ProCare Training Manual
Chapter 9
Wound Care Products

The abundance of commercially prepared dressings and adjunct products, along with the fact that many have similar names and functions, can make choosing the appropriate wound care dressing a daunting task. To provide the best care for your patient, it is important to always be aware of the latest and greatest wound care products available. Given the number of products available today, it is hard to believe that there could be anything new around the corner. The truth is that new products arrive daily and others are updated or improved regularly. Because the quality of care you provide depends on your knowledge level, it is very important that you stay up to date on the new products being introduced and the product improvements.

In this chapter, we will look at the basic and advanced wound care products and the indication, advantages and disadvantages of each. It is imperative that you understand the products being discussed are only tools to assist you with wound healing. Unless concurrent problems, such as circulatory disorders, malnutrition, diabetes, and patient knowledge deficits are addressed, the healing process is delayed.

Gauze is the core dressing with the most longevity for use in wound care. This dressing has been around longer than any other dressing available on the market. With improvements in technology, manufacturers have developed numerous alternatives to gauze dressings.

Moisture level, tissue adherence, infection control and wound dimensions are just some of the factors that affect wound dressing selection. The level of moisture in the wound bed is critical, as is the temperature of the wound. When a dressing is changed, it can take up to 8 hours for the wound to achieve homeostasis, therefore, longer intervals between dressing changes is often better if it does not compromise the wound in other areas, such as drainage, infection, etc..

Table 9-A is a listing of dressings and their absorptive mechanisms.

Table 9-A

Absorbs Moisture	Neutral (Maintains existing moisture level)	Adds Moisture
Alginates	Hydrocolloids	Sheet hydrogels
Specialty Absorptives	Composites	Amorphous hydrogel
VAC devices	Biological dressings	Debriding agents
Gauze	Collagen dressings	Occlusive dressings
Foams	Contact layers	
Compression dressings	Warm up therapy	
	Transparent Films	

DRESSING CLASSIFICATIONS

Now let's take a look at some of these dressings more specifically.

Gauze

Although gauze remains a good choice for secondary dressings, it no longer represents the most effective choice for a primary dressing. Various sizes of gauze are available. Investigate your product to determine if it is made of natural or synthetic fibers and if there is any latex in the product or the packaging. Natural fibers typically absorb and allow better air exchange than synthetic fibers. When using gauze for packing, whether it's a 4x4, roll gauze or packing strips, be cognizant of any loose fibers on the gauze. Gauze, depending on the brand, often "sheds" and stray fibers could be left in the wound acting as a foreign body. When using a 4x4 gauze, it is always best to unfold it completely prior to soaking with saline and placing in wound bed. This is commonly referred to as "fluffing" and allows greater surface coverage than simply laying the gauze in the wound.

Alginate Dressings

These non-woven dressings are made of seaweed and are packaged in the form of white, sterile pads or ropes. Alginate dressings can absorb 7 to 10 times their own weight in fluid. They can be cut to fit within wound dimensions, layered for additional absorption, or the ropes can be packed into deep and or tunneling wounds. As the dressing absorbs the exudates, it turns into a gel that keeps the wound bed moist and promotes healing. Alginates are nonadhesive, nonocclusive, and promote autolysis. When using an alginate, it is important that you irrigate the wound with normal saline during dressing changes in order to remove any excess fibers or byproducts of the alginate dressing. These dressings require a secondary dressing and should not be used on third degree burns or wounds that potentially may become dehydrated. Periwound skin should also be protected to prevent maceration in the wound with large amounts of drainage.

Biological Dressings

Biological dressings are temporary dressings that function similarly to skin grafts. They are made from amnionic or chorionic membranes woven from manmade fibers, harvested from animals (usually pig) or cadavers. These dressings are typically impregnated with growth hormones or other biochemical substances that expedite wound healing. In some instances, these dressings can only be used temporarily because the body begins to reject them. If ejection occurs before the underlying wound heals, the dressing must be replaced with a skin graft. When used in non-infected clean wounds, these dressings can also act as a biological covering for wounds. This is especially helpful in very painful arterial ulcers.

Collagen Dressings

Collagen dressings, which are made with bovine or avian collagen, accelerate wound healing by encouraging the organization of new collagen fibers and granulation tissue. These dressings should only be used on chronic, clean, non infected, granulating wound beds. Collagen dressings are available in gel, granule, and sheet forms. Some also contain alginate to absorb excess moisture. These dressings should not be used on anyone with a reported allergy to bovine or avian products, nor should they be used on third degree burns or wounds that could possibly become dehydrated. They should be covered with an appropriate secondary dressing to maximize the healing process.

Antimicrobials

There are numerous forms of antimicrobial dressings. They come in the forms of gels, pads, packing strips, sheets and powders. One of the newer introductions to the antimicrobial lines are the dressings incorporating the use of silver. Research has shown that silver inhibits microbial growth and is non-toxic to human cells. Thus, the silver products lower the bacterial load of the wound, allowing important angiogenesis to occur at a more rapid rate. It is important to become familiar with the dressing medium the silver in contained in and the time allowed for the silver to be released into the wound, as some preparations are quick acting, requiring BID to TID dressing changes, and others are long acting, only requiring a dressing change weekly.

Composite Dressings

Composite dressings are hybrids that combine two or more types of dressings into one. An example of a simple composite dressing would be the standard Band-Aid. As the wound care industry has become more advanced, there are several composites available on the market. Some combine gauze and adhesive, some include an antibacterial component, a non-adherent layer, or an absorptive layer. There are a multitude of composites available. When choosing a composite dressing, one should be cognizant of the function of each layer. Composite dressings are typically all-in-one dressings and therefore should not require a secondary dressing. They are available in multiple shapes and sizes. Unfortunately, depending on your choice, most can not handle heavily draining wounds and should not be cut to fit as it often decreases the integrity and/or function of the dressing.

Contact Layer

The contact layer dressing is exactly as it sounds. It is a dressing designed by a single layer of woven or perforated material that is suitable for direct contact with the wound's surface. The nonadherent contact layer allows the flow of drainage to a secondary dressing while preventing the dressing to adhere to the wound. These dressings are especially helpful for use over very painful wounds and over skin grafts. In many instances, the contact layer can be cut 1-2 cm larger than the wound bed and secured with steri-strips to prevent accidental removal (such as over a new skin graft) and to allow for observation of the wound or for changing the secondary (outer) dressing. Contact layers should not be used over infected wounds.

Foam Dressings

Foam dressings are a sponge like polymer dressing that provides a moist wound environment. These dressings are somewhat absorbent and some include an adhesive border. Most have a nonadherent surface for increased comfort over the wound and can be used on wounds with minimal to moderate drainage. Foam dressings can be used as a primary dressing (if adhesive border present) or with other secondary dressings. Hydropolymer foam dressings can manage heavier drainage as they wick moisture away from the wound and allow evaporation. Most foam dressings are recommended to be changed every 3-5 days or when the wound drainage has saturated more than 75% of the dressing. If not changed frequently enough, the periwound may become macerated. Foam dressings are especially beneficial over non-complicated, non-infected stage II pressure ulcers that have minimal to moderate drainage. These are often preferred over the hydrocolloid in bed bound patients because they do not roll as easily or "melt" (turn to gel) which decreases maceration.

Hydrocolloid Dressings

Hydrocolloids are adhesive, moldable wafers made of a carbohydrate based material. They are impermeable to oxygen, water, and water vapor. Most hydrocolloids provide some absorption but should only be used on wounds that drain very scant amounts. As this dressing absorbs moisture, the dressing turn to gel, often referred to as "melting". This "melting" helps to maintain a moist wound bed and promote autolytic debridement. This dressing typically does not stick to the wound bed and is available in numerous forms such as sheets, powders and gels. When removing a hydrocolloid you may notice a distinct odor. The wound should not be noted as having an odor until the dressing has been discarded and the wound cleaned with normal saline. Many hydrocolloids required extra securing methods to prevent rolling or displacement once the dressing begins to "melt'.

Hydrogel Dressings

Hydrogel dressings are water or glycerin based polymer dressings that are non-adherent but provide limited to no absorptive properties. Many of these dressings are made up of up to 96% water. Hydrogel dressings are available in the form of amorphous gel or sheets. These dressings add moisture to a wound and/or promote autolytic debridement; therefore they should only be used on dry wounds or those wounds with very little drainage. The viscosity of the gel or sheet will vary among brands depending on the base of the product, whether it is water or glycerin.

Absorptive Dressings

Specialty absorptive dressings have multiple layers of highly absorbent material, such as cotton or rayon. Some have non-adherent layers and/or adhesive borders. These dressings are often used on either infected or non-infected wounds with moderate to heavy drainage. Using a specialty absorptive dressing will hopefully decrease the dressing change interval, but should not be used over wounds with little drainage as this is typically less cost effective.

Wound Fillers

Wound fillers are specially designed pastes, gels, granules, powders, beads or strands that are used to fill a deeper wound. Depending on the product, wound fillers can either add moisture or absorb moisture and can be used on infected or non-infected wounds unless otherwise noted.

There are numerous wound care products available on the market. As stated before, many dressings are available from different manufacturers that appear similar with only very subtle differences or are a combination of multiple dressing types. Therefore, it is important that you are familiar with a variety of product lines in order to provide the most appropriate dressing for your patient. The table (Table 9-B) on the next page is a brief summary of some of the dressings available and the comparable products for a few of the more common manufacturers. Depending on the purchasing contract with your hospital, a particular dressing may not be available but a comparable dressing can be used. This can be determined by speaking with the materials management director.

Classification	Dressing Name	Manufacturer
GAUZE	Kerlix	Tyco/Kendall
	Telfa	Tyco/Kendall
	Versalon	Tyco/Kendall
	Cuirty	Tyco/Kendall
	Avant	Medline
	Conform	Cypress
ALGINATES	Sorbsan	Bertek
	Algisite-M	Smith & Nephew
	Curasorb	Tyco/Kendall
	Kaltostat	Convatec
	Kalginate	DeRoyal
	Maxorb	Medline
BIOLOGICALS	Oasis	Healthpoint
	Biobrane	Bertek
	GammaGraft	Preomethian
	Apligraf	Organogensis
	Humatrix	Care-Tech
COLLAGE	Fibracol	Johnson & Johnson
	Promogran	Johnson & Johnson
	Cellerate Rx	Wound Care Innovations
	Stimulen	Southwest Technologies
ANTIMICROBIALS	Arglaes	Medline
(Silver Products)	Silvasorb	Medline
	Silverlon	Argentum
	Aquacel AG	Convatec
	Acticoat	Smith & Nephew
	Silvercel	Johnson & Johnson
COMPOSITES	Covaderm	DeRoyal
	CovRSite	Smith & Nephew
	Medipore	3M Health Care
	Op-Site Post-Op	Smith & Nephew
	Tegaderm + Pad	3M Healthcare
	Telfa Plus	Tyco/Kendall
	Viasorb	Tyco/Kendall
CONTACT LAYER	Drynet Wound Veil	Smith & Nephew
	Conformant	Smith & Nephew
	Dermanet	DeRoyal
	Mepital Silicone	Monlnlycke
	Tegapore	3M Health Care
	Telfa Clear	Tyco/Kendall

Table continues on next page.

Classification	Dressing Name	Manufacturer
FOAMS	3M Foam	3M Health Care
	Allevyn	Smith & Nephew
	Boatain	Coloplast
	Optifoam	Medline
	Hydrasorb	Tyco/Kendall
	Lyofoam	Convatec
	Mepilex	Monlnlycke
	Tielle	Johnson & Johnson
HYDROCOLLOIDS	Comfeel	Coloplast
	Tegasorb	3M Health Care
	Combiderm	Convatec
	Duoderm	Convatec
	Cutinova	Smith & Nephew
	Exuderm	Medline
	Replicare	Smith & Nephew
	Restore	Hollister
HYDROGELS	Curasol Gel	Healthpoint
	Intrasite Gel	Smith & Nephew
	Nu-Gel	Johnson & Johnson
	Saf-Gel	Convatec
	Solo-site Gel	Smith & Nephew
	Curagel Pads	Tyco/Kendall
	Flexigel Sheets	Smith & Nephew
	Nu-Gel Pads	Johnson & Johnson
ABSORBTIVES	ABD Pads	Cypress
	Tendersorb ABD Pads	Tyco/Kendall
	Aquacell Hydrofiber	Convatec
	Curity ABD	Tyco/Kendall
	Exu-Dry	Smith & Nephew
	Primapore	Smith & Nephew
	Sofsorb	DeRoyal
WOUND FILLERS	Iodosorb Gel	Healthpoint
	Iodoflex Pads	Healthpoint
	Flexigel Strands	Smith & Nephew
	Hyalofil	Convatec
	Multidex Gel or Powder	DeRoyal
	Silverlon Strips	Argentum

Please be aware that this list in not all inclusive and many products may fit into more than one category. It is always best to familiarize yourself with each product and its use.

Your drug representatives are a good resource for obtaining information on their products but it is always wise to do an independent research and comparison of products.

ADJUNCTIVE THERAPIES

There are literally thousands of wound products available to complement a wound dressing. Above we discussed some of the topical applications that are commonly used in wound care, excluding the antimicrobial creams such as Silvadene, Sulfamylon, Bactroban, etc… which can be prescribed by the physician. Various therapeutic modalities promote wound healing by debriding, controlling bioburden, decreasing edema, increasing blood flow and

tissue oxygenation, and providing a scaffolding for tissue growth. Some of these therapies have been around since the early 1900's and some are new or an enhancement of an older therapy. When selecting an adjunctive therapeutic modality, it is advisable that you thoroughly research the product including the treatment requirements and time involved as well as FDA approval and cost effectiveness the treatment will have on your patient.

Enzymatic Debriders

Debriding agents are chemical or enzymatic preparations designed to remove necrotic, devitalized tissue from the wound bed. These products are applied directly to the devitalized tissue in the wound bed in a layer that is about 1/8 of an inch thick. (More is not necessarily better in wound care). These products are especially helpful in wounds with moderate to large necrotic tissue in patients that may not tolerate a surgical debridement.

Some common debriding agents available are Accuzyme and Panafil (Healthpoint) and Collegenase Santyl (Ross Pharmaceuticals). Panafil contains chlorophyll which helps control odor in a wound. The Chlorophyll also stains devitalized tissue a bright green color for ease in selective sharp debridement. The green discharge noted when using Panafil is often incorrectly interpreted as infection. These side effects may be alarming to your patient, so it is best to forewarn them of the expected outcomes. Accuzyme is very similar to Panafil, yet it may be a little more aggressive than Panafil. Santyl is the final enzymatic debriding agent that is reported safe for use until closure of the wound, although, you should NOT use a moist saline cover dressing over Santyl as it will decrease its effectiveness. Patients should be instructed that they may feel a slight burning sensation for the first few hours after application, but this is rare.

In the past, chemical and enzymatic debriders were very harmful to healthy tissue and careful attention had to be given with their application. With the advances in wound care this is not nearly the concern it was in the past, but care should be taken to apply only a thin layer to the wound bed to prevent maceration of the periwound. Some patients also build up an allergic reaction to some of the debriding agent's ingredients so they must always be monitored carefully.

Vacuum-Assisted Closure Device

The vacuum-assisted closure device, which is commonly known as the VAC, was first introduced to the wound care community in 1993. It is also referred to as negative pressure wound therapy. VAC therapy encourages healing by applying localized subatmospheric pressure at the site of the wound. This reduces edema and bacterial colonization and stimulates the formation of granulation tissue.

This system consists of an open-cell polyurethane ether foam dressing that is cut to fit inside the wound. The foam can also be placed into undermined areas as well as tunnels as directed by the VAC guidelines. Once the foam is placed in the wound, it is covered with an Op-site or Tegaderm type dressing to provide a sealed, closed system. A TRAC pad (a specially designed tubing that helps regulate the pressure) is then placed over a precut hole in the sealed dressing to allow the vacuum device to work. The negative pressure is usually set at 125 mmHG continuous or intermittent therapy depending on the wound. The VAC guidelines have a list of pressure settings and recommended delivery detailed for each type of wound. The dressings are typically changed every 48-72 hours, or every Monday, Wednesday and Friday, depending on the patient's needs.

The contraindications for VAC therapy are also listed in the VAC guidelines. One contraindication that has since been reviewed and revised is the use of VACs over a fistula. Fistulas typically form off of the digestive tract due to a mechanical or physical obstruction below the site of the fistula. They are most often seen in chronic open abdominal wounds, but can occur anywhere throughout the body. The intestines, in this case, must create a new exit route for the contents. This often results in fistula formation. When placing a VAC over a fistula without correcting the underlying causes, you could actually encourage the fistula to mature. You should never place anything (not even a q-tip) in the opening of a fistula. They should never be packed. There are very specific recommendations that should be followed when using a VAC over a fistula and when quick response is not seen, it is recommended that the therapy be discontinued as this may encourage the fistula to mature.

When attempting to heal an open abdominal wound with a secreting fistula, it is often beneficial to contact a WOC (wound, ostomy, continence) nurse for guidance and/or assistance. WOC nurses have been specially trained in managing wounds with fistulas and can usually apply pouches to collect the drainage to prevent it from contaminating the wound. If your hospital does not have a WOC nurse, call ProCare's corporate office. There is a certified WOC nurse available to assist you or help you locate a WOC nurse in your area.

Warm-Up Therapy System

Noncontact normothermic wound therapy, commonly referred to as warm-up therapy, is a temporary therapy that increases the temperature of the wound bed, thereby promoting increased blood flow in the area of the wound. Normothermia is the theory that all biological, chemical and physiological processes are optimized at normal body temperature. Normal body temperature is considered to be 37° C ± 1°C. Most wounds are hypothermic, at an average of 5.6°C cooler than normal body temperature. Hypothermia can contribute to vasoconstriction, tissue hypoxia,

decreased collagen production and deposition, increased risk of infection and a delay in the normal wound healing process. Warming the tissues to core body temperature increases vasodilatation and increases oxygen delivery to the tissues.

The Warm-Up system is designed to deliver controlled, moist heat, by way of an infrared warming card placed in a noncontact, semiocclusive dressing. The system contains a temperature control unit, a sterile dressing and a warming card that delivers radiant heat to the wound bed. The dressing remains in place for up to 3 days and is disposable. The dressing also insulates the wound, protecting the tissues from heat loss when the warming card is not active. When activated, the warming card raises the temperature to 38° C. In case studies, it has been shown that it is not necessary to pack tunneling/undermining wounds. However, when choosing a cover dressing, it is necessary to select a dressing that will cover the entire area of the tunneling/undermining. Typically, the clinician should see an increase in drainage for the first 7-10 days of treatment. This may indicate the transition of the wound back into the inflammatory phase and would be part of the normal healing process. The Warm-Up therapy system may be used for acute or chronic wounds, full or partial thickness wounds, regardless of etiology, that have failed to thrive with traditional therapies, including wounds with compromised blood flow, such as arterial and diabetic foot ulcers.

Biotherapy

There are two main forms of biotherapy currently being used in modern wound care. They are growth factors and living skin equivalents. Growth factors play an important role in the healing process by stimulating cell proliferation. Wound healing is a complex process that the body undertakes to replace or repair injured tissue. Think of it like a concert performance by an orchestra with many musicians. When everyone knows their part, the music is beautiful. However, if one member is off key or out of sync, the result is a jumbled mixture of noise. Similarly, growth factors are the musicians in wound healing. When they are not synchronized, the wound bed is left in a chronic state of confusion and is unable to heal.

There are several growth factors that have been identified in contributing to wound healing. The main growth factor that has been identified as the leader of the pack is PDGF (platelet derived growth factor). PDGF plays a central role in healing by attracting fibroblasts and inducing them to divide. This is key to wound healing because the fibroblasts are responsive for collagen formation and are one of the components of granulation tissue. Table 9-C contains a summary of growth factors.

Table 9-C

Acronym	Growth Factor	Function
PDGF	Platelet derived growth factor	Attracts fibroblasts inducing them to divide, encouraging collagen formation.
TGF-ß	Transforming growth factor beta	Controls movement of cells to sites of inflammation and stimulates extracellular matrix formation.
bFGF	Basic fibroblast growth factor	Stimulates angiogenesis (the development of blood vessels)
VEGF	Vascular endothelial growth factor	Stimulates angiogenesis
IGF	Insulin like growth factor	Increases collagen synthesis
EGF	Epidermal growth factor	Stimulates epidermal regeneration

To date, Regranex® (becaplermin 0.01%), a platelet derived growth factor (PDGF-ßß), is the only single agent growth factor that has been formally released for use to heal dermal wounds. Regranex® is a non-sterile topical gel that is a bio-engineered recombinant human platelet-derived growth factor. Regranex® attracts macrophages, which secrete vascular endothelial growth factor (VEGF), initiating angiogenesis. Since Regranex® is an active enzyme it requires specific storage and handling. It should be stored in the refrigerator until ready to use; it should not be frozen. If left out of the refrigerator, the heat (or room temperature) will deactivate the enzyme and render the medication ineffective. It is recommended that Regranex® be applied once daily, and should not be used for longer than 20 weeks.

Buffy-Coat derived Mediators have also made an appearance on the wound care scene. Two of the more publicized are Procuren® (from Curative Health Systems, Inc., now licensed to Cytomedix, Inc.) and Autologel® (Cytomedix, Inc.). These products have essentially taken the buffy coat layer of the patient's blood and produced it into a wound gel. The buffy coat is the leukocyte/platelet-enriched fraction of the blood which is obtained by centrifuge. It contains from 2.5 to 9 times more DNA material than the same volume of whole blood and accounts for 1% of total blood volume. The buffy coat contains the platelets and five types of leukocytes. Like the erythrocytes, leukocytes express a number of antigens on the cell surfaces that are important in transplantation or acceptance of the

wound gel or autologous graft (blood derived tissue graft). Since these products are obtained from the patient's own blood, at the bedside, and returned to the same patient, FDA approval has not been sought. Since the product is not stored, the blood-banking rules do not apply, although, all Clinical Laboratory Improvement Amendments (CLIA) regulations should be followed.

Hydrotherapy

Hydrotherapy is one of the oldest therapeutic modalities, dating back to ancient times. There are basically four types of hydrotherapy currently being used in wound care today. They are: pulsatile lavage with concurrent suction, whirlpool, jet irrigation and irrigation with a bulb syringe or syringe with angiocatheter. The irrigation with bulb syringe or syringe with angiocatheter is typically done at the bed side. Jet irrigation is usually done by the surgeon. Pulsatile lavage with concurrent suction can be done at the bedside by appropriately trained personnel. And finally, whirlpool is usually provided by physical therapists as part of their wound care regimen.

The pressures and temperatures associated with hydrotherapy are very important to wound healing. Increases in pressure and temperature can actually delay wound healing and should be avoided. Below are two tables (9-D and 9-E) that depict the recommended pressures and temperatures for hydrotherapy.

Table 9-D

Irrigation Pressures

PSI	Therapeutic Effects
<4	Not effective to remove bacteria from the wound
4-8	Safe, effective irrigation, removes bacteria, is atraumatic to granulating tissue; this pressure is recommended for tunneling and undermining when the tissue is not easily visualized.
9-15	Sage, effective irrigation, removes bacteria, effective debridement of necrotic tissue or debris (such as road rash).
>15	Not recommended for routine use, may traumatize wound and drive bacteria into tissues.

Table 9-E

Effects of Water Temperature

Description	Temperature	Physiological Effects	Appropriate Wound Patient
Nonthermal/ Tepid	80-92° F	Local vasoconstriction, decreased oxygen uptake, tissue cooling	Venous disease for debridement
Neutral Warmth	92-96° F	Endothelial cell proliferation	PVD, sensory impairment, full body immersion
Normothermal	98.6° F	Optimizes cellular function, increases enzymatic and biochemical functions, circulation, pulse rate and blood pressure	Cardiovascular or pulmonary disease
Hot	98-104	Increased circulation, pulse rate and blood pressure	Higher temperatures are not recommended due to physiological stress

High impact pressures are used for dirty, necrotic wounds, whereas intermediate pressures are used for infected wounds and low pressures are used for granulating clean wounds. The temperature of whirlpool therapy is very dependent on the type of wound and the patient's significant medical history such as PVD or arteriosclerosis. Whirlpool therapy is a non-selective form of debridement that is slowly becoming antiquated in modern wound care. The potentially detrimental side effects of mechanical trauma to the new granulating tissues far out weigh the benefits of whirlpool therapy in most instances. Historically, the frequency and duration of whirlpool therapy was associated with dressing changes on burn units to facilitate the removal of topical creams and ointments. Whirlpool treatments should be discontinued when a clean wound bed is present or when there is a lack in the healing response. At ProCare Healing Centers, whirlpool therapy will not be offered as a method of wound therapy. Sharp or surgical debridement, otherwise known as selective debridement, is the treatment of choice.

Therapeutic light

Although not a form of light, UV energy or radiation is commonly categorized as therapeutic light. UV energy lies between X-rays and visible light on the electromagnetic spectrum. UV radiation is divided into 3 bands, UVA, UVB and UVC. Below is a list of the effects of each type of UV energy. (Table 9-F)

Table 9-F

UV Energy	Action
UVA	Non-Ionizing and produces the most tanning effects
UVB	Non-Ionizing, produces more erythema, blistering and is carcinogenic
UVC	Ionizing, is bactericidal and virucidal

In several experimental studies, the bactericidal and wound healing effects have been noted. However, controlled clinical studies have not been able to adequately duplicate these findings. The increasing report of MRSA, VRE and other antibiotic resistant bacteria makes this an appealing treatment modality that justifies further clinical research.

Ultrasound

Ultrasound (mechanical pressure waves) is rarely used in wound care treatments. It is used for its nonthermal and thermal effects. The nonthermal effects include acoustic cavitation and microstreaming. In acoustic cavitation, gaseous bubbles are made to expand and contract rhythmically in the tissues being treated. These bubbles are thought to stimulate the biological phenomena of activating ionic channels in the cellular membranes. Microstreaming is another nonthermal effect that results from cavitation. Cavitation causes fluids close to the bubbles to stream by, thus stimulating the cells in close proximity. By doing this, the conductivity of calcium is increased in the fibroblasts, which is important because collagen secretion is a calcium-dependent process. The thermal effects of ultrasound include increased blood flow and increased WBC migration which promotes a more orderly arrangement of collagen in wounds.

Ultrasound appears to have optimal effects when used early on, in the inflammatory phase. It has been said that this accelerates the wound through the healing phases. Several researches have demonstrated that the application of thermal ultrasound, during the inflammatory phase, increased collagen deposition, tensile strength and elasticity in the healed wound. (Traditionally, a scar that is formed from wound healing is weaker and less elastic than uninjured tissue.)

Unfortunately, current literature and trials that have been conducted on ultrasound therapy have shown mixed results. Many of the studies have combined ultrasound with other modalities, making the results of the study unreliable. As with all therapeutic treatments, further research in this area is warranted.

Electrical Stimulation

Electrical stimulation is used to enhance healing of recalcitrant (stubborn) wounds, especially chronic pressure ulcers. Electrical stimulation is delivered through a device that has conductive electrodes, which are applied to the skin. The current can either be high voltage or low voltage, with constant or pulsed current. Electrical Stimulation was originally given little or no support from the wound care industry, but in 1998, the Guidelines for Pressure Ulcer treatment and prevention (AHCPR- Agency for Health Care and Policy research, now known as AHRQ- Agency for Healthcare Research and Quality) revised it's original guidelines giving Electrical Stimulation an evidence based rating of "A", meaning that 2 or more randomized or controlled clinical trials on pressure ulcers in humans provide support for its use. In 2003, HCFA (Health Care Financing Administration) put two new HCPCS (Healthcare Common Procedure Coding Systems) codes into effect related to electrical stimulation. The drawback of this therapy is the initial costs of the equipment and training, the amount of time required for treatments, leading to compliance issues, coupled with low reimbursement levels are often difficult to overcome in the outpatient setting.

Hyperbaric Oxygen Therapy

Wounds with inadequate tissue oxygenation levels will not heal despite the best wound care provided. Tissue oxygen levels may be reduced due to a lack of vascular supply, edema, infection, trauma, radiation injury or reperfusion injury. When tissue oxygen levels fall below the minimum needed for healing, a number of well described effects occur, including reduced response to infection, defects in the body's ability to repair itself, such as fibroblast migration and proliferation, and the arrest of collagen secretion. Collectively, these prevent angiogenesis (the production of new blood vessels).

Oxygen is a drug with many pharmacological effects. The mechanism by which oxygen is supplied to tissues is via respiration of the oxygen and subsequent delivery to the vascular system. There is no significant topical

absorption of oxygen that has been undoubtedly scientifically proven. Therefore, for additional oxygen to be absorbed systemically, it must be inhaled. The UHMS (Undersea Hyperbaric Medical Society) is the primary, worldwide source of information on hyperbaric and diving medicine. The purpose of the UHMS is to improve the scientific basis of hyperbaric oxygen therapy, and promote sound treatment protocols and standards of practice.

Disease states such as diabetes, peripheral vascular disease, compromised skin flaps or grafts, irradiated skin and crush injuries contribute to the development of chronic, problematic and recalcitrant wounds. It is well documented that oxygen is required for a number of the basic healing process to occur. It is needed for energy metabolism, collagen synthesis, neovascularization, polymorphonuclear cell function, and antibacterial activity. Cellular integrity, function or repair can not be maintained or occur without adequate oxygen levels. To achieve this, HBO is often used as an adjunctive therapy to some wound healing situations.

Hyperbaric Oxygen Therapy (HBO) is a systemic, intermittent administration of 100% oxygen delivered at pressures greater than 1 ATA (atmospheres absolute). A hyperbaric environment exists when pressures are increased above 1 ATA. 1 ATA is considered to be at sea level or at surface. At 1 ATA, the normal healthy individual, breathing room air, will have an oxygen saturation level of about 97%. Loosely translated, the hemoglobin is carrying 97% oxygen. If the patient were to breathe 100% oxygen at sea level, it would have very little effect on the hemoglobin because it is already nearly saturated (97%) with room air. (Room air has 21% oxygen.) The plasma in the blood is ready to take up the extra oxygen and put it to work. To explain this, let's translate the measurements into volume percentages.

- 1gram of fully saturated HGB carries 1.35 cc of oxygen
- A healthy person has about 15 grams of HGB with the average oxygen carrying capacity of 20 volumes percent (20cc of oxygen for every 100cc of blood)
- 1gram HGB = 1.35cc
- 15 x 1.35 = 20.25 (20 vol %)

On the other hand, blood plasma carries only 0.3cc of oxygen for every 100 cc of blood (0.3 vol %), so blood plasma makes no real contribution to oxygen carrying capacity when one breathes room air at 1 ATA (sea level or surface). However, once hemoglobin is fully saturated, the only way to increase oxygen carrying capacity is to increase *plasma dissolved oxygen.* Breathing 100% oxygen at 1 ATA increases plasma dissolved oxygen from 0.3 vol% to about 2.0 vol %. When adding a hyperbaric environment to this mix, an increase of pressures of 2 times sea level (2 ATA) will increase the blood oxygen carrying capacity nearly ten fold. In general, the blood oxygen carrying capacity increases approximately 2 vol% for every atmosphere of pressure increase. Under hyperbaric conditions, enough oxygen can be dissolved in plasma to keep tissues alive in the total absence of hemoglobin. Therefore, during hyperbaric oxygen treatments, the body is able to not only carry oxygen via the hemoglobin, but also the plasma. This greatly increases the amount of oxygen that is delivered to the wound bed and in turn promotes angiogenesis and wound healing.

So, in order to get wounds to heal more quickly, everyone should be placed in hyperbarics, correct? Unfortunately this is not the case. The UHMS has set forth guidelines that are followed by CMS (Centers for Medicare and Medicaid Services), AHRQ (Agency for Healthcare Research Quality), and most private insurance companies. These guidelines dictate the wounds that have been scientifically proven to improve with the use of hyperbarics medicine and provide the parameters for treating such patients. On the following page is a list of the currently approved diagnoses for hyperbaric medicine treatments. (Table 9-G)

Some, if not all, of ProCare Healing Centers wound care clinics will have access to Hyperbaric Oxygen treatments for their patients. Hyperbaric Medicine is too complex to go into fully during this learning session. You are encouraged to research these topics as they will apply to you. A very good starting place is the UHMS website (**www.uhms.org**). All employees of ProCare Healing centers, physicians, nurses, and hyperbaric technicians will be provided with intense specialized training in Hyperbaric Medicine at a facility that has been approved and accredited by the UHMS.

There are numerous other therapeutic modalities that could be discussed in this section. When investigating a therapeutic or adjunctive treatment modality, it is always important to investigate all of the research first. Then, you must determine the goals of treatment, and understand what physiological effect you are attempting to achieve. With that in mind, the choice to make for the most appropriate modality that will enhance wound healing. The final thing to remember is that you are not only treating a wound, you are treating the whole patient. Therapeutic and adjunctive therapies assist us with wound healing, but without treating the patient in their entirety and utilizing all members of the treatment team, you are fighting an uphill battle.

Table 9-G

Recommended Thresholds for Hyperbaric Oxygen Treatments

Medical Diagnosis	Number of recommended Treatments	Depth (ATA)
Air or Gas Embolism	QD or BID until no further improvement (Appx. 10)	2.5-3.0
Decompression Sickness	Variable and case specific (Appx. 10)	Case specific
Carbon Monoxide Poisoning & Smoke Inhalation	5-10	2.4-3.0
Gas Gangrene (Clostridal Myositis and Myonecrosis)	TID for 1st 24 hrs Then BID for 4-5 days (Appx. 10-15)	3.0
Crush Injury, Compartment Syndrome and other Acute traumatic Ischemias	TID for 48 hrs, then BID for 48 hrs, then QD for 24-48 hrs (Appx. 5-30)	2.0-2.4
Enhancement of healing in SELECTED Problematic Wounds	10-40	2.4-3.0
Compromised Skin grafts & Flaps	6-40	2.0-2.5
Necrotizing Soft Tissue Infections	5-30	2.5-3.0
Refractory Osteomyelitis	20-40	2.5-3.0
Delayed Radiation Injury (Soft Tissue and Bony Necrosis)	20-60	2.5-3.0
Thermal Burns	5-45	2.5-3.0
Exceptional Blood Loss Anemia	Until stable hematocrit or patient is stable/asymptomatic	2.5-3.0
Intracranial Abscess	5-20	2.5-3.0