body section of this paper include: **1) gauze dressings that facilitate autologous debridement of the wound base, 2) impermeable/semi-permeable covering agents that minimize dressing changes, 3) agents designed to absorb secretions, and 4) gels, ointments, and salves which may or may not have additives to promote specific aspects of wound healing.** Once the category of the wound dressing agent is known, the wound care provider can make appropriate decisions as to what product is needed for the particular wound. Likewise, as the wound improves, the optimal dressing agent should be changed from a category requiring more complex care to one that only needs simple management is less expensive, or combinations of both.

Finally, of the five management strategies for serious wounds, the wound dressing agent selection undoubtedly has the least likelihood of causing iatrogenic complications. This makes almost any dressing agent “a good choice” and elevates the patient’s opinion of the provider’s knowledge and wound care acumen. Since side-effects from wound dressing agents are so infrequent, other secondary considerations (in addition to the characteristics of the wound base) need to be considered when selecting these agents. These include pain associated with the dressing change, location of the wound, size of the wound, skills of the person applying the dressing, and costs.

Cost Accountability for Wound Dressing Agents

Efficacy and cost-effectiveness are buzz words in our contemporary practice of medicine. This applies to the selection of wound dressing agents, also. It has been reported that by 2010, over $15 billion would be spent yearly on wound care products.[10] Costs of products to cover wounds can vary from a few cents for a gauze dressing, to hundreds of dollars for a small tube with growth factors in it, to a hundred dollars a day for negative pressure wound therapy (NPWT), to several thousand dollars for a bioengineered skin covering agent. Costs of the wound dressing agent, however, are not the only consideration. If the selection of

a product, for example NPWT, makes it possible to transfer a patient from the acute hospital setting to a lower level of care, the hundred dollars a day for NPWT is relatively very cost-effective. Likewise, if the patient or a family member can do the dressing changes several times a day at home using moist gauze dressing, it becomes cost-effective in contrast to skilled nursing facilities or home health nurses doing dressing changes three times a week with more mostly wound dressing agents that require less frequent changes than gauze dressings.

Dollar amounts are only relative. For example in the United States in 2000, $65 billion was expended on cosmetics; in 2005, $10 billion for anti-depressants; in 2004, $3.83 billion for multivitamins; and in 2005, $20 billion for yoga training. Even though these dollar amounts are larger than the wound dressing agent costs previously discussed, they represent much larger population groups than the patients with chronic wounds. When costs are factored per person, those for wound dressing agents become significant as compared to the other "indulgences" just cited.

II. CONSIDERATIONS FOR SELECTING WOUND DRESSING AGENTS

Over a half dozen items need to be considered when deciding what wound dressing agent should be used (**Figure 1**): They include **1) providing a physiological environment, 2) infection/ bioburden management, 3) ease of wound dressing application, 4) comfort with dressing changes, 5) frequency of dressing changes, and 6) cost-effectiveness versus cost-benefit.** Many wound dressings agents have benefits additional to the primary consideration for selecting the agent (**Table 7**). This is especially true of some of the newer agents that add bioburden-controlling agents to agents whose primary function are absorption of secretions. By pairing the appearance of the wound base with the wound dressing agent category, appropriate dressing choices are easy to make. The dilemma arises with so many choices being available with so many companies each promoting their own product lines. The wound protection/ stabilization strategy complements the dressing agent selection strategy since the best outcomes from any dressing agent will occur with a wound at rest and well protected.[6] Four goals must be sought when employing the wound dressing strategy. They include: **1) achieve and maintain a moist physiological covering to optimize the wound environment, 2) control the infection/bioburden in the wound, 3) make the dressing changes as comfortable as possible for the patient, and 4) result in the dressing changes being as easy as possible for the care provider.**

Figure 1

CONSIDERATIONS IN CHOOSING A WOUND DRESSING AGENT

Legend: There are many considerations for selecting an agent to cover the wound base. Usually there are primary and secondary considerations based on the characteristics of the wound. Fortunately most agents have more than one role in wound management.

Moist Physiological Environment

The concept of moist wound healing is fundamental to the management of wounds.[11-13] All body tissues within the skin envelope (and all mucus membranes are bathed in) tissue fluids. The tissue fluids provide a physiological environment for cell function as well as a medium for exchange of essential products such as oxygen, metabolic products, growth factors, leucocytes, and antibiotics. It is logical that for optimal wound healing, the wound environment should be as close to the normal physiological environment as possible. This means keeping the wound moist with substances as close to the physiology of tissue fluids as possible. The single

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Table 7

PRIMARY AND OTHER CONSIDERATIONS FOR SELECTING A WOUND DRESSING AGENT

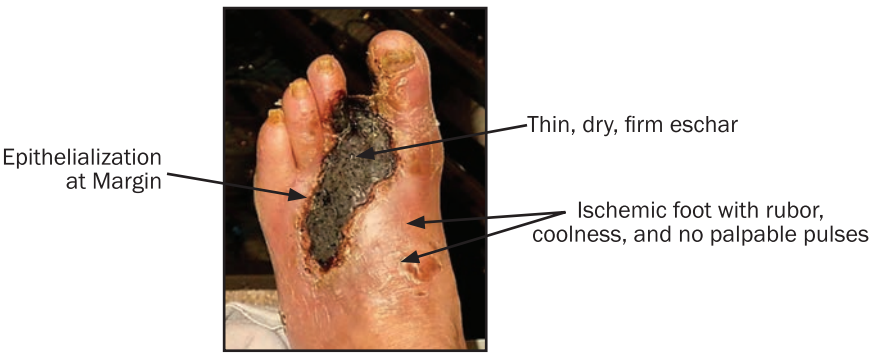
Primary Considerations for Selecting the Dressing Agent	Other Benefits						
	Bioburden Management	Costs	Reduced Frequency of Dressing Changes	Maintenance of Moist Environment	Odor Control	Pain Management	Psychological Benefits
Absorption of Secretions	✓				✓		✓
Bioburden Management					✓		✓
Comfort			✓	✓		✓	✓
Costs (Materials & Nursing)			✓				✓
Debridement Effects	✓				✓		✓
Ease of Dressing Changes		✓	✓		✓	✓	✓
Independence (doing own* dressing changes)		✓					✓
Maintenance of Moist Environment		✓	✓			✓	
Occlusiveness (Barrier Effects)		✓	✓	✓	✓	✓	✓
Size of Wound	✓	✓		✓		✓	✓

*Own implies patient and/or family member being able to do wound care without visiting nurses or other paid caregivers.

substances that comes the closest to meeting this requirement are crystalloid fluids such as normal saline that have electrolyte concentrations similar to tissue fluids. Other agents such as gels help maintain a moist environment by placing a covering over the wound base to keep it from drying out. Of the entire spectrum of wound covering agents, the thin, dry eschar provides the most physiological environment for the underlying wound base (**Figure 2**). Even though the outer layer is dry, the eschar maintains a sealed, bacterial-free, moist environment between its under-surface and the base of the wound. Less than ideal types of moist wound bases are from edema fluid oozing through the wound base or from exudate secondary to infection. Excessively moist wound bases are commonly found in wounds in dependent portions of the body, especially in edematous lower extremities and are analogous to fluid leaking out of a hole in the bottom of a barrel. Venous stasis disease, fluid retention secondary to heart failure, obesity, lymphatic obstruction, and hypoproteinemia are co-morbidities that may contribute to this problem. Frequently the leakage is so perfuse that it saturates the dressing as well as macerates the surrounding tissues. In these situations, the first step in appropriate management of the wound base is that of control of the excessive moisture in the wound base. This is where agents to absorb secretions and moisture are indicated and will be discussed in detail in Section III of this article.

Figure 2

THE DRY, FIRM ESCHAR; THE OPTIMAL WOUND "DRESSING" AGENT



Legend: The thin, dry, non-fluctuant crust is an ideal covering agent for a wound base. It requires the least oxygen and metabolic demands to achieve healing of any wound covering/closure technique. Epithelialization occurs at the margin of the eschar.

If infection occurs, it will most likely develop at the margin between the intact skin and the eschar. Consequently, it is essential that the margins of the eschar be kept clean and free of debris such as crusts. Many times healing is achieved, albeit slowly with this technique, whereas other techniques such as skin grafting fail due to the ischemic nature of the wound.

The thin, dry eschar wound base covering requires the least oxygen and metabolic requirements of any of the wound coverage-closure choices.[3] This becomes an important consideration in patients with advanced peripheral artery disease, vasculitis, or arterial-venous shunting (such as fistulas for hemodialysis). Whereas debridements and grafting might be considered, the best chance for avoiding more proximal amputations is to allow epithelialization to proceed under the margins of the eschar while periodically trimming the edges of the eschar (and reducing its size) over the ingrowth of new skin. As long as the margins remain sharply demarcated this process will eventually proceed to complete wound healing even in the markedly ischemic environment.

A corollary of this process is the auto-amputation of mummified digits associated with frostbite and other insults to the most distal portions of the circulatory system. The auto-amputation process which may take months to accomplish, conserves the most possible tissue of any intervention—and certainly much more than establishing clean surgical margins and resecting body elements sufficiently such that the mummified site can be closed primarily with flaps. Tissue conservation is especially important in patients with residuals of purpura fulminans where retaining the longest possible finger and thumb digit lengths becomes so crucial for hand function.

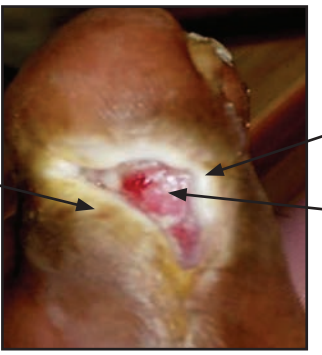
Infection/Bioburden Management

The surfaces of open wounds are usually colonized with bacteria, as are the skin and mucus membranes covering all the other parts of the body. This is a normal finding and is consistent with a healthy wound base. It equates to a grade of 2 points (on the 2-to-0 scale with two being the best possible situation and zero the worst) on the **Wound Score** (**Table 3**). When bacteria invade and multiply in the wound base, an exudate is produced. This is the bioburden and it may be scant, intermediate, or copious in amount.[14-16]

Even though the exudate may make the wound base moist, it is not physiological because of the bacteria it contains, as well as the metabolic waste products from the bacterial invasion. When bacteria invade and multiply in the surrounding skin, cellulitis occurs. With exuberant exudate or marked leakage of fluid, the skin margins adjacent to the wound macerate. This is easily recognized as a moist-appearing white rim of the skin around the wound (**Figure 3**). The finding of cellulitis and/or maceration equate to a grade of 1 point on the infection/bioburden assessment of the **Wound Score** (**Table 3**). If the bacteria invade and multiply in deeper tissues and they or their products enter the blood stream, sepsis results (grade 0 of the infection/bioburden assessment of the **Wound Score**). Many of the wound dressing agents have bacteriostatic/bacteriocidal effects. Their goal is to reduce the bioburden. There are many wound dressing agents with bacteria killing effects.[17] While these agents may control superficial infections and multiplication of

Figure 3

MOIST CALLUS AROUND AN EXUDATIVE WOUND COVERED WITH A BIOFILM



Legend: Moist callus is undesirable. It harbors bacteria, interferes with epithelialization impedes wound contraction. It usually appears around highly exudative wounds. The shiny biofilm in the wound base indicates that the bioburden is not being adequately controlled.

We advocate debriding moist callus to underlying healthy skin. This often causes punctate bleeding that is easily controlled with silver nitrate tipped cautery sticks.

bacteria in the normal wound, they are not effective with deeper infections or when biofilms develop.[18] Other interventions such as systemic antibiotics, wound debridements, and wound oxygenation must be considered when infection extends deep to the base of the wound and/or extends into the peripheral tissues.

Moist callus around the wound margin is a sign of pathology in the wound. It is undesirable because it harbors bacteria—an ideal environment for bacteria to multiply by being shielded from host factors and systemic antibiotics by its avascularity. In addition, it interferes with epithelialization around the wound margins and wound contraction.

Consequently, we strongly recommended that with surgical debridements of the wound, all moist callus is removed. This may require actually removing the moist callus to the level that punctate bleeding is observed in the healthy underlying skin. The punctate bleeding can usually be controlled easily with use of silver nitrate tipped applicators. This is more desirable than leaving residuals of the moist callus. This degree of debridement is appropriate to do in the outpatient wound care setting. Since the moist callus is non-viable skin, debridements can usually be done without the patient experiencing pain even in the absence of a sensory neuropathy.

Ease of Wound Dressing Agent Application

Comfort for the patient, accessibility of the wound, and the availability of caregivers must always be considered. The dressing should be easy to apply, remain in place until the next dressing change, be commensurate with the patient's activity, be effective until the time for the next dressing change, and be easy to remove. Tracking wounds and those with recesses require that the dressing agent come in contact with the entire wound surface.

There are both science and art features to application of the wound dressing agent. Use of long-stemmed cotton tipped applicators to ensure the wound dressing agent contact all the wound surfaces, positioning the patient to provide easier access to the wound (for example, turning the patient to the side for posterior leg and heel wounds), and staging all the dressing agents needed for the dressing change at the patient's location before starting the dressing change are examples of "science" features of the dressing change. "Art" features of the wound dressing application include ensuring the dressing agent only come in contact with the wound itself (which is somewhat of a challenge with irregularly shaped wounds), using drying agents around macerated or moist callus wound margins, and making the dressing changes as comfortable as possible (which will be discussed shortly).

Once the patient returns to the home setting, ideal timing and execution of dressing changes can be a challenge. The least expensive, but in our experiences among the most effective wound agents require the most frequency of dressing changes. With decreasing availability of home health nursing services due to regulatory and budget considerations, it may not be feasible for the professional care provider to change dressings at optimal intervals. Options include switching to dressing agents that require less frequent dressing changes, which is not always the best choice for the particular wound, or teaching the patient and/or his/her family members to do the dressing changes. The motivated patient/family member can be instructed in the dressing change techniques and from our observations can learn to do flawless wound care. Some of our most resounding successes with limb-threatening wounds are when the family members assume the home-based wound care for the patient.

Clinical Scenario

A 50-year-old female diabetic with end stage renal disease developed a limb-threatening wound on the back of her right heel. Because of exposed Achilles tendon and a previous ipsilateral midfoot amputation, a below knee amputation was recommended. The patient refused. The patient's family was instructed in the application of the most fundamental and least expensive dressing agent, that is, gauze moistened with acetic acid solution. They did the dressing changes, as instructed, twice a day. Biweekly rechecks at our wound center with debridements of nonviable tissue in the wound base and crusts around the margins of the wound were done.

The family members became "artists" in doing the dressing changes, with avoidance of the dressings extending beyond the wound margins to prevent maceration of the surrounding skin. Gradually, the necrotic wound base was replaced with granulation tissue and then epithelialization of the wound margins occurred. After nine months, the wound healed completely. During the epithelialization stage, the patient resumed her pre-morbid level of activity. A fitting addendum to this scenario is that the family member most instrumental in the patient's home wound care decided to enter the nursing profession with the goal of working with patients with problem wounds.

Comment: This synthesized scenario is informative for several reasons. First, it demonstrates how beneficial family member involvement in wound care can be. Second, limited insurance resources would have made it impossible for the patient to receive the same level of care that her family provided. Third, although other wound dressing agents considerably more expensive and perhaps more convenient than the gauze moistened with acetic acid solution could have been used, the gauze dressings were the most inexpensive and the one dressing agent that could be used through all the stages of healing. Finally, the family member's decision to enter the nursing profession after the above experience was particularly gratifying to the medical team that directed the patient's wound care.

Comfort with Dressing Changes

Comfort with dressing changes must always be a primary consideration. There is a range of patient responses to dressing changes from no discomfort whatsoever to the requirement for dressing changes to be done in the operating room under anesthesia (**Table 8**). For the majority of wounds in diabetic patients, dressing changes are not painful because of impaired or total loss of sensation from sensory neuropathy. For patients with normal sensation, the initial dressing changes after surgery can be excruciatingly painful. Administration of narcotic analgesics before the dressing change in the sensate patient is usually of minimal benefit during the actual dressing change. However, after the dressing change is completed, the analgesics usually provide some comfort for the patient. By wetting the portion of the dressing adherent to the wound due to crusted blood or fibrinous material with normal saline or during a hydrotherapy treatment (whirlpool or pulsatile lavage), the dressing can usually be removed in a slow, deliberate fashion. As the wound improves, the dressing changes typically become less painful to the point that when they are nearly painless, the wound is usually ready for coverage and/or closure.

At the opposite extreme of the insensate patient is the patient with the hyperesthetic, hyperpathic (exaggerated pain response) wound. These situations are seen in wound patients with profound ischemia in their lower extremities, collagen vascular disease, and those with complex regional pain syndrome/reflex sympathetic dystrophy. Pain management during dressing changes is a major challenge in these patients and usually needs to be done in conjunction with consultation from a pain management specialist. Not infrequently, these patients require a lower limb amputation for the reason of pain management rather than the wound being refractory to healing.

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Table 8

GRADING OF PAIN RESPONSES AND MANAGEMENT FOR DRESSING CHANGES

Pain Response	Examples	Management for Dressing Changes	Points*
Insensate — no significant pain with dressing changes	**Diabetic patients with profound sensory neuropathies. Spinal cord injuries. Multiple sclerosis.**	**No pain management required**	**0**
Minimal Discomfort	**Moderate sensory neuropathies. Superficial wounds. Nearly healed wounds.**	**No analgesics with verbal reinforcement and/or mild oral analgesics**	½
Moderate Discomfort	**Minimal sensory neuropathies. Post-op dressing changes a week or more after surgery.**	**Intravenous analgesics such as morphine before dressing changes; Use of anesthetic gels**	**1**
Severe Discomfort — with or without unabated pain, even between dressing changes	**Normal sensation. Patients with drug-seeking behavior. Hyperesthetic/hyperpathic wounds; dysvascular patients. Patients with CRPS/RSD.** Apprehensive pediatric patients.**	**Patient controlled analgesics. Continuous epidural analgesia. Strong maintenance analgesics supplemented with strong IV analgesics during dressing changes. Dressing changes (with or without debridements)in the operating room.**	**1½ - 2 (Patients with hypersthesia, hyperpathia and /or allodynia need to be recognized and so designated)**

*This 2 (normal sensation) to 0 (insensate) grading system is part of the "Quick & Easy" pain evaluation scoring tool.
**CRPS = Complex regional pain syndrome; RSD = Reflex sympathetic dystrophy.

Frequency of Dressing Changes

The frequency of dressing changes is another important consideration in selecting wound dressing agents. Some wounds require dressings be done two or three times a day in order to manage the wound exudate. If the wound base is necrotic with heavy bioburden, the gauze dressing may be the only logical alternative. As wound characteristics change, the wound dressing agent may need to be changed. This is done for the considerations previously discussed. When dressing changes are painful, the fewer the dressing changes, the more comfortable it is for the patient, which helps to justify the use of more expensive, but less frequent dressing changes and perhaps less effective dressings.

Clinical Scenario

A 62-year-old female with painful, necrotic-based bilateral venous stasis ulcerations involving over 30% of the surface area of both legs was eventually persuaded to be hospitalized for management. Because of pain, she refused all dressing changes even though the dressings were foul smelling from the exudate. The decision was made by the plastic surgeon to perform a debridement in the operating room with general anesthesia and immediately apply negative pressure wound therapy (NPWT) dressings in an attempt to avoid bilateral lower limb amputations.

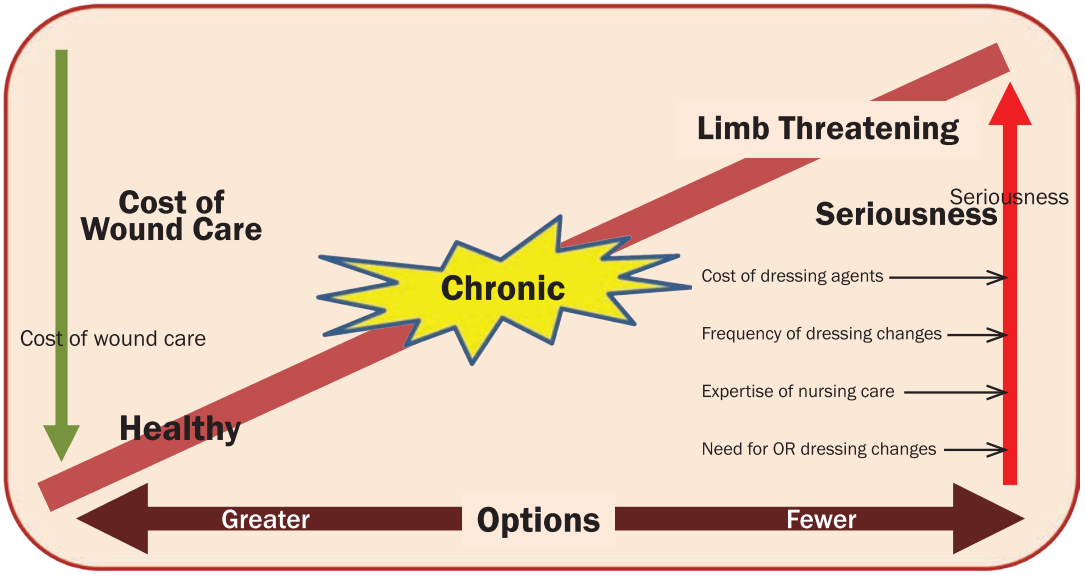
The initial NPWT dressing was changed three days post-operatively. It took over three hours of nursing time to remove the dressing and reapply a new dressing because of the patient's discomfort.

Comment: Although the nursing time was prolonged with the change of the NPWT dressing, it was more reasonable than them spending three hours twice a day to perform moist gauze dressing changes. Another important consideration in this patient's scenario was less pain for her with the less frequent need for dressing changes with NPWT.

There is a dichotomy between frequency of dressing changes and seriousness of the wounds. This needs to be coupled with economic considerations (**Figure 4**). Generally, the least expensive wound dressing agents are most applicable to the healthy wound. More serious wounds require greater frequency of changes, more expert nursing care, and usually more costly wound dressing agents. Two exceptions to this require discussion. Moistened gauze dressings are inexpensive, but the frequency of dressing changes makes them costly in terms of nursing care. When nursing service time is factored

Figure 4

SERIOUSNESS VS. COST OF WOUND DRESSING AGENT



Legend: The more serious the wound, the greater the expenditures for its management and the fewer the wound dressing options. With healthy wounds , multiple wound dressing options exist and very economical choices can be made.

Chronic wounds are in an intermediate position where intelligent wound dressing agent selections can be very cost-effective.

into the expenses, the total costs often exceed more expensive wound dressing agents that require less frequent dressing changes. However, as previously mentioned, when outside the hospital setting, with the patient and family involved with the wound care, the nursing services expenses are mitigated. The second exception is in the chronic wound that has a relatively healthy appearing base. Selection of bioengineered dressings increases the costs from less expensive wound dressing agents to these special, and relatively expensive, products.

Cost-Effectiveness versus Cost-Benefit

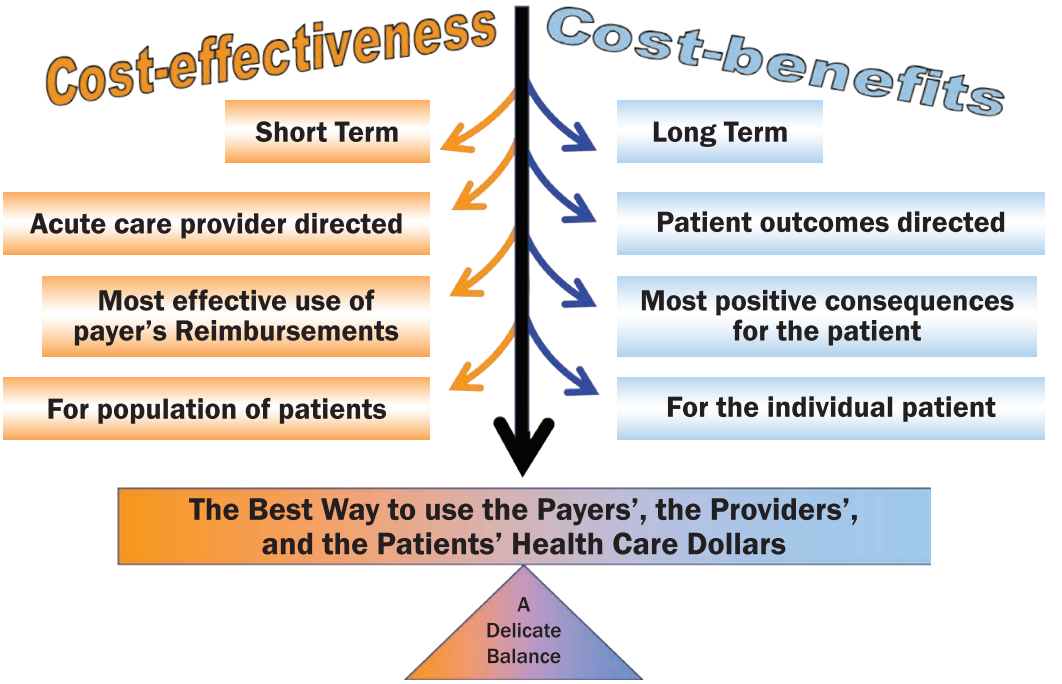
The sixth consideration in selection of wound dressing agents is economics. Cost-effectiveness and cost-benefit are somewhat confusing terms (**Figure 5**). Cost-effectiveness implies that the intervention and its outcomes make economic sense in the short term for those paying for the care provided. As an example, the most cost-effective method for dealing with a limb-threatening "problem" wound might be an amputation and the discharge of the patient to a lower level of care a couple of days after surgery instead of an extended hospitalization and long-term wound care and antibiotics. The amputation would be cost-effective for the acute care insurance payer and the hospital. However, the overall cost-benefit may be substantially less since subsequent expenses and responsibilities would be shifted to other facilities, other payers, and/or the patient and his/her family. When the costs of prostheses, rehabilitation, and changing from independent living to assisted living or skilled nursing facilities, the cost-benefits of limb salvage may outweigh those of amputation. Consequently, the considerations of cost-effectiveness and cost-benefit need to be based on quality of life issues. The **Health Status Score** and **Goal Score** provide objective criteria for making decisions regarding the best choices for wound management in general and amputation versus limb salvage in particular (**Tables 5, 6**). In summary, cost-effectiveness tends to be the short-term solution while cost-benefit is the long-term overall total economic consideration.

III. CATEGORIES OF WOUND DRESSING AGENTS

Before describing the four categories of wound dressing agents, the concept of multi-functionality requires elaboration. Generic criteria can be utilized for evaluating wound dressing agents and include adaptability, availability, costs, versatility, and effectiveness (**Table 9**). Multiple functions of a wound dressing agent are usually a desirable feature. However, there can be complications from multi-function wound dressing agents. This is usually attributed to one or more of the ingredients being

Figure 5

COST-EFFECTIVENESS VERSUS COST-BENEFITS



Legend: There are many ramifications when comparing cost-effectiveness with cost-benefits. Managing chronic and limb threatening wounds requires decisions be made from both of these perspectives.

Table 9

CRITERIA FOR EVALUATING WOUND DRESSING AGENTS WITH SPECIFIC REFERENCE TO MOISTEN GAUZE

Criteria	Moistened Gauze	Comments
Adaptability	It can be applied to any size or shape of wound. It works well for wounds with tunneling, tracking, bridges of recesses.	The more complex the wound, the more expertise required for application of a dressing
Availability	Usually universally available; when not, clean cloths sterilized in boiling water can be used.	Many choices available including: packing, mesh, conforming, roller, compression and absorbent varieties
Costs	In terms of material supplies alone, no dressing agent is less expensive.	Materials alone are but one item that needs to be factored-in when considering costs of dressings
Effectiveness	Wide spread usage with predictable outcomes.	The moist gauze dressing should always be considered when deciding which wound dressing to use
Versatility	Applicable for all wound bases from healthy to necrotic. Dressing changes remove wound debris i.e. autologous debridement.	The moist gauze dressing is often the only logical option for the initial management of the serious wound

*Examples of serious wounds include large wounds, deep wounds, wounds after surgical debridements, and wounds associated with necrotizing soft tissue infections.

tissue toxic, an irritant, or allergenic. Pain in the sensate wound is probably the most frequent side-effect/complication associated with the multi-functionality of wound dressing agents.

Although the standard of practice is becoming more directed towards using wound dressing agents with multiple functions, there can be other undesirable features in addition to those listed above. These include increased costs, the lack of indications for the secondary effects of the wound dressing agent, or the secondary effects interfere with overall management of the wound. The latter consideration is frequently observed when an antibiotic ointment is used for an exudative wound. The vehicle to carry the antibiotic, usually petrolatum-based, may act as an occlusive agent and consequently retain exudative material in the wound. The remainder of this article discusses the four categories of wound dressing agents based on their primary mechanisms, considers their other effects, and provides answers to myths, misconceptions, and fallacies about wound dressing agents.

Category 1: Gauze Dressings

The moist gauze dressing is the standard by which all wound dressing agents should be measured. The dressing can be applied to any size or shape wound. Only in exceptional circumstances, for example a very moist wound with fluid transudation from massive edema in the extremity, would dry gauze alone be applied to the wound base. Typically, the gauze dressing is moistened with normal saline with or without other additives. It then can be layered over a superficial flat-based wound, wicked into a tracking wound or recess, or shaped to fill a cavitary wound. When the gauze dressing is removed, debris from the wound clings to the dressing resulting in autologous debridement of the wound.

We feel the moist gauze dressing is the standard for judging other wound dressing agents because of its adaptability, availability, cost-effectiveness, and versatility. The more acute and/or exudative the wound, the better it serves these purposes. Even so there is criticism of the gauze dressing with comments such as it is archaic with the availability of newer products, it is not cost-effective due to the caregiver time required, that it rapidly dries out and does not maintain a moist environment for the wound base, and the agents that used to moisten the dressing only have durations of actions of a few minutes and/or only penetrate the wound base a few millimeters. The following comments address these criticisms:

Bioburden Management: It is correct that bacteria thrive in the moist dressing. Often, the dressing that has been left on the wound for an extended period of time has a more pungent odor than the wound base itself. While additives to normal saline such as acetic acid or sodium hypochlorite solution (Dakin's) may impede bacteria proliferation in the exudative wound and gauze dressing, their durations of action may be short-lived.[19, 20] This criticism is resolved by the appreciation that the moistened gauze dressing with additives should be changed a minimum of twice a day, and if the wound is very exudative and odorous, as frequent as three to four times a day. In addition, agents are added to the solution to moisten the gauze to help with the bioburden management (**Table 10**).

Cost-Effectiveness: Although the dressing materials themselves may be the least expensive of any choice of wound dressing agent, nursing care to perform the dressing change three or four times a day may make the aqueous gauze dressing less cost-effective than other choices. In the in-patient hospital setting, this becomes a relative consideration since nurses are already present on duty. However, the dressing changes take time away from their other responsibilities. In the outpatient setting, it is more than wishful thinking to expect home health nursing services to do these dressing changes this frequently. Because of economics, home health services are being reduced and typically can only be provided on a daily basis or several times a week. The answer to this concern is education of the patient and/or family member in the dressing change technique so they can do it between home health nursing visits or even without this service.

Evaporative Heat Loss: The normal body temperature is the ideal temperature for wound healing. Cooling from evaporative heat loss from the moist dressing may lower the temperature of the wound base. This coupled with impaired perfusion from peripheral artery disease may contribute to cooling of the wound site and slow metabolic reactions. For small wounds typically of those found in the foot and ankle, this concern is probably inconsequential. The concern is probably only realized in very large wounds or during anesthesia when the body's heat regulating mechanisms may be disturbed. Moisture in the dressing and heat in the wound can be maintained with a non-permeable barrier such as cellophane placed over the gauze layers that come in contact with the wound. This technique is inappropriate for exudative wounds, but useful for healthy wounds

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Table 10

ADDITIVES FOR MOISTURIZE THAT PROVIDE MICROBIOLOGICAL EFFECTS FOR GAUZE DRESSINGS

Additive	Comments
Normal Saline	Moisturizes the gauze; provides a physiological interface with the wound base. Helps the gauze conform to the wound shape.
Acetic Acid Solution	Acidifies the dressing and has static action against many bacteria. Effective for pseudomonas. Easily formulated at home with white salad dressing vinegar. ¼ strength = 0.25%
Dakin's Solution	Diluted bleach solution; also can be formulated at home. Useful especially for coliforms and odor mitigation. Full strength = 0.45%, ½ strength = 0.25%, ¼ strength = 0.125%
Metronidazole Solution	Addition of 2 grams of this antibiotic to a liter of saline provides a useful moisturizing and deodorizing agent that is especially effective for anaerobic organisms.
Shur-Clens	Utilized to help maintain a moisturized base in desiccated, but not exudative wounds.

free of exudates. When used in this situation, the frequency of changing the moist dressing can be reduced.

Material Choices: Although the moist gauze dressing implies that fine mesh gauze is used, there are other options. These include gauze packing strips (Nu-gauze®), coarse meshed gauze, roller gauze (stretch and non-stretch), and thick absorbent gauze (abdominal pads). Each has its own special applications. For example, gauze packing strips are useful for small tracking wounds, fine mesh for optimal contact with wound base, roller gauze for large cavernous wounds, thick-absorbent gauze pads for oozing wounds, and stretch roller gauze (plus elastic wraps) for compression of wounds surrounded by edematous tissues. Although, the decision which is the ideal gauze dressing for the particular wound is somewhat objective, experience and the characteristics of the wound are paramount in deciding what the best choice is.

We advocate using elastic wraps over all extremity dressings with gauze dressings. They provide compression over the wound and help maintain the underlying dressing in place. In addition, the elastic wrap improves contact between the dressing material and the wound base and helps to control edema in the extremity. With edema reduction, fluid leakage through the wound base decreases.

Skin Maceration: Moisture from the moist gauze dressing may extend onto the adjacent skin and cause maceration. Skin maceration is undesirable. It harbors bacteria and can initiate or contribute to periwound cellulitis. In addition, it may interfere with wound contraction and epithelialization of the wound margins, both important factors for wound healing. This concern with moist gauze dressing is mitigated by only having the moist gauze come in contact with the wound base and with the use of moisture barrier controlling agents such as zinc oxide and related agents to keep the wound margins dry.

Wound Moisturization: Because of evaporation, the moist dressing may dry out between dressing changes, especially if not changed frequently. While this may be desirable for exudative wounds and may facilitate removal of debris through autologous debridement when the dried dressing is removed, it is not optimal for vascular-based, non-exudative wounds. The superficial cells responsible for wound healing and infection control may desiccate and die. It is our observation that the healthy wound base, such as one covered with granulation tissue, maintains its moisture content through its intrinsic hydration even if the gauze dressing dries out between changes. There may be some serendipity in this mechanism as debris will attach to the dry gauze and promote the autologous debridement process.

Wound Severity: It is paradoxical that the wounds least suited for moist gauze dressings are those that are the healthiest, smallest, and most superficial. Because of their small size, the moist gauze is likely to dry out before the next dressing change. When the

patient is mobilized, the gauze is prone to slip off the superficial wound especially in highly mobile sites such as the toes, foot, and ankle. Conversely, the moist gauze dressing accommodates the cavitary, tracking, or undermined wound because of its conformability.

Side-Effects: Agents such as acetic acid, sodium hypochlorite (Dakin's), hydrogen peroxide, etc., have varying degrees of toxicity to fibroblasts, keratinocytes, and leukocytes (**Table 10**).[21-23] When used as dilute solutions, their help in controlling the bioburden outweighs their possible toxicities. Our observations have not demonstrated harmful effects on tissues when these agents are used for moist gauze dressings. This is probably due to their transient effects as mentioned above, their minimal penetrability, the robust nature of the underlying granulation tissue, and if exudate or biofilm is present, the barrier nature of these substances between the agent and the underlying tissues. As the bioburden is controlled, the wound dressing agents should be changed to more physiological solutions such as normal saline, then transition to agents that require less frequent applications such as gels or ointments.

The Moist Dressing as a "Work of Art:" The optimal application of the moist dressing is as much a "work of art" as it is a routine nursing skill.[6] Clean technique, that is using disposable clean (but not necessarily sterile) gloves and gowns if multiple drug resistant organisms are present, is required for those doing the dressing change. All dressing materials should be staged at the patient's bedside before beginning the dressing change. The old dressing should be removed in as painless a fashion as possible and disposed of properly. In the institutional setting, disposal of the dressing should be in labeled biohazard bags for the non-sharp materials.

Pain is controlled with a combination of methods including oral and/or intravenous bolus analgesics, gentle removal of the old dressing with use of normal saline to wet the adherent portions, and use of local anesthetics dripped over the adherent portions contact with the wound base. In extreme conditions the initial dressing changes may need to be done in the operating room under general anesthesia. This is the situation when the wounds are large, as blood is likely to be dried and adherent to the dressing and additional debridement may be needed. The dressing is especially a "work of art" when wounds are deep, irregularly shaped, have recesses ,or have tracts. Wetting the gauze that is to come in contact with the wound base can be done by pouring the aqueous solution onto it or by soaking it in a small container. In either case, the wet gauze should be squeezed to remove excess liquid to the degree that it remains moist. However, the gauze should neither be so wet that fluid drips from the dressing (which could then ooze onto the adjacent skin and lead to maceration) nor so dry that the wound base desiccates between dressing changes. The dressing should be applied so that all parts of the moist dressing come in contact with the wound base. If this is not done properly, secretions and exudates can collect in the interstices of the wound and be the source of ongoing sepsis and lack of improvement. The moistened gauze dressing should remain in the confines of the wound, that is, it should not wet the skin margins surrounding the wound.

In the majority of diabetic patients with foot wounds, pain does not interfere with dressing changes. This is because of diabetic sensory neuropathy. In such situations the absence of pain is a boon to wound care. The lack of protective sensation which may have contributed to causing the wound problem is certainly undesirable.

Often diabetic patients complain of such severe pain in their lower extremities that they require narcotic analgesics even though the wound site is insensate. These patients usually are not hypochondriacs; their pain is genuine. The non-wound pain typically is from painful diabetic neuropathy and/or severe peripheral artery disease. Both need to be evaluated and appropriately addressed in the overall management of the patient with the chronic wound.

Experience and motivation are needed to properly "pack" the moistened gauze dressing into the wound cavity. In addition to the moist gauze coming in contact with all surfaces of the wound base, the dressing should provide gentle compression. It should not be packed too tightly to avoid interfering with wound contraction. The exception to this is for temporary compression to achieve hemostasis. When the well-applied dressing is placed into the irregularly shaped wound, it looks like a "work of art" with its margins perfectly conforming to the shape of the wound and not bulging above the skin surface. Finally, ingenuity is required to apply the remainder of the dressing so it remains in place, applies compression, and is easy to remove. This includes using dry gauze padding, gauze roller wrapping, elastic bandage, bias cut stockinette, or surgical netting.

Transfer to Lower Level of Care: A crucial consideration in the management of all wounds is minimizing the length of hospitalization. Criteria for transferring a patient to a lower level of care are threefold: First, control of sepsis usually confirmed by normalization of the white blood cell count; second, improvement of the wound to the point it is free of moist gangrenous tissue; and third, being able to do dressing changes without significant pain for the patient.

Category 2: Covering Agents for the Healthy-Based, Non-Secretion Producing Wound

Once a wound develops a vascular base, additional options become available for wound dressing agents. The wound dressing agents described in this section (**Table 11**) work well for healthy appearing, non-exudative, superficial wounds. The epitome of this type of wound is the donor site of the split-thickness skin graft.

Table 11
WOUND COVERING AGENTS FOR WOUNDS WITH HEALTHY, SUPERFICIAL BASES

Agent/ Categories	Examples*	Primary Effects	Other Effect(s)	Miscellaneous (Costs**, Side Effects, Comments)
Semi-permeable membrane coverings (Impregnated and non-impregnated)	Adaptic® Parachute silk Scarlet red gauze Telfa® Vaseline® gauze Xeroform™ gauze	Maintains a moist environment. Fluids able to ooze through to the next layer.	Comfort. Antibacterial for the impregnated choices. Less frequent need for dressing changes. Changes of outer dressing possible without disturbing the covering.	Minimally expensive (< $10 per application). Minimal side effects; occasional infections develop under the coverings. Removal may be painful due to adhesions. Outer coverings changed as needed, some daily, some remain until healed.
Non-permeability membrane coverings	OpSite® Tegederm™	Maintain a moist environment over the wound.(i.e. hermetic seal).	Comfort Occlusive, non-absorptive, membrane-like covering	Minimally expensive; fluid collections under the membrane can be a source of pain and a site for infection to develop; they may require aspirations. Changed as needed (weekly) for wound hygiene.
Hydrocolloid dressings and Foams	Duoderm® Lyoderm®	SAA (Same as above) Impervious	Padding over pressure points. Resist shear and abrasion stresses. Comfort.	Minimally-to-moderately expensive ($10-to-$20 per application); occlusiveness of dressing may retain exudates and macerate tissues; changed usually one to three times a week.
Matrix metallo-proteinase Inhibitors	Promogran®	Inhibits formation of matrix metal-protein enzyme complexes. These complexes interfere with wound healing.	Semi-permeable; membrane-like covering.	Moderately expensive. No methods currently exist to ascertain which wounds are failing to heal due to matrix metalloproteinase inhibitors; Changed weekly.
Silicon covered padded dressing	Mepitel®	Padding plus silicon interface with skin prevents shear.	Padding over pressure points. Resist shear and abrasion stresses. Comfort.	Minimally-to-moderately expensive. ($10-to-$20 per application); prevents progression of early pressure ulcers.

"Covering" implies that the dressing is placed over the entire wound and may even extend beyond its margins to include the adjacent skin. The goals for covering agents are that they remain in place for sustained periods of time, keep the wound base moist, and prevent contamination. These agents are usually impermeable or semi-permeable.

In addition to donor sites for split-thickness skin grafts, other wounds appropriate for these covering agents include superficial pressure ulcers, superficial venous stasis ulcers, abrasions, and wounds that have improved enough that closure-coverage options are being considered. The unifying factor for these wounds is that they are healthy enough that the covering agent can remain in place over the wound for several days (or longer) without jeopardizing wound healing. These wound dressings agents are also appropriate for covering healthy wounds that require casting for reasons such as stabilization, managing fractures, permitting ambulation, and/or protecting the surgical site.

Advantages and Disadvantages of Covering Agents for Healthy-based Wounds: The main advantage of this choice is that it reduces the frequency of dressing changes. This is important for those patients whose dressing changes are painful, as is so often the case over a donor site of a split-thickness skin graft. Another important advantage of the covering selections is that they substantially reduce the nursing care costs related to dressing changes. These covering agents also help maintain a moist environment over the wound. This is especially appreciated in the split-thickness graft donor site, where the entire base of the site epithelializes in contrast to chronic wounds where epithelialization occurs at the margins of the wound.

Disadvantages of the wound covering agents include increased costs of the dressing as compared to the gauze dressing. However, this is only a relative consideration because decreased frequency of dressing changes and health care provider costs can make this dressing agent cost-effective. Another problem is fluid accumulation from transudation under the coverings that are sealed to the skin surrounding the wound. This acts like a bulla which may be a cause of discomfort for the patient. A more worrisome concern is that bacteria inoculate the fluid and multiply in this ideal growth medium being warm at body temperature, moist, and essentially devoid of antibiotics and white blood cells. Bacteria growing in the fluid can lead to cellulitis of the adjacent tissues, maceration of the surrounding skin, damage to the underlying wound base, interference with epithelialization, or combinations of these. The fluid collections under non-permeable membrane are easily managed by aspiration with a needle and syringe.

Whenever using the wound covering category of dressings, several maxims need to be followed. These include that the wound base is vascular, superficial, and not infected. Even more important is that the three components of what we term the "Treacherous Triad," specifically **1) ischemia/hypoxia, 2) underlying infection, and 3) deformity, have been recognized, addressed, and rectified before applying this category of wound dressing agents.**[9]

Evaluation Criteria for Wound Covering Agents: When wound covering agents are evaluated using the criteria of adaptability, availability, costs-effectiveness, and versatility, they compare favorably with moist gauze wound dressing for the properly selected wound as follows:

Adaptability: These dressing selections are adaptable to almost any small or medium-sized wound. For larger wounds, the adhesive based options can overlap with each other to cover almost any sized wound. If coverings without adhesives are used for wounds, then compression-type dressings need to be applied over the agent. When the wounds are larger than the surface area of the agent which is often the situation with the bioengineered dressings, patchwork applications to the wound base may be necessary. These agents can be applied to regular as well as irregular shaped wounds.

Availability: Selections from this category of wound dressings are generally available at hospitals and wound clinics. They can also be obtained for use in private offices. Because of the costs of some these agents, especially tissue-engineered products, the standard of practice is not to inventory (i.e. keep a supply in the office or clinic), but rather obtain them on an as-needed basis from pharmacies or representatives of the manufacturers. The formularies of payers often dictate which products can be used. Frequently, pre-authorizations from the payer are required before they can be used.

Of all the categories of wound dressing agents, the wound covering group has the widest range of costs. Costs may range from a few dollars for bismuth impregnated (e.g. Xeroform®) or scarlet red impregnated gauze, to ten to twenty dollars for adhesive membrane type coverings, to hundreds to several thousands of dollars for the bioengineered skin substitutes.

Bioengineered wound covering agents are receiving much attention in the wound healing literature and are heavily promoted by their manufacturers. Many of these agents can be applied in the office setting. Some require application in the operating room which, of course, significantly increases the cost-benefit of the agent. In defense of the operating room application is the usual need for wound debridement and possible tissue mobilization that is beyond the scope of the clinic setting. Rather than merely being wound covering agents, they are touted for their stimulation of healing by introducing growth factors and related agents to the wound base. How effective this is in the actual wound setting versus laboratory assays remains open to question.

In our text *MasterMinding Wounds*, we were able to identify 15 monolayer and 7 bi-layered bioengineered wound dressing agents.[24] The listing was felt to be accurate at the time of publication of our text (2010). However, new products have appeared, changes in product names have occurred, and manufacturers have switched since that time.

Costs: As mentioned previously, costs of the wound covering category vary from inexpensive to very expensive and probably exhibit the widest range of costs, especially when bioengineered dressings are included, of all the wound dressing agents. Consequently, the prescriber must be mindful of the cost-benefits and contraindications (i.e. that is components of the "Treacherous Triad") when making decisions about using these agents. With single or infrequent applications and reducing nursing costs, they can be cost effective compared to less expensive agents that require frequent dressing changes by wound care providers.

Effectiveness: For appropriately selected wounds, that is those with healthy bases this category of wound dressing agents can be very effective. Usually wound healing is observed and highly predictable when they are used for the proper indications. Healing is often reported, especially with bioengineered dressing coverings, when wound healing did not improve with other types of dressings.[25-27]

Versatility: Of all the categories of wound dressing agents, the wound covering choices are the least versatile. Generally, they can only be used for healthy, vascular-based wounds that are free of the components of the "Treacherous Triad" (ischemia/hypoxia, underlying infection, and/or deformity). Nevertheless, many wounds meet the criteria for these dressings, and for the reasons cited should only be used in appropriate wounds.

Category 3: Dressing Agents for Secretion Producing Wounds

Secretion producing wounds are those that we categorize as generating discharges beyond the normal tissue moisturization of a healthy wound base. The secretions may be exudates, transudates, blood, or combinations of these. Exudates are fluids rich in protein and cellular elements that are infected with bacteria. Transudates are watery fluids from tissues or edema such as commonly seen under blister bases. Although secretions may appear to be desirable because they keep the wound base moist, they have many undesirable features. When exudative, they may contain bacteria, breakdown products of tissues, waste products of metabolism, enzymes cytokines, leucocytes, matrix metalloproteinases, or combinations of these (**Figure 6**). Most of these interfere with healing at the least and at the worst cause tissue destruction.

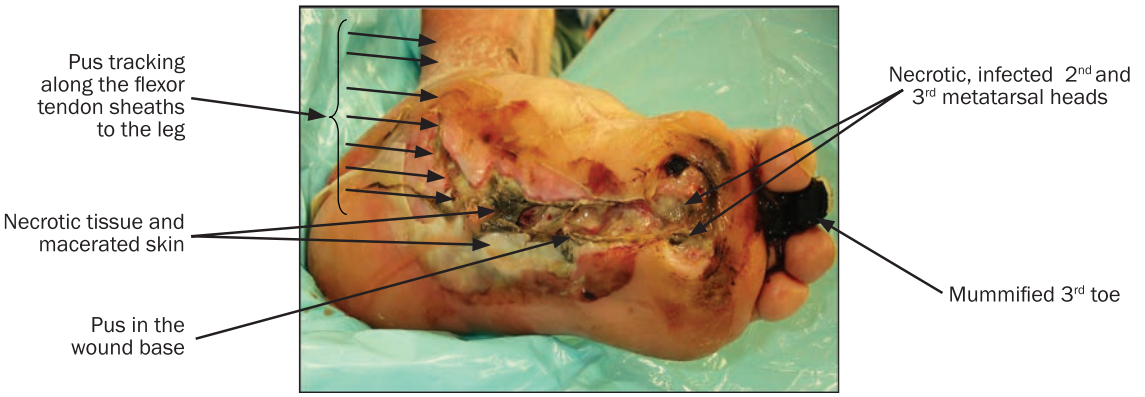
Transudates wet the wound. When large, they keep the wound too moist. Dressings quickly become saturated and the fluids leak out (recall comments about the "art" of applying a moist dressing to cover a wound base) beyond the wound margins. This leads to maceration and cellulitis of the surrounding skin. Because transudates contain the same substances as found in serum such as glucose, protein, and other components of tissue fluid, they provide an ideal environment for the growth of bacteria. We have identified six different interventions for managing the secretion producing wound (**Table 12**). Special interventions, including surgical procedures, may need to be used to most effectively manage secretion producing wounds.

Causes of Secretion Producing Wounds:

Secretion producing wounds have a variety of causes. Generally small-sized secretory wounds have foreign or infected material in their wound base. The foreign material may be sutures, retained vascular bypass grafts, remnants of dressings, or implanted hardware. Non-foreign material contributing to exudate formation may include sequestered exudates (i.e. a pus pocket); osteomyelitis; non-viable relatively avascular tissues

Figure 6

A SEPTIC FOOT THAT REQUIRES IMMEDIATE DEBRIDEMENT FOLLOWED BY AN ABSORPTIVE AGENT WOUND DRESSING



Legend: Surgical debridement is the first tactic that must be employed for management of this ischemic, necrotic, infected, heavily exudative, limb threatening wound.

Once the infected, necrotic material is removed, a variety of absorptive wound dressing agents (Table 12) including negative pressure wound therapy could be used for the wound dressing agent.

such as tendon, ligament, articular cartilage, and joint capsules; infected cicatrix; purulent bursas; or combinations of these.

In moderate sized wounds, underlying necrotic tissues are likely to be the cause of persistent exudate formation. This is often observed in poorly perfused tissues such as connective tissues (e.g. septic joints), articular cartilage, and osteonecrosis (dead bone). Infected joint prostheses and bone cement are also causes.

Large wounds can produce secretions due to the large surface area they have for the transudation of fluids. Large fluid losses can lead to protein depletion, which can contribute to the non-healing of wounds. The first measure for management of secretion producing wounds is to identify and remove the above mentioned causes.

Challenges of Secretion Producing Wounds:

The secretion producing wounds are probably the most challenging with regard to selection of wound dressing agents. The options range from simple absorption devices such as sponges, to negative pressure wound devices, to surgical debridements (**Table 12**). Obviously, this category of wound dressing agents requires the most sophistication in choice selection for the wound. Although secretion absorption is the primary mechanism of this category, many have important secondary effects such as managing the bioburden, moisturizing the wound base, and stimulation of wound healing through angiogenesis, fibroblast function, and epithelialization.

When the choices to manage secretion producing wounds using the same criteria as used for the two previous wound dressing agent categories, their roll becomes obvious as follows:

Adaptability: Although there are a variety of products available, almost every conceivable wound size and shape can be managed by one or more of these products once the wound base is appropriately managed with debridements.[5]

Negative pressure wound therapy (NPWT) is a technique that has recently become available and has, in our opinion, contributed more to the advancement of the selection of the dressing agent strategy than any product since the gauze dressing moistened with normal saline. The concept of NPWT is simple, however the proper application requires training in order to be effective and avoid complications. A porous, foam-like interface or even gauze is trimmed or shaped to conform to the shape of the wound. A tube is placed in the center of the interface usually with a special adaptor. The entire system is then sealed with a non-permeable adhesive covering that extends well beyond the wound edges over healthy skin. The tube is connected to a vacuum pump which collapses the interface (flexible foam) and withdraws secretions. Typically the interface and tubing is changed two to three times a week, thereby greatly reducing the need for frequent dressing changes.

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Table 12
INTERVENTIONS FOR MANAGING THE SECRETION PRODUCING WOUND

Categories	Examples*	Primary Effects	Other Effect(s)	Miscellaneous (Costs**, Side Effects, Comments)
Absorbents	Aquacel® PolyMem® (Coated polyurethane material) Kaltostat® (Calcium sodium alginates) Mepilex® (Silicone contact layer)	Absorption of secretions	Convenience, reduced frequency of dressing changes; Comfort; Desiccating effect;	Minimally expensive (< $10 per application). Minimal side effects Heavily secretory wounds may overwhelm the absorbing capacity of the agent. Not practical for large wounds; Dressing changes every 1 to 3 days.
Absorbents with Bioburden Control Additives	Acticoat™ (Silver coated) Aquacel® Ag (Silver impregnated) Iodosorb™ (Cadexomer dressing with iodine)	SAA (same as above) Control of bacteria growing on the surface of the wound.	SAA	About 1 ½ times more expensive than the absorbents alone (above row); Same side effects as above, but contraindicated in those with allergies to the bactericidal ingredients (silver or iodine). Dressing changes every 1 to 3 days.
Continuous Wound Irrigation	Plastic or silicone catheter placed in wound base; irrigation with normal saline.	Washout of secretions and debris. Maintains moist environment.	Reduction of bioburden Comfort (No dressing changes while employed).	Minimally expensive Used for several days after debridement of septic wounds. Side effects include maceration of tissues and wetting of dressings, etc., from the irrigation.
Closure with Suction-Irrigation	Perforated portions of drain tubes are tied together; the ends exit at opposite ends of the closed wound.	Inflow (with normal saline) and outflow continuously lavage the closed wound.	Wound closures are possible even with heavy bioburden at the time of debridement	Inflows (typically 50 cc/hr) decreased by 10 cc/hr each day; tubes removed about the 6th post-op day. Inflow & outflow directions changed each hour—i.e. countercurrent effect.
Negative Pressure Wound Therapy	A contact layer trimmed to wound size is covered with an impervious membrane and connected to a vacuum pump.	Removal of secretions. Wound contraction. Maintains moist environment.	Angiogenesis Reduction of bioburden Contact/contraction effects enhance fibroblast activity	Costs about $100/day); cost-effective by eliminating hospitalization. Not limited by wound size. Contraindications include wounds with necrotic bases & untreated osteomyelitis. Rarely discontinued due to pain or skin maceration. Changed 2-3x/wk.
Surgical	Debridement, revision and/or stabilization. Vein surgery.	Eliminate bioburden & necrotic tissue. Prepare wound for closure/coverage.	Switching to simpler dressing agents. Control sepsis.	Operating room time is expensive. Side effects occur with anesthesia; bleeding & other surgical complications.

*These are examples with which the authors have had experiences. The list is not intended to be all inclusive. Consequently, the omission of an item is not intended to deprecate the value of other products or techniques nor suggest that they do not have features equal to or better than those in the above table.

Different interface materials may be used for special situations as tracking wounds, wounds with recesses, infected wounds, and wounds over critical structures such as blood vessels, bowel, bone, joint, and tendon. Initially, continuous suction is recommended, especially for secretion management. After several days, intermittent suction is recommended. Intermittent suction is reported to promote angiogenesis and fibroblast function through micro- and macro-strain tissue deformation.[28] The "total contact" of the interface with the wound base may also be a signaling mechanism to promote these wound healing functions. Many articles have been published supporting the effectiveness of NPWT.[29-31] Over a dozen NPWT product lines are available, each with various wound interface materials, pressure settings, connection devices, etc.[24]

Availability: Because of economics, the manufactures of these products are well-advertised, actively promoted, and readily available to the wound care practitioner. In addition, company representatives can be very helpful in providing information to obtain authorizations from payers to use NPWT.

Costs: Costs for these products vary from moderately to relatively expensive. However, their use facilitates the transfer of patients to lower levels of care. This is especially appreciated with the use of NPWT, which often makes it possible to transfer a patient from the acute care facility to a lower level of care and supports the cost-effectiveness of this device.[32,33] Obviously, less expensive wound dressing agents can be used for wounds with healthy bases.

Effectiveness: These agents generally work well for secretion producing wounds, but it is questionable whether they are more efficacious than moist gauze dressings, coupled with debridements and sutures to stepwise reduce wound size.

Versatility: The products to manage secretion producing wounds especially NPWT have applications for a wide variety of wounds that range from cavitary to secretory to vascular based. Contraindications for using NPWT include necrotic tissue in the wound base, malignancy in the wound, untreated osteomyelitis, exposed vital organs, close proximity to blood vessels, and wounds in locations where a seal cannot be obtained, such as the perianal/gluteal region, around digits, or where the skin is macerated, cellulitic, or extremity friable. Bleeding and even deaths from exsanguination have been reported when the interface was placed over blood vessels and the vessels ruptured with application of suction.[34] Other secretion absorbing agents that are changed less frequently than moist gauze dressings may become so adherent to the exudates and/or wound bases that their periodic changes generate more than tolerable pain for the patient.

Category 4: Gels, Salves, Ointments, and Solutions with Additives

The number of gels, ointments, and salves with additives used for wounds accounts for a large part of the over 2,000 wound dressing agent choices. Generally, these agents are used for small-sized wounds that have relatively healthy appearances. Many have additives which make them useful for specific wound challenges and indicate their primary benefit (**Figure 7**). A good example of additives is the array of ointments that have antimicrobial activity (**Table 13**). Secondary benefits include convenience, comfort, ease of use, and costs. Typically, applications are done once or less each day. For these reasons, they are ideal for patients whose wounds can be managed outside the hospital setting. When the agents that have additives are evaluated with the criteria used for the other wound dressing selections, their wide scope of applications is appreciated.

Adaptability: Usually gels, salves, and ointments are used for small and medium-sized superficial wounds. One notable exception is silver sulfadiazine (Silvadene®) used for burn, blister, and superficial abrasion wounds of almost any size.

Availability: Many of the gels, ointments and salves with additives are available without prescriptions, that is, they are sold over the counter. This tends to make them easily accessible and reduces their costs. Many of the products, especially those with microbiological properties have similar or overlapping effects, so if a specifically prescribed agent is not available, a generic substitute with similar properties usually is.

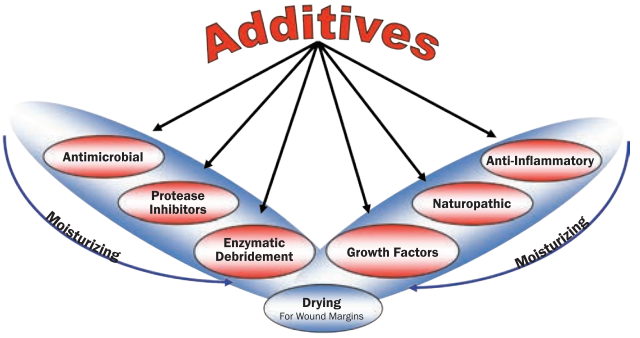
Costs: The prices of these agents vary from a couple of dollars for a small tube (about 1 oz/15 g) of antibiotic ointment to over $500 for agents with genetically engineered additives. In general, since the sizes of the wounds appropriate for this category of agents tend to be small, the cost per application is nominal.

Effectiveness: These agents are effective, especially when selected for the primary functions for which they were designed. Usually by the time these agents are selected, the infection in the wound is controlled and the wound base has become vascular. Consequently, they are ideal for convenience, comfort, ease of use, and cost. However, they will be ineffective if the wound continues to have elements of the "Treacherous Triad," namely ischemia/hypoxia, unresolved infection, and/or deformities.

Versatility: Because there are so many specific indications, for example antimicrobial, moisturizing, debridement, drying, growth factor stimulation, anti-inflammatory, protease inhibitors, etc., as a group they are very versatile (**Figure 7**). Many secondary and tertiary effects such as moisturizing and acid-base regulation add to their versatility. The antimicrobial agents are now being combined with absorption agents to combine the beneficial effects of both these categories into one dressing.

Figure 7

ADDITIVES TO GELS, OINTMENTS, AND SALVES TO EXTEND THEIR EFFECTIVENESS



Legend: Additives are combined with gels, ointments, salves or solutions to achieve the effects depicted above. Often 2 or more items are added in order to increase the scope of actions.

Almost all the agents help moisturize the wound base due to their petrolatum or similar vehicle (red ovals). The additives are usually one percent or less.

The exception to wound moisturization are the drying agents such as Zinc oxide that are placed around the wound to prevent maceration, cellulitis and allergic reactions.

The following is a list of gels, ointments, and salves that have additives is based on the primary effect of the agent:

Antimicrobial Agents There are many antimicrobial agents that use gels, ointments, and salves as vehicles for maintaining the agent in the wound site. Local antimicrobial agents are not a substitute for systemic antibiotic and fungicidal agents, but are a useful adjunct to wound management when these flora reside on the surface of the wound.[35] In addition, the vehicles, usually petrolatum based, help maintain a moist environment for the wound. Some of the antimicrobial agents are combined with agents that absorb secretions, as mentioned above, which make them doubly effective for infected, exudative wounds.

Even though these agents' antimicrobial activities are primarily at the wound surface, systematic side-effects can occur. Consequently, these agents are contraindicated for those patients with known allergies to the antibiotics they contain. These agents should be avoided in cavitary, recessed, and tract wounds because the vehicles that contain the antibiotic, for example petrolatum, may seal off secretions and drive the infection inward, which could lead to systemic sepsis. In addition, petrolatum based agents may interfere with cleansing of the wound base during dressing changes and lead to less than ideal wound hygiene.

Honey, although not an actual antibiotic agent, has merits with respect to bioburden management. We classify it as a naturopathic agent. It is reported to be effective for managing superficial wound infection, inflammation, and necrotic tissue.[36]

Costs of antimicrobial agents range from less than 5 dollars for a small tube of an over the counter product, to more than 50 dollars for a prescription item (**Table 13**). A thin application of the agent over the wound base is more effective than thick, totally occlusive applications. Usually a single-layer gauze dressing is then placed over the agent for protection and keeping the agent in contact with the wound. An easier application technique is to apply the agent to the gauze dressing conforming to the surface area of the wound using a wooden tongue blade, then placing the gauze with the agent on it directly onto the wound.

Drying Agents: The need to keep the skin around the wound edges dry and free of maceration is almost as important as maintaining a moist environment for wound healing. This can be a challenge in exudative

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Table 13

AGENTS THAT ARE GELS, OINTMENTS, SALVES OR SOLUTIONS THAT HAVE ANTIMICROBIAL ACTIVITY

Agent	Special Features	Comments, Side Effects, Costs, Etc.
Bacitracin	Anibacterial agent for gram positive bacteria Moisture (petroleum based)	Non-prescription About $6 for a small tube
Bacitracin + Neomycin + Polymyxin (Triple Antibiotic Ointment®)	Improved spectrum of bactericidal activity (Gram positives & gram negatives) Moisturizes (petroleum based)	Non-prescription About $6 for a small tube Nephrotoxicity & ototoxicity concerns from neomycin; restrict to small wounds
Bacitracin + Polymyxin (Polysporin®)	Plastic or silicone catheter placed in wound base; irrigation with normal saline	Washout of secretions and debris Maintains moist environment
Cadexomer Iodine Gel (Iodosorb®)	Activity against oxacillin resistant staphylococcus and vancomycin-resistant enterococcus; Dries; absorbs secretions	Prescription required Dressing changes every 2 to 3 days; About.$40 for a small tube
Chlorhexidine (Hibiclens®)	For removal of colonized oxacillin resistant *Staphylococcus aureus* from skin (cleanser)	Non-prescription Decolonization by daily showering with product over a 3 to 4 day period
Clotrimazole (Lotrimin®)	For superficial fungus infections, best used for macerated skin rather than directly on the wound base	Non-prescription Other agents with similar effects include Tolnaftate (Tinactin®) and miconazole (Micatin®) Cream or lotion formulations
Clotrimazole + Betamethasone (Lotrimin®)	Useful agent when combination of fungus infection and skin inflammation are present adjacent to the wound	Prescription required because of higher strength steroid Generic formulations are relatively inexpensive; Analogous effects achieved with using component agents in combination with each other
Mafenide Acetate (Sulfamyalon®)	Excellent for blister bases, especially burns Silver ion provides bactericidal activity Excellent for large wounds	Prescription required About $20 for a small jarContraindicated in patients with allergies to sulfa drugs Leads to oxygen toxicity when used with hyperbaric oxygen
Mupirocin (Bactroban®)	Activity against Oxacillin-resistant *Staphylococcus aureus* (ORSA); Moisturizes (petroleum based)	Prescription required About $40 for a small tube
Silver Sulfadiazine (Silvadene®)	Excellent for blister bases; similar to Sulfamyalon® Silver ion gives bactericidal activity; Excellent for large wounds Softens debris; facilitates superficial debridements	Prescription required About $20 for a small jar Contraindicated in patients with allergies to sulfa drugs OK to use with hyperbaric oxygen

Note: These are examples of agents from the gels, salves solutions and ointments category that have antimicrobial additives with which the authors have had experience. The list is not designed to be all inclusive. Consequently, an omission is not intended to deprecate the value of a product not listed in the table nor suggest it does not have features equal to or better than those in the table.

By using information in this table for comparisons, thoughtful decisions can be made about the merits of products not included above and/or new products as they become available.

Other additives for the gels, etc., typically have more than one option, but not to the extent of the antimicrobial additives.

wounds and may require the dressing to be changed more than twice a day. To avoid moisture from the wound harming the surrounding skin, moisture barrier ointments such as zinc oxide can be very effective.

This is another situation where agents from two wound dressing agent categories, for example, an absorbing agent and a drying ointment can provide greater benefits than using a single agent alone.

Enzymatic Debridement Agents: These agents degrade proteinaceous material. Currently in the USA only one agent, Santyl®, is available for these purposes. It is a proteolytic enzyme that degrades collagens. It is useful in wounds that are covered with a thin layer of necrotic material, such as a fibrinous exudate. This agent is indicated when the necrotic material in the wound base is not amenable to surgical debridement because it lies over relatively avascular, but important structures such as ligaments, tendons, or bones. Granulation tissue formation appears to be enhanced by enzymatic debriding agents, perhaps by removal of the barrier effect of the proteinaceous debris. Few side-effects have been observed with these agents, but some patients did not tolerate the papain-urea based preparations because of pain. A small tube of these agents may cost fifty dollars or more. However, their once a day application and use for small wounds makes then relatively inexpensive per application.

Unfortunately, the papain-urea enzymatic debridement agents (Accuzyme® and Panafil®) have been removed from the USA market by direction of the Food and Drug Administration due to a few reported local allergic reactions. These agents are a papain-urea cysteine endopeptidase. Chlorophyll addition made the Panafil® agent green and is a supposed aid to wound healing.

The papain-urea agents are effective over a wide acid-base range, are selectively active against non-viable tissue, but are harmless to viable tissue. Urea acts as an activator to the papain which is the primary enzymatic agent.

Growth Factors: Agents with growth factors were introduced with extensive marketing and great expectations. Unfortunately, the clinical experiences with these agents have not lived up to expectations. They probably should be considered when chronic wounds fail to improve and no reasons are apparent to explain why the wound is not improving. Use of becaplermin is expensive. The retail price for a 15 g tube is more than $500. Other than for small-sized wounds, their costs alone would be prohibitive. Many of the bioengineered skin substitutes and allograft skin substitutes are also purported to introduce growth factors into the wound.

One of the previous highly marketed and commercialized products, an autologous platelet derived growth factor called Procuren® is no longer available.

A second product that has received "premarket approval" by the Food and Drug Administration, becaplermin (Regranex®), is not being used to the extent it was when first introduced to the wound care community. The reasons for this are probably due more to lack of proper selection indications than from lack of clinical efficacy. Certainly any wound with components of the "Treacherous Triad" (ischemia hypoxia, unresolved infection, and/or deformity) that keep it from healing would not be expected to heal with the addition of growth factors.

Photo stimulation and electrical therapies have also been advocated as a technique to stimulate wound healing. The energy they impart to the tissues is postulated to stimulate the subcellular components of wound healing somewhat analogous to the roles ascribed to growth factors and negative pressure wound therapy.[37]

The role of growth factor additives for wound healing remains unanswered. One of the challenges is that multiple growth factors, cytokines, inflammatory mediators, interleukins, lymphokines, oxygen, and other cell signaling agents, most likely interact to heal wounds. The currently available growth factor is a single agent. The roles of the growth factors ascribed to the bioengineered skin covering agents are primarily based on bioassays in the lab; how effective they are in the *in vivo* wound setting remains to be determined.

At this time there is much interest, especially for orthopaedic applications, in using autologous platelet-rich plasma to speed healing of ligament and tendon injuries. However, reports are inconclusive about its benefits.

Moisturizing Agents: This group of agents is hydrophilic; that is, they maintain a moist environment to optimize wound healing. Daily applications are usually sufficient to achieve this goal for the wound base. When they are water-based, rather than petrolatum-based, cleansing of the wound with each dressing change is facilitated in contrast to dealing with greasy residuals from hydrocarbon-derived products.

These agents are inexpensive, generally only costing a few cents per application for a small-sized wound. The water-based generic name is hydrogel. Few side-effects are observed when using these agents for the properly indicated wound.

A purified water, liquid paraffin, ethylene glycol mixture with other ingredients (Biafin®) is another agent in this group. The other ingredients are added to its petrolatum base to provide an optimal environment for wound healing and a barrier from harmful bacteria. It is a prescription item and costs about thirty dollars for a small wound.

The moisturizing agents are useful for wounds in their final stages of healing with healthy granulating bases, free of significant bioburdens, and generating an epithelial covering (**Figure 8**).

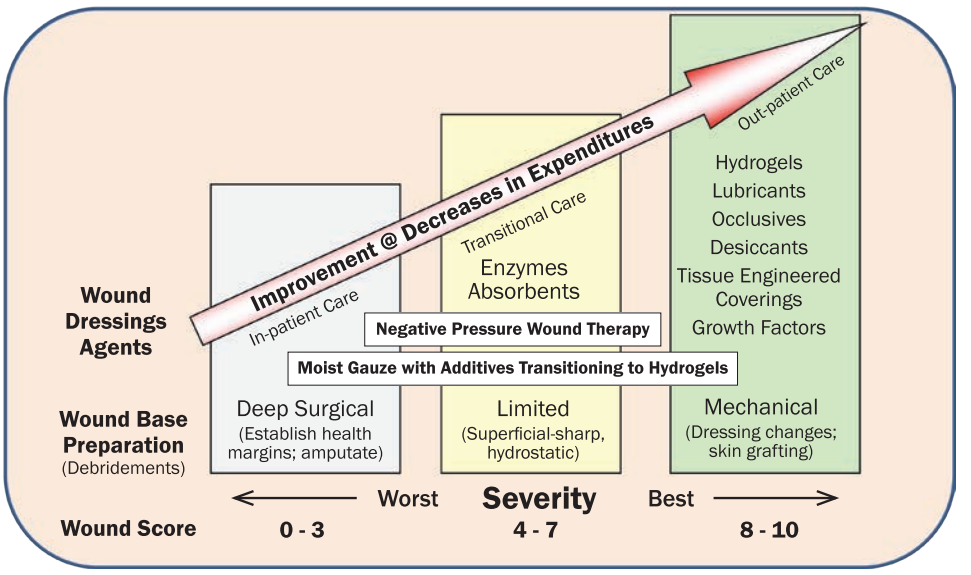
Steroids and Vitamin E: Steroids reduce erythema and swelling around a wound through their anti-inflammatory actions. The steroid ointments are particularly helpful for treating stasis dermatitis that is associated with venous stasis ulcers. Those with low concentrations of hydrocortisone (1% or less) can be purchased over the counter for a couple of dollars for a 15 g tube. For higher concentrations, prescriptions are required and costs are higher.

Frequently, venous stasis ulcers cause maceration and erythema from leakage of fluid from the ulcer base and become secondarily infected with fungus. This often leads to an allergic, eczematous reaction. The combination of a locally-applied fungicidal agent (Tinactin®, Clotrimazole, Lotrim®, etc.) and a steroid ointment are usually very effective in managing this complication of the venous stasis ulcer.

The use of vitamin E ointment for wound healing and inflammation reduction is controversial. Sometimes it is advocated for softening and reduction of erythema and scaring. Its efficacy for this application is in question. Perhaps the real benefit from it is the massaging effect of trying to get it to penetrate the skin.

Figure 8

THE CHANGING ROLES OF WOUND BASE MANAGEMENT AND WOUND DRESSING SELECTIONS AS THE WOUND IMPROVES



Legend: As a wound improves the management of the wound base changes from more complex to merely mechanical/autologous debridement with dressing changes. Likewise, for the wound dressing agents which change from frequent and expensive (at least in caregivers' time) to inexpensive and infrequent.

Notice that the moist gauze dressing can be used through the entire continuum of improvement while negative pressure wound therapy could be a majority of the time.

IV. MYTHS, MISCONCEPTIONS, AND FALLACIES ABOUT WOUND DRESSING AGENTS

There is much misinformation about the use of wound dressing agents. The following ten items are myths, misconception, and fallacies about wound dressing agents.

1. The moist gauze wound dressing is archaic. The moist gauze dressing is the starting point for the management of most serious wounds. The more complicated the wound, the more likely the moist gauze dressing is the dressing of choice. As the wound improves, the moist gauze dressing can be substituted for less labor-intensive, but probably little or no more effective wound dressing agents. Immediately after debridements in highly exudative wounds, bloody-based wounds, wounds with uncontrolled sepsis, and wounds over exposed blood vessels, the moist gauze dressing may be the only choice. Aqueous gauze dressing can be applied to any size wound. To improve the effectiveness of moist gauze dressings, antimicrobial, acidifying, and moisturizing agents may be added while achieving the basic requirement of maintaining a moist interface over the wound base.

2. The more frequent the dressing changes, the better the chances of wound healing. Dressing changes should be done as frequently as necessary. For exudative wounds, frequent dressing changes are required. Improving wounds need less frequent dressing changes; agents can then be selected that remain effective for longer periods of times as is characteristic of gels, salves, and ointments. When the wound evolves to this stage, increasing the frequency of dressing changes does not speed healing.

3. One wound dressing agent is ideal for all wounds. Obviously, with the innumerable options for wound dressing agents, no single agent is ideal for all situations, nor is there a situation where a particular agent might not be effective. Of all the wound dressing agents available, the normal saline dressing is the one that comes closest to being the universal dressing agent. The normal saline dressing is the standard for judging cost-effectiveness and cost-benefits of other dressing choices.

4. Wound size, shape, and depth should not be considerations when making decisions about the selection of wound dressing agents. These factors, along with the appearance of the wound base, are instrumental in making decisions about which wound dressing agents to use. It is not sensible to use a very expensive wound dressing agent that requires daily dressing change or multiple bioengineered skin substitute applications for very large wounds when less expensive alternatives could be used. Gels and ointments should not be used in tracking wounds because residuals of the petrolatum base may trap bacteria and debris. The **Wound Score** provides objective criteria for which agents to use. For example, “healthy” wounds (**Wound Scores** of 8 to 10 points) are better managed with the gels, salves, and ointments with or without appropriate additives.

5. The use of expensive wound dressing agents is the best assurance that wound management will be successful. Wound dressing agents need to be selected on the basis of the wounds’ requirements. Usually, the most cost-effective choices are the most cost-beneficial. Use of more expensive agents does not guarantee successful healing. Their use needs to be determined by the particular requirements of the wound. The three major reasons wounds do not heal, which are persistence of deformities, uncontrolled infection (osteomyelitis), and ischemia/hypoxia, must always be addressed before seeking a “magic cure” with a wound dressing agent.

6. When scientific data supporting the benefits of a particular wound dressing agent is reported, it is incontestable. Unfortunately, bench laboratory studies and patient trials do not always correlate with the clinical realities of wound healing. The benefits of a particular wound dressing agent are only fully appreciated when used in conjunction with the other four components of strategic management of a “problem” wound (i.e. medical management interventions, preparation of the wound base, protection and stabilization of the wound, and wound oxygenation). Additionally, correction of the three major reasons a wound does not heal (reiterated in item 5) must be addressed.

7. Failures with the use of a particular wound dressing agent can always be attributed to lack of patient compliance and/or failure to follow the manufacturer's instructions. There are many reasons that wounds fail to heal. From the **Wound Score**, failures can be predicted with almost 100% accuracy for the "futile" wound (0 to 3 points on the **Wound Score**). Other failures are due to using the agent for the wrong indications, for example the use of an occlusive wound covering for an exudative wound. Finally, "problem" wounds may fail to heal and require lower-limb amputations because of new vascular occlusive events, multiple drug-resistant organism infections, unresolvable mechanical problems, coexistent collage vascular diseases, and/or intractable pain.

8. There is only a small range in costs among the different wound dressing agents. As the preceding information has shown, there is a vast range of costs among the many choices for wound dressing agents. The supplies can vary from a few cents a dressing for normal saline, salves, gels and ointments to more than one hundred dollars a day for negative pressure wound therapy. Tissue engineered wound coverings and genetically derived growth factors can likewise be very costly, and in many situations can only be used for the smaller sized wound. The bottom line, in terms of costs, is pairing the cost-effectiveness with the cost-benefits of the wound dressing agent.

9. If one wound dressing agent is effective, it is not appropriate to change to another even if the wound improves. As has been discussed, no agent is ideal for every wound. Likewise, no agent is ideal for each stage of wound healing. As the wound improves (or worsens), the wound dressing agent should be selected to meet the needs of the wound. Finally, if the wound is not improving with a particular agent, consideration for switching to a different agent with different functions is indicated. In addition, the three primary reasons the chronic wound is failing to improve (persistence of deformities, uncontrolled infection (osteomyelitis) and ischemia/hypoxia) must be mitigated.

10. Wound dressing agents that have two or more functions should be avoided; likewise, the use of two or more agents on the same wound is counterproductive. Many agents have multiple functions and more than one active ingredient as has been described in this article. Newer agents are taking advantage of this concept and as is observed in the many wound absorbents that have silver or iodine derivatives added to them. Also, use of two or more agents, such as an absorbing agent to control secretions and a drying agent for the skin margins to prevent maceration is an example of a technique where two agents work in a mutually beneficial fashion.

V. CONCLUSIONS

Wound care centers appear to focus on two of the five essential strategies for managing serious wounds, namely wound debridements and selection of wound dressing agents, but should not overlook medical management, wound oxygenation, and wound protection/stabilization (**Table 1**). While there are over 2,000 choices for wound dressing agents, there is much science to support which agent is most effective for the particular wound. Appropriate decisions can be greatly aided by assessing the characteristics of the wound. Once this is determined, a dressing appropriate for that assessment; namely **1) gauze dressings, 2) wound covering agents, 3) secretion absorbing agents, and 4) gels, ointments, and salves without or with additives can be selected with good justification (Table 2).** When new agents become available, this categorization will help the wound care provider appreciate the role of the agent. Many of the newer agents combine properties from two or more categories such as absorbing and antimicrobial agents. Again, by knowing in which categories the combination agents fall, the provider can make appropriate decisions about their use.

At this time the wound center facility is fulfilling a vital role in caring for wounds. Wound care has largely moved from the private practitioner's office to the wound care facility because of economics, logistics, and familiarity with wound care products. The wound care facility is designed to handle these contingencies with an inventory of wound care products to treat the patients and knowledgeable, dedicated staff to handle wound problems.

It makes little sense for the primary care physician to have an array of products and equipment and remain up-to-date on wound care products when only treating an occasional patient for a wound problem. Conversely it behooves the wound facility to provide state-of-the-art wound care. Information from this article helps clarify one of the most difficult challenges; that is categorizing wound care products.

The costs of wound dressing agents range from a few cents per application to thousands of dollars, for example for application of a bilayered bioengineered skin substitute in the operating room. While some may decry the use of gauze dressings as a wound dressing agent, we feel strongly that this choice remains appropriate for a variety of wounds. It is ideal for packing wounds and achieving hemostasis in wounds that have just had major debridements. It is useful for removing superficial necrotic material and debris in the wound through its autologous debridement properties. With antimicrobial wetting agents, it helps control the bioburden. In wounds that are heavily exudative or have much necrotic material in their bases, the moistened gauze dressing is the only logical alternative. While other categories may be better suited or more cost-effective (if wound care providers have to do the dressing changes), the moist gauze dressing is the only agent that is suited for all four wound categories (**Figure 8**).

As wounds improve, the wound dressing agents should change to best suit the characteristics of the wound and be most cost-effective (**Figure 8**). A typical sequence is to start with gauze moistened with double antimicrobial solutions. Once the bioburden is controlled and the base is free of necrotic tissue, negative pressure wound therapy or absorbing agents with or without antimicrobials can be used. After the wound base becomes vascular and superficial, gels and ointments can be used. With each improvement, a different category of wound dressing agent is selected, the wound care becomes simpler and the care becomes more cost-effective.

In summary, there is rhyme and reason for selecting dressing agents for wounds. Although the number of choices is overwhelming, our four-category system simplifies making decisions. Each wound care provider should become familiar with a list of about ten agents with which they are comfortable using and which subtend the four categories of wound dressing agents. There should be several choices available for each category (**Table 2**). When new agents become available, rational decisions can be made for using it by determining which category of dressing the new agent falls in and how its mechanisms and outcomes compare with other agents in that category.

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Dr. Jayesh B. Shah's Q. & A. Corner

Test your knowledge in Wound Care and Hyperbaric Medicine

1. **Which Braden Subscale rating applies to a patient with "very moist" moisture?**
   - **a.** 1
   - **b.** 2
   - **c.** 3
   - **d.** 4

2. **A patient who makes occasional, slight changes in body or extremity position but is unable to make frequent or significant changes independently would receive a Braden Subscale rating of . . .**
   - **a.** 1
   - **b.** 2
   - **c.** 3
   - **d.** 4

3. **Which statement about Braden Scale is not true?**
   - **a.** The assessments are unreliable approximately 50% of the time.
   - **b.** Risk factors provide information needed to plan prevention interventions.
   - **c.** A score of 18 or lower means the patient is at risk for developing pressure ulcers.
   - **d.** A score of 18 or above means the patient is at minimal risk for developing pressure ulcers.

4. **Which method is considered to be quick and efficient to debride an infected pressure ulcer?**
   - **a.** Autolytic debridement.
   - **b.** Maggot therapy.
   - **c.** Surgical debridement.
   - **d.** Enzymatic debridement.

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Dr. Jayesh B. Shah's Q. & A. Corner

5. Which swab culturing technique is thought to be the most effective method for sampling moist tissue bioburden?

a. Dry swab.
b. Z stroke.
c. Levine technique.
d. Wet surface swab.

Answers

1. b 2. b 3. a 4. c 5. c

Question 1. Answer (b)

Braden Subscale ratings of moisture are constantly moist: skin is kept moist almost constantly by perspiration, urine etc., Score 1; very moist: skin is often but not always moist, linen must be changed at least once a shift, Score 2; occasionally moist: requiring an extra linen change approximately once a day , Score 3; rarely moist: skin is usually dry, linen only requires changing at routine intervals, Score 4.[1,2,3,4]

Question 2. Answer (b)

Braden Subscale ratings of mobility are completely immobile: does not make even slight changes in body or extremity position without assistance, Score 1; very limited: makes occasional slight changes in body or extremity position, Score 2; mobility slightly limited: makes frequent though slight changes in body or extremity position independently , Score 3; mobility no limitation: makes major and frequent changes in position without assistance, Score 4.[1,2,3,4]

Question 3. Answer (a)

The Braden Scale is one of the validated tools for pressure ulcer risk assessment. It has six categories including sensory perception, moisture activity, mobility, nutrition, and friction and shear. Risk factor provides information needed for plan interventions; Scores of 18 and lower means the patient is at risk for pressure ulceration, and scores of 18 and above means the patient has less chance of developing pressure ulcers.[3,4]

Question 4. Answer (c)

The quickest way to debride the infected pressure ulcer is surgical debridement. Enzymatic debridement is most selective and autolytic debridement is most cost-effective way of debridement.[3,6]

Question 5. Answer (c)

Levine technique is thought to be the most effective swab culture to sample moist tissue bioburden. Levine technique consists of rotating a swab over a 1 cm^2 area with sufficient pressure to express fluid from within the wound tissue.[5, 6]