Wound Management Comprehensive

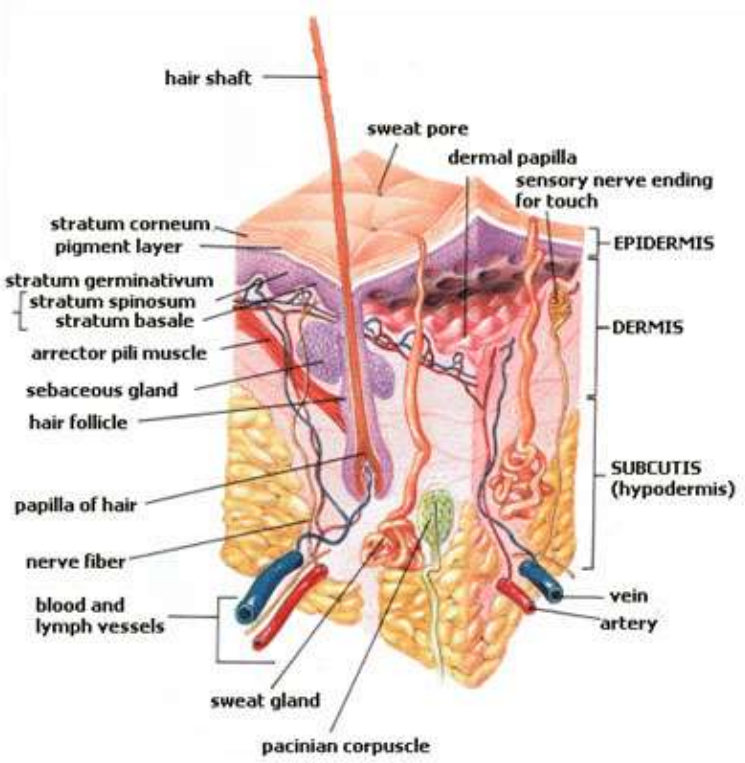
WWW.RN.ORG®
Reviewed October, 2018, Expires October, 2020
Provider Information and Specifics available on our Website

By Wanda Lockwood, RN, BA, MA

Introduction

There are many different types of wounds (burns, ulcers, dermal lesions, surgical incisions, traumatic injuries), and these wounds may be classified or staged differently, with some (such as burns) requiring special treatment, but there are general principles of wound assessment and management that apply to all different types of wounds. Since the days of the simple “wet to dry” saline dressings, wound care has changed markedly. There are different dressings and wound materials available to manage exudate, debride the wound, decrease bioburden, decrease pain, and promote granulation.

Understanding the skin is necessary for assessing and treating wounds. The skin provides protection and immunity, sensation, and thermoregulation. The skin is also involved in metabolism as it synthesizes vitamin D, necessary for the metabolism of calcium and phosphate. Additionally, the skin is critical for the individual’s body image.



National Cancer Institute

Epidermis	Outer avascular layers of skin with a basement membrane separating it from the dermis. The epidermis regenerates every 4 to 6 weeks. The basal layer contains melanocytes, which provide pigmentation and protection from sunlight.
Basement membrane zone (BMZ)	Between the epidermis and dermis. It provides support for the epidermis.
Dermis	Below the BMZ. It contains nerves, sebaceous glands, sweat glands, hair follicles, lymphatic vessels, veins and arteries. Fibroblasts produce the primary proteins of this layer, collagen and elastin. The dermis also contains mast cells, macrophages, and lymphocytes, all involved in the skin immune system.
Hypodermis	Subcutaneous tissue below the dermis, providing vasculature, cushioning, and insulation.

Assessment

Initial assessment must comprise a complete physical assessment and history. The patient's medical history can provide useful information about issues such as tissue perfusion, circulatory impairment edema, infection, chronic illness (such as diabetes, cancer, autoimmune disorders), skin abnormalities (scarring, radiation changes, dermatitis), and stress. Some medications, such as chemotherapy or corticosteroids, may contribute to skin breakdown or delay healing. The wound

history should be detailed and include history of previous wounds and any difficulty or delay in healing. For the current wound, the patient should be questioned about the cause of the wound, the duration, any treatments done and the type of diagnostic testing, such as vascular studies, imaging studies, biopsies, and cultures, done related to the wound.

When assessing the skin, age is an important consideration.

Wikimedia Commons, Azoreg

An infant ‘s skin is thinner than an adult’s. The epidermis is fully developed, but the dermis layer is only about 60% of that of an adult. Thus, the infant’s skin is soft and hair is fine. The dermis layer develops as the child grows. During adolescence, the hair follicles activate and the thickness of the dermis decreases about 20% and epidermal turnover time increases, so healing slows. As people continue to age, Langerhans’ cells decrease in number, making the skin more prone to cancer, and the inflammatory reactions decrease. The sweat glands, vascularity, and subcutaneous fat all decrease, interfering with thermoregulation and contributing to dryness and irritation of the skin. The epidermal-dermal junction, the BMZ, flattens, resulting in skin prone to tearing. The elastin in the skin degrades from the combination of aging and exposure to ultraviolet rays of the sun. The thinning of the hypodermis can lead to pressure ulcers.

Wound assessment should include notations of the following:

Measurements (length, width, depth)	The wound should be measured in centimeters at its widest points for length and width. Depth can be measured by inserting a sterile swab into the wound and marking the depth or using special wound measuring instruments.
Undermining	Damaged tissue underneath intact skin, usually about the perimeter of the wound. If this tissue is open, it can be measured by insertion of a sterile swab. In some cases, the tissue is damaged but intact; however, the tissue may feel very spongy on palpation. Undermining should be reported according to its relation to the open wound by reference to a

	clock face: “Undermining of 1.5 cm width extends from 2 o’clock to 4 o’clock.”
Tunneling	Extends from the wound under normal tissue but does not open to the skin or other structures. If the tunnel is of adequate diameter and position, a sterile swab may be inserted to measure length. Described by reference to clock face.
Fistula	Similar to tunneling but connects two structures, such as from the wound to an organ or the wound to the skin. Described by reference to clock face.
Abscess	Localized collection of purulent material (often associated with fistulae). Area above is usually swollen, inflamed, and painful, but deep abscesses, such as in an organ, may be difficult to assess by observation and palpation alone.
Wound appearance	All aspects of the wound should be noted: granulation, necrotic tissue, eschar, inflammation, slough, and exposure of underlying tissue, such as muscles, ligaments, or bone.
Drainage	The amount, odor and type of exudate (serous, purulent, sanguinous, serosanguineous) should be noted.
Periwound	The area about the wound should be carefully palpated and assessed for maceration, scarring, irritation, rash, and fluctuance.
Pain	The degree and type of pain should be described. The patient can use the 1 to 10 scale or other scale according to age and mental ability.

Wound classification Systems

A number of different classification systems are in common use, depending on the type of wound.

Degree

Burns are typically classified according to degree of injury:

First-degree	Superficial and affect the epidermis only (sunburn).
Second-degree	Extend through the dermis and involve blistering. 

Third-degree	Extend through the dermis and into underlying tissue, including vasculature, muscles, and nerves.

Thickness

Describing wounds by thickness is similar to classifying by degrees, but it is less specific than the degree classification for burns and can include different types of wounds, such as ulcers and traumatic injuries as well as burns.

Partial thickness	Wounds involve the epidermis and may extend into the dermis but not through it, so that the vessels and glands that provide nutrients and repair skin are intact. Bleeding activates hemostasis and temporarily provides a barrier to bacteria. Coagulation occurs and fibrin is formed with the clot sealing disrupted vessels. This is followed by fibrinolysis, during which the clot breaks down and repair begins with the inflammatory stage. Wounds usually heal within about 2 weeks. Typical partial thickness wounds include blisters, skin tears, and first or second degree burns.
Full thickness	Wounds, which may be acute or chronic, extend through the dermis and into the subcutaneous layer or below into the muscle or even to the bone. Full-thickness wounds may heal by primary or secondary intention. Examples of wounds healing by secondary intention include dehisced surgical wounds and those resulting from underlying morbidities that interfere with normal healing. Bleeding and hemostasis do not occur with healing by secondary intention, so the healing process is compromised. Typical full thickness wounds include third degree burns and deep pressure ulcers.

National Pressure Ulcer Advisory Panel (2007) Staging System

The NPUAP defines a pressure ulcer as a “localized injury to the skin and/or underlying tissue usually over a bony prominence, as a result of pressure, or pressure in combination with shear and/or friction.” The depth of an ulcer may vary depending on location. For example, a stage III ulcer of the ear has significantly less depth than a stage III ulcer of the hip. Stages include:

Suspected deep tissue injury	Purple or reddish discolored intact skin or blood blister. Tissue may be boggy, mushy, or firm and temperature may vary from that of adjoining areas. The area may be painful or itchy
Stage I	Skin is intact with localized non-blanching reddened area, often at areas where pressure is exerted, such as over bony prominences. Darkly pigmented skin may show only a darker change in coloration
Stage II	Ulcer may appear as an abrasion or blistered area or slightly depressed with red/pink wound bed without slough. Skin loss is partial-thickness and involves the epidermis and/or dermis.
Stage III	Deep full-thickness ulceration of skin exposes subcutaneous tissue. Slough may be present. Underlying muscle, tendon, and bone are not visible, but tunneling and undermining may be

	evident.
Stage IV	Deep full-thickness ulceration of skin with extensive damage, necrosis of tissue extending to muscle, bone, tendons, or joints.
Unstageable	The extent of slough and/or eschar at the base of the wound makes accurate staging impossible until after debridement.

Modified Wagner's Foot Ulcer Classification

The Modified Wagner Ulcer Classification System divides foot ulcers into six grades, based on lesion depth, osteomyelitis or gangrene, infection, ischemia, and neuropathy. This classification does not include the size of the ulcer, so it cannot be used alone to fully evaluate the ulcer, but it is useful for predicting outcomes.

Grade 0	Pre-ulcerative and at risk. May have healed ulcers or bony deformities.
Grade 1	Superficial ulcer, extending into subcutaneous tissue; superficial infection with or without cellulitis.
Grade 2	Full-thickness ulcer to tendon or joint with no abscess or osteomyelitis.
Grade 3	Full-thickness ulcer that may extend to bone with abscess, osteomyelitis, or sepsis of joint and may include deep plantar infections, abscesses, fascitis, or infections of tendon sheath.
Grade 4	Gangrene of the forefoot, but the rest of foot is salvageable.
Grade 5	Gangrene of entire foot, requiring amputation.

SAD Grading Classification for Lower Extremity Neuropathic Ulcers

The size, area, depth (SAD) classification system is a modification of the Wagner system and includes observations of arteriopathy, denervation and sepsis as well as size parameters.

Grade 0	No pathology is evident.
Grade 1	Ulcer is <10mm^2 and involves subcutaneous tissue with superficial slough or exudate, diminution or absence of pulses, and reduced sensation.
Grade 2	Ulcer is 10-20 mm^2 and extends to tendon, joint, capsule, or periosteum with cellulitis. Pulses are absent except for neuropathy dominant ulcers that have palpable pedal pulses.
Grade 3	Ulcer is >30 mm^2 and extends to bones and/or joints, with osteomyelitis, gangrene, and Charcot's foot.

Staging of Tissue Damage from Irradiation

Skin cells subjected to irradiation are particularly vulnerable because they are constantly undergoing mitotic division. Most skin reactions subside within 3

months after completion of radiation. Damage is staged according to the type and degree of reaction.

Stage I	Slight edema and inflammation occurs. Dilation and increased permeability of capillaries resulting in erythema that may cause itching burning, or pain.
Stage II	Skin is dry, itching, and scaly with partial sloughing of epidermis, because of the inability of basal epidermal cells to adequately replace surface cells and impairment of glands.
Stage III	Skin is moist and blistering skin with loss of epidermal tissue, serous drainage, and increased pain caused by exposure of nerves as skin continues to erode.
Stage IV	The accumulation of radiation in the tissues causes permanent hair loss, tissue atrophy, changes in pigment, and ulcerations.

Payne-Martin Classification for Skin Tears

Skin tears most often result from shear and friction and result in injuries that are partial thickness (the epidermis separating from the dermis at the basement membrane) or full thickness (both epidermis and dermis separate from underlying structures).

Category I	Skin tear w/o tissue loss	-Linear: Full-thickness wound in wrinkle or furrow with epidermis and dermis pulled apart (incisional appearance). -Flap: Partial thickness wound with a flap that can cover wound with ≤ 1 mm of dermis exposed.
Category II	Skin tear w/ partial tissue loss	-Scant tissue loss: Partial thickness injury and ≤25% of epidermal flap lost. -Moderate-large tissue loss: Partial thickness injury with >25% epidermal flap lost.
Category III	Skin tear w/ complete tissue loss	Complete partial thickness injury with loss of epidermal flap.

Ayello's ASSESSMENTS

Ayello (1992) developed the ASSESSMENTS tool for use with pressure ulcers, but this format has been adapted for assessment of various types of wounds. ASSESSMENT comprises a checklist for each section, covering all aspects of the wound.

A	Anatomic location & Age of wound	Upper/lower chest, abdomen, trochanter, foot, etc. Post-op acute < 7 days or > 7 days. Chronic < 1 month or > 1 month
S	Size, Shape, Stage	Measurements in metrics, geometric shape.

		Staging per NPUAP (for pressure ulcer) or Wagner (for neurotrophic ulcer).
S	Sinus tract, tunneling, undermining, & fistula	Presence, location (per clock face), and depth.
E	Exudate	Amount, color, and consistency.
S	Sepsis	Systemic, local, odor.
S	Surrounding skin	Erythema, edema, induration, discoloration, temperature, and skin character (moist, dry).
M	Maceration	Extent, location.
E	Edges & epithelialization	Edges (attached, unattached, or rolled), surgical incisions, and presence of epithelialization (new tissue over wound).
N	Necrotic tissue	Description (slough, black) and percentage of wound.
T	Tissue bed & tenderness	Absence or presence of granulation and percentage. Pain assessment with 0-10 scale, indicating when pain present and pain control method.
S	Status of wound & Supportive therapy	Initial, periodic, and at healing. Compression, offloading.

CDC Categories of Surgical Wound Infections

Category 1: Superficial incisional	Occurs ≤30 days post-op, related to surgery and involving only skin and subcutaneous tissue with ONE of following: • Purulent discharge. • Pathogens found in wound culture. • Localized infection with wound opened by physician. • Physician diagnosis.
Category 2: Deep incisional	Occurs ≤30 days (no implant) or within 1 year (with implant), related to surgery and involves fascia and muscle layers and includes ONE of the following: • Purulent discharge from wound. • Pathogens found in wound culture. • Wound dehisces or opened by physician in response to signs of infection (unless wound culture negative). • Evidence of abscess of deep infection.

	• Physician diagnosis.
Category 3: Organ space	Occurs ≤30 days (no implant) or within 1 year (with implant), related to surgery and involves any part of the body manipulated during surgery (except skin incision, fascia, or muscle) and includes ONE of the following: • Purulent discharge from organ/space (from drain). • Pathogens found in wound culture (aseptically obtained). • Evidence of abscess or deep infection in organ/space. • Physician diagnosis.

Primary, secondary, and tertiary healing

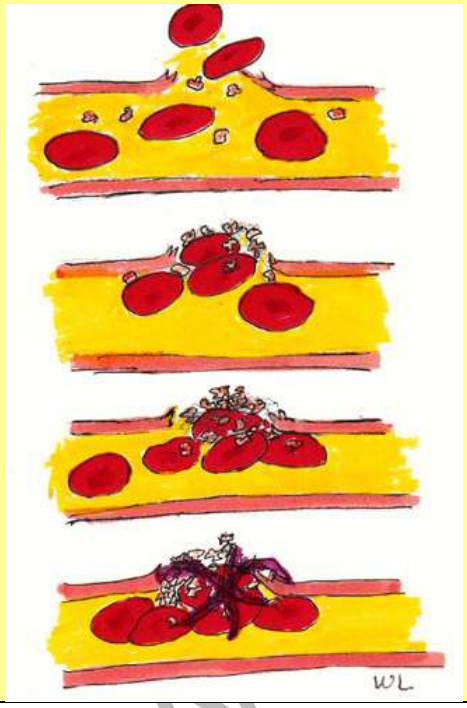
Healing of surgical and/or traumatic wounds may be described by the method of closure:

Primary healing (healing by first intention)	The most common approach for surgical wounds or uncomplicated ("clean") wounds or lacerations. With primary healing, the wound is surgically closed by suturing, flaps, or split or full-thickness grafts to completely cover the wound.
Secondary healing (healing by second intention)	Involves leaving the wound open and allowing it to close naturally through granulation and epithelialization. The wound is debrided to clean the wound bed and promote healing. Secondary healing is often used with contaminated "dirty" or infected wounds (such as puncture wounds or animal bites) to prevent the formation of an abscess and to allow the wound to drain.
Tertiary healing (healing by third intention)	Also sometimes called delayed primary closure because it involves first debriding the wound and leaving it open to allow it to begin healing and then later closing the wound through suturing or grafts when there is less risk for infection. This approach is common with wounds that are contaminated, such as severe animal bites, or wounds related to mixed trauma.

Phases of healing

Acute wounds heal usually heal fairly quickly and move through the stages of healing in a predictable manner; however chronic wounds are less predictable. Chronic wounds often occur secondary to other conditions, such as arterial insufficiency, and are not acute injuries. Circulatory impairment can slow initial bleeding and may impair fibrin protection and the release of growth hormones necessary for healing. The inflammatory phase may be prolonged because of necrosis, infection, or lack of adequate perfusion. Inadequate enervation interferes with the inflammatory response and slows healing. Additionally, the person may have other factors, such as inadequate nutrition or substance abuse,

which impair healing. Thus, the timeline associated with the phases of healing can serve as a guide but may vary with individuals.

Phase I: Hemostasis (Within minutes)	The platelets begin to seal off the vessels and secrete substances that cause vasoconstriction and cytokines that gather cells necessary for later phases of healing. Thrombin is produced to stimulate the clotting mechanism, forming a fibrin mesh. 

Phase II: Inflammation (Begins 1st day and usually last to day 4 or 6)	During this phase (also called lag, exudative, defensive, or reaction), there is erythema and edema along with pain as the blood vessels release plasma and leukocytes (neutrophils or granulocytes) to begin phagocytosis to remove debris, stimulate inflammation, and prevent infection. By day 4, macrophages replace leukocytes and are active in cleansing the wound of debris and bacteria and producing cytokines and growth factors as well as converting macromolecules into amino acids and sugars to promote healing. **Day 2** (Palm injury)

	 **Day 4**  Wikimedia Commons, Aria Belli

Phase III: Proliferation (Days 5-20)	During this phase (also called regenerative or fibroblastic), fibroblasts produce collagen to provide support, and granulation tissue starts to form, causing the edges of the wound to contract. Epithelization occurs as keratinocytes move from the wound margins, dividing and closing the wound and forming a scar. Epithelialization requires adequate blood supply. **Granulation tissue** (granular, bright red)

	 Wikimedia Commons, Stiepan Pietrov **Day 11** 

Phase IV: Maturation (Day 21+)	During this phase (also called remodeling or differentiation), fibroblasts leave the wound and the collagen tightens to reduce scarring. The tissue gains tensile strength. Maturation continues until the scar tissue that forms has about 80% of the tissue's original strength. The wound is not healed when it's closed because the underlying tissues continue to repair themselves in a process called remodeling for up to 18 months, during which time the wound is vulnerable to reopening, so healing and healed

	tissue both require protection. The wound can break down easily again during this phase. **Day 20 (Remodeling occurring)** 

Wound Management

There are many steps to wound management, and these may vary according to the type of wound, but understanding basic principles of wound care is essential.

Maintain perfusion

A wound will not heal without an adequate blood supply to carry oxygen and other nutrients to the tissues. The approach to ensuring and maintaining perfusion varies according to the wound condition and underlying health problems.

Positioning	• Reposition and turn patients every 2 hours**.** • Protect bony prominences using pillows and foam. • Avoid sliding patients and creating friction or shear, which can erode tissue. • Use assistive devices as needed to move patients. • Ensure chairs are correct size and height and feet supported. • Place pressure-relieving devices on chairs/wheelchairs. • Use pressure redistribution support surfaces (such as pressure reducing mattresses) on beds. • Restrict chair time to ≤2 hours at a time for those acutely ill. • Teach patients to move and redistribute weight every 15 minutes if they are cognizant and able to do so. (Use a timer if necessary.)

	• Place the patient in the 30° lateral position rather than 90° side lying position, using supportive bolstering and padding as necessary. • Do not position on ulcers.
Surgical intervention	Three different types of surgical procedures are used to treat severe arterial insufficiency in order to promote healing and prevent further deterioration: • ***Bypass grafts****:* A section of the saphenous vein or an upper extremity vein are harvested to use to bypass damaged arteries and supply blood to distal vessels. The veins must be reversed or stripped of valves before being attached. Synthetic grafts are available but have a higher rate of failure. • ***Angioplasty*** can be effective if occlusion is limited and arteries are large enough to accommodate the procedure. Initial results are positive, but long-term success rates are less positive although using anticoagulants improves success rates. • ***Amputation*** is sometimes required if ischemia cannot be reversed or if severe necrosis and infection is life threatening.
Hyperbaric oxygen therapy	HBOT is provided in a high-pressure chamber while the patient breathes 100% oxygen. Oxygen under pressure increases available oxygen to tissues by 10-20 times. HBOT decreases the need for amputation and is especially important for hypoxic wounds, such as those related to peripheral arterial insufficiency, compromised skin from grafts, and diabetic ulcers. Treatments are limited to 90 minutes to avoid oxygen toxicity. The number of treatments varies according to the type of wound and the patient's general condition. HBOT effects include: • Hyperoxygenation of blood and tissue. • Vasoconstriction, reducing capillary leakage. • Angiogenesis because of increased fibroblasts and collagen. • Increased antibiotic effectiveness for antibiotics that need active transport across cell walls, such as fluoroquinolone, amphotericin B, aminoglycosides.
Topical hyperbaric oxygen therapy	THOT uses pure oxygen topically using a Numobag® or other patented device to enclose part of the body in a pressurized container. Because this treatment uses oxygen under pressure, it has been classified as a hyperbaric treatment, and this is technically true, but the pressure is so low that there are major differences between THOT and HBOT, as high levels of pressure can be systemically toxic, and the low pressure levels of THOT

	avoid this complication. While HBOT depends on the pressure to force oxygen through miles of capillaries to bring oxygen to the wound, THOT applies the oxygen directly to the wound. While traditional hyperbaric oxygen treatment uses 100% oxygen at 2-3 ATA (30-45 psi), THOT uses 100% oxygen, but at a pressure just slightly greater than standard air, 1.03 ATA. Since oxygen is not absorbed through intact skin, the treatment is only used for open wounds (burns, ulcers, skin grafts, gangrenous lesions), not systemic disorders. When 100% oxygen is applied directly to an open, moist non-healing wound, at a pressure slightly above one atmosphere, oxygen is dissolved in the wound fluid and then absorbed by ischemic surface wound tissue.
Pharmacology	• ***Antiplatelet agents,*** such as aspirin, Ticlid®, and Plavix®, which interfere with the function of the plasma membrane, are ineffective to treat clots but prevent clot formation. • ***Vasodilators*** risk diverting blood from ischemic areas, but some may be indicated, such as Pietal®, which dilates arteries and decreases clotting and is used for control of intermittent claudication. • ***Antilipemics,*** such as Zocor® and Questran®, slow progression of atherosclerosis and arterial occlusion. • ***Thrombolytics*** may be injected into a blocked artery under angiography to dissolve clots. • ***Anticoagulants,*** such as Coumadin® and Lovenox®, prevent blood clots from forming and reduce risk of deep vein thrombosis.
Intermittent pressure device	Intermittent pressure devices, such as the Circulator Boot® compresses part of the leg to improve circulation and can be used to treat venous, arterial ulcers, neuropathic, and diabetic ulcers. The Circulator Boot® is an end-diastoilic device, synchronized with the heartbeat by an EKG to compress the leg at the end of diastole while some other similar devices cycle on a regular schedule, such as every 60 seconds, so they can impair arterial perfusion. However, the Circulator boot doesn't contract during the systolic phase when there is blood flow to the peripheral arteries, so it can be used to increase and assist perfusion. There are two types of Circulator Boot®: short boot (foot to below the knee) and long boot (foot to thigh).

	 Used with permission of Circulator Boot Corporation, Malvern, PA. Treatments are usually done for 40 to 60 minutes, 3 to 5 times weekly for about 8 weeks, but this may vary with the individual, depending on the condition of the patient and the ulcer.

Manage nutrition

A nutritional assessment should be done within the first 24 hours as part of routine wound management. Malnutrition, starvation, dehydration, underweight, and obesity all interfere with wound healing. Nutritional management must be individualized because of differences in age, condition, co-morbidity, nutritional status, and wound severity. The average healthy person requires about 0.8g of protein per kilogram every day (40-70 g). However, additional protein and vitamins are needed to promote healing. The patient should be carefully monitored to ensure that hydration is adequate and that s/he is eating the food served. Nutritional assessment tools include:

MNA® (Mini-Nutritional Assessment) (by Nestle Nutrition)	This tool is only valid for those >65. It is a screening and assessment tool to determine the risk for malnutrition. The assessment includes15 questions about dietary habits and 4 measurements, including Body Mass Index (BMI) using height and weight, mid-arm and calf circumference.
Nutritional Screening Initiative®	This tool is only for geriatric patients and screens for dietary information as well as social and environmental factors, such as whether the person eats alone, prepares his/her own meals, drinks alcohol, and has sufficient income to purchase food.
Subjective Global Assessment®	This tool includes complete history and physical examination, assessing weight change, dietary intake, GI symptoms (heartburn, reflux) and functional impairment. The results are evaluated

	subjectively and scores assigned that rate malnutrition risk from normal to severe.

If the patient is unable to ingest adequate food and fluids orally, then s/he may need enteral or parenteral feedings. Daily dietary supplements to promote healing include:

Protein	1.2 to 2.0 g/kg (total)
Vitamin A	1600 to 2000 retinal equivalents
Vitamin C	100 to 1000 mg
Zinc	15 to 30 mg
B-Complex	200% of recommended daily allowance.
Iron	20 to 30 mg

A number of laboratory tests are used to diagnose malnutrition and dehydration and to monitor status during treatment. These tests may include:

Total protein	Levels can be influenced by many factors, such as stress and infection, so it is not a reliable indicator in isolation.
Albumin	Because albumin's half-life is 18-20 days, it is more effective for long-term protein deficiencies than short-therm.
Prealbumin	This is useful for monitoring acute changes in protein because its half-life is only 2 to 3 days. Levels change rapidly in response to adequate or inadequate protein.
Transferrin	This measure iron transport, but the levels can vary widely with different conditions, so it's not reliable in isolation.
Lymphocyte count	Because a decrease in protein impairs immunity, this is reflected in decreased lymphocytes.
Hemoglobin	Decreases in amino acids (derived from protein) cause hemoglobin to decrease although dehydration and large wounds associated with fluid loss (such as burns) may cause hemoglobin to increase.
Serum osmolality	Levels increase with dehydration.
Urine specific gravity	Levels increase with dehydration.

Cleanse wound

The wound should be cleaned of pathogens that are non-adherent, but care must be used to avoid causing trauma to the wound surface. Most wounds should be cleaned with isotonic saline although sterile water can be used since wound contact is for a limited period of time. Exudate may be gently removed with soft gauze or cotton swabs, wiping from the center to the perimeter of the wound and using a new piece of gauze or swab for each wipe.

If there is heavy exudate or extensive infection, a commercial wound cleaning product may be necessary as these products contain surface-active agents or surfactants that help to breakdown the bonds adhering contaminates to the

wounds. Skin cleaners, such as those used to remove fecal material from the skin should never be used on open wounds, as they are more toxic than wound cleaners. Antiseptics should not be used to cleanse open wounds because they are not effective and are cytotoxic to all cells, including white blood cells and fibroblasts necessary for wound healing.

<table>
<tr><td>Wound irrigation</td><td>Wound irrigation is an effective cleaning method for wounds as long as the pressure is adequate. Wound irrigation pressures should be 10 to 15 psi. Wound irrigation of <4 psi is inadequate to clean a wound. Using a mechanical irrigation device is more effective than a bulb syringe (which delivers only about 0.05 psi) as the pressure can be more accurately calibrated. Low-pressure irrigation can be done with a 250 mL squeeze bottle (4.5 psi) or a piston irrigation syringe (4.2 psi). A 35-cc syringe with 19-gauge needle is more effective than a bulb syringe and delivers irrigation at about 8 psi. The pressure of irrigant varies according to syringe size and needle size. Pressures >15 psi can result in trauma to the wound.
<table>
<tr><td>Syringe size/ mL</td><td>Gauge</td><td>Psi</td></tr>
<tr><td>35</td><td>25</td><td>4</td></tr>
<tr><td>35</td><td>21</td><td>6</td></tr>
<tr><td>35</td><td>19</td><td>8</td></tr>
<tr><td>12</td><td>22</td><td>13</td></tr>
<tr><td>12</td><td>19</td><td>20</td></tr>
<tr><td>6</td><td>19</td><td>30</td></tr>
</table></td></tr>
<tr><td>Hydrotherapy</td><td>Hydrotherapy, usually in whirlpool, can be used to cleanse extensive wounds, such as burns; however, the equipment must be thoroughly disinfected between uses as hydrotherapy treatments have been implicated in a number of outbreaks of wound infections because of cross-contamination. Water temperature should be maintained at 37°C. Patients with venous ulcers should not receive hydrotherapy because it causes vasodilation that can worsen the condition. Wounds related to arterial insufficiency usually do not benefit from hydrotherapy, and diabetic patients must be monitored carefully as they may be insensitive to heat.</td></tr>
<tr><td>Pulsed lavage</td><td>Pulsatile high-pressure lavage uses an electrically powered device to irrigate an infected or necrotic wound with normal saline at pressures between 8 and 15 psi, usually once or twice daily. The pressure can be varied as needed. The irrigant should not be directed at exposed blood vessels, graft sites, or muscle tissue. If patients are taking anticoagulants, the wound should be observed carefully for signs of bleeding and irrigations discontinued if bleeding is</td></tr>
</table>

	evident. The hose and irrigating nozzle are disposable, intended for one-time use. This form of wound irrigation requires a separate enclosed space because of the risk of mist contamination. Staff must wear personal protective equipment during the irrigation. 

Debride wound

A wound will not heal properly unless the wound bed is debrided of slough and eschar. There are a number of different methods to debride the wound. A common method of debridement, the wet-to-dry dressing, is no longer recommended for wound care because it is painful for the patient, slow, and can damage granulation tissue.

Autolysis	Debridement by autolysis requires an occlusive or semi-occlusive dressing that creates a warm moist wound surface, so any moisture-retentive dressing can promote some degree of autolysis. Autolysis alone is generally used only for debridement of small wounds without infection, as it is less effective than other methods. Drainage and odor tend to increase as debridement occurs, so surrounding tissue must be protected to prevent maceration. Dressings that promote autolysis include: • ***Hydrocolloids:*** Provide absorbancy if a small amount of exudate is present, but they pose the risk of anaerobic infections with occlusive dressings. • ***Alginate dressings:*** Provide absorbancy for large amounts of exudate, but require a secondary dressing to hold in place. • ***Hydrogels:*** Add moisture to dry wounds and promote rapid autolysis. • ***Transparent films:*** Promote autolysis for small, shallow wounds and may be used as a secondary dressing.
Enzymes	Chemical debridement with enzymes is effective for wounds with necrosis and eschar and is often used for burns or chronic ulcers.

	Enzymes work in a moist environment, so dry eschar must be crosshatched through the upper layers of eschar. Debridement of large eschar may take days to several weeks. Any type of dressing can be used in conjunction with enzymes, but they must be easily removable because the enzymes must be applied one to two times daily. Enzymes include: • ***Collagenase*** (Santyl®) is derived from *Clostridium* bacteria and digests denatured collagen. It is applied to wounds one time daily. A tongue blade can be used to apply the enzyme to deep wounds while it can be applied to gauze packing for shallow wounds. The pH of the wound must remain in the 6 to 8 range to prevent inactivation. Burrows solutions, hexachlorophene, and heavy metal ions (mercury, zinc, silver) also inactivate the enzyme • ***Papain/urea*** combinations (Accuzyme®, Panafil White®, Panafil®, Gladase®) are derived from papaya, with or without chlorophyllin copper complex sodium, which reduces inflammation and odor. This enzyme digests the nonviable protein that forms necrotic tissue. This enzyme must be applied one to two times daily and requires a pH of 3 to 12. Hydrogen peroxide and heavy metal salts (lead, silver, mercury) inactivate the enzyme.
Maggots (Biological)	Medical Maggots® provide biological debridement through secretion of proteolytic enzymes (collagenase), growth factors, and cytokines. Maggots are fast and as effective as other non-surgical methods, but they are usually reserved for cases that are not responding well to other methods because most patients don't like the idea of maggots in their wounds. Maggots are applied with a special "cage" dressing to keep the maggots within the wound and protect the surrounding tissue. Maggots cannot be used with hydrogels or other occlusive dressings and must have oxygen supply. Maggots should not be applied to exposed vessels as they may cause bleeding. The maggots are usually left in the wound for 48 hours and then wiped out and the wound irrigated with NS.
Sharp	Instrumental or sharp debridement of necrotic tissue with scissors or scalpel is the fastest form of non-surgical debridement. This type of debridement can be done at bedside using forceps to hold the tissue taut during excision.
Surgery	Surgical debridement is similar to sharp debridement but done under general, local, or spinal anesthesia and usually reserved for large or extensive wounds, such as burns, that involve severe pain for the patient. Surgical debridement may also be done by lasers. Pulsed lasers pose less risk of damage to adjacent tissue than continuous lasers.

Treat infection

Classic signs of infection include erythema about the wound, increased skin temperature, edema, increasing pain, and purulent discharge, but these signs are most common to acute infections and may not be evident in chronic wounds or in those who are immunocompromised. Pain may be the only sign of infection in immunocompromised patients, and some people with low grade chronic infections may only exhibit delay in healing. In some secondary wounds, infection may present as serous drainage along with inflammation and delay in healing. A chronic wound may have a foul odor, pocketing and tissue breakdown, usually indicating disruption during the proliferative phase.

Antibiotics are an important part of treating a wound infection, but they will not be effective without adequate blood and oxygen supply to the wound. Antibiotic therapy should be based on wound cultures and sensitivities. Physicians may prescribe an antibiotic (usually broad spectrum effective against Gram-positive organisms) prior to results of a culture and then adjust the medication as needed.

Topical antibiotics can be effective in reducing surface pathogens, but they can cause systemic reactions in some people, so patients must be monitored carefully. Care should be used to avoid using the same antibiotic for both systemic and topical treatment as this increases the risk of resistance. For the same reason, topical antibiotics should not be used on clean healing wounds as this also can increase resistance. Topical antibiotics commonly used for wounds include:

Cadexomer Iodine (Iodosorb®)	Powder, paste, or ointment	Beads of iodine in the formulation swell in contact with exudate, releasing the iodine into the wound. It is effective against a wide range of bacteria (*Staph, MRSA, Strep,* and *Pseudomonas)*, viruses, and fungi.
Gentamicin sulfate	Cream or ointment	Gentamicin sulfate is effective against *Staph, Strep, and Pseudomonas* but ineffective against viruses or fungi.
Metronidazole	Gel or wax-glycerine cream	Metronidazole is effective against bacterial infections, such as *MRSA.*
Mupirocin (Bactroban®)	Cream or ointment	Mupirocin is effective against Gram-positive organisms (such as *Staph* and *MRSA)* and may be used to treat nasal colonization that increases risk of wound infection.
Polymyxin B sulfate-Bacitracin zinc-neomycin (Neosporin®)	Ointment	Neosporin® is most commonly used for small cuts or wounds but is effective against Gram-positive organisms (*Staph, Strep,* and *Pseudomonas).*
Polymyxin B sulfate-	Cream or ointment	Similar to Neosporin® but also effective against *MRSA.*

Gramicidin		
Silver sulfadiazine 2 to 7%	Various preparations	Silver preparations are commonly used to treat burns and are effective against Gram-positive organisms, including *Staph, MRSA, Strep,* and *Pseudomonas.*
Ionized silver	Absorbant sheets	Requires activation with sterile water and is effective against the same organisms as silver sulfadiazine but provides a moist environment to promote epithelialization.

Establishing the correct pathogen is extremely important for healing, and this requires culture and sensitivities based on a specimen. A wound biopsy of tissue provides the most definitive sample although needle biopsies can also obtain adequate samples. The most common method, swabbing the area, is the least effective as it obtains samples only from the surface of the wound and can include both pathogens causing infection and contamination from the skin surface.

Apply dressings

Many different types of dressings are available, and the choice depends on the type and extent of the wound. Dressing products include:

Gauze (cotton, polyester, rayon)	Traditional dressings are appropriate to cover dry wounds with primary closure and minimal exudate, secondary dressings, or to provide cushioning to protect wounds.
Impregnated gauze	Gauze may be impregnated with petrolatum, paraffin, zinc oxide and iodoform. They may be used to pack wounds, to prevent the dressing from adhering to shallow wounds, or to apply antimicrobials.
Semi-permeable film	Semi-permeable film (OpSite®, Tegaderm®) may be used over intravenous sites or over dry, shallow, partial thickness wounds. Because it doesn't allow room or absorption of exudate, it is not used for infected wounds. They may be used to provide protection to skin and can be left in place up to a week.
Hydrocolloid	Hydrocolloids (DuoDerm®, Tegasorb®) are sheets or wafers with occlusive covering. They are effective for clean wounds with granulation and minimal to moderate exudate and can remain in place for 2 to 5 days. Hydrocolloids pose an increased risk of anaerobic infection and hypergranulation and are not used for third degree burns.
Alginate	Alginates (AlgiSite®, Hydrofiber®) wafers, rope, or fibers are made from brown seaweed and are very absorbant as they

	absorb exudate and form an hydrophilic gel that conforms to the shape of the wound. They are effective for full-thickness wounds with undermining, tunneling, and large amounts of exudate. They can be used with infected wounds. Alginates must be packed loosely in the wound to allow for swelling and are usually changed daily. They are covered with a secondary dressing. Different alginates require differing times to gel.
Composite	Composite dressings are combinations of different types of dressings and usually an occlusive external layer, an absorbant layer, a semi-or non-adherent layer to lie next to the wound and a rim of adhesive material to secure the dressing. They usually stay in place 2 to 3 days, depending on the amount of exudate.
Polyamide net	These contact layers, sometimes coated with silicone, lay next to the wound and are only slightly adherent so that they don't damage the wound surface and serve a protective function. Polyamide nets are porous and allow drainage of exudate onto secondary dressings.
Foam & foam/film	Hydrophilic foam dressings come in a wide variety of shapes and forms (wafers, pillows, rolls, film) and provide absorption and protection. They may have an impermeable covering or charcoal layer to control odor. Some forms are used for packing to absorb exudate. They are not effective for dry wounds or those covered with eschar. They may be used as secondary dressings over alginates, pastes, or powders. They usually have an adhesive border and are changed every 2-7 days
Hydrogel	Hydrogel dressings (AquaForm®, Elastogel®) are effective for partial or full-thickness wounds that are dry or have only a small amount of exudate and can be used with necrotic and infected wounds. Hydrogels come in various forms, including paste, sheets, and packing strips. Hydrogel dressings are applied directly to the wound to provide moisture and autolysis. They should be covered with a secondary dressing and are contraindicated with heavy exudate.
Absorptive	Absorptive dressings (SurgiPad®, ABD® pad) have cellulose fibers to absorb moderate to heavy amounts of exudate and are usually changed every 1 to 2 days.
Wound fillers	Wound fillers are starch copolymers that come in various forms (paste, granules, beads, gels, powders) and are used to fill wounds. They provide a warm, moist environment to soften necrotic tissue and also absorb minimal to moderate exudate. They can be used with infected wounds and are used with a secondary dressing and changed daily. They are contraindicated for dry, tunneled, or eschar-covered wounds.
Pouches	Pouches (Hollister® Wound Manager), similar to ostomy appliances, are used to contain large amounts of exudate. They

	have a skin barrier and a drainage spout. The skin opening is cut to fit about the wound snugly. Pouches are usually left in place for 4 to 7 days.
Negative pressure wound therapy	NPWT uses negative pressure with a suction unit attached to a semi-occlusive vapor-permeable dressing. The suction tube drains exudate into a canister, creating a closed system. NPWT is used after debridement, especially for slow-healing wounds or those with large amounts of exudate (pressure ulcers, diabetic ulcers, arterial/venous ulcers, dehiscence, burns). NPWT is contraindicated with malignancy, osteomyelitis, exposed vessels, and non-explored fistula (non-enteric). Electrical suction systems available include the VAC® and Versatile I®. Wounds are covered with porous foam comprised of either polyurethane (contraindicated with wounds that are painful, traumatic, and/or have tunneling) or polyvinyl (contraindicated for deep wounds with granulation and deep pressure ulcers or flaps). Suction pressure is set at 75 to 125 as needed, and the complete dressing is changed 2 to 3 times weekly.
Compression	Static compression therapy applies graduated increasing compression distally to proximally, usually from the ankle to the knee, and is used primarily to prevent venous ulceration or further deterioration of existing ulcers. Compression therapy is contraindicated with peripheral arterial disease. Compression products are graded according to the amount of compression they exert: • High level: 30 to 40 mmHg at ankle. • Low level: ≤ 23 mmHg at ankle. Compression products (some of which have visile pressure guides) include: • ***Layered wraps*** (Profore®, ProGuide®, and Dynapress®) have 2 to 4 layers of both elastic and non-elastic material with cushioned inner layers that protect bony prominences and absorb drainage. These wraps are changed 1 or 2 times weekly. • ***Single-layer wraps*** (SurePress®) are long elastic wraps that used for early treatment or maintenance and are reusable. • ***Compression stockings*** (Jobst®, Therapress Duo®) are used after edema is controlled and are classed according to compression o *Class I:* 20-30 mm Hg (varicose veins). o *Class 2:* 30-40 mm Hg (venous ulcers, prevention). o *Class 3:* 40-50 mm Hg (refractory venous ulcers, lymphedema). o *Class 4:* 50-60 mm Hg (lymphedema). • ***Unna's boot*** (ViscoPaste®) utilized an impregnated

	gauze wrap (zinc oxide, glycerine, or gelatin) to provide support to the calf muscle pump during ambulation, so they only used for ambulatory patients and can be used with peripheral arterial disease. The boot is applied without tension and left to dry or covered with a self-adherent wrapping. The boot is generally changed every 2 to 14 days, depending on the patient's condition. • ***Short stretch wrap*** (Comprilan®) is used for ambulatory patients but tends to slip out of place and requires frequent reapplication. • ***Non-elastic orthotics*** (CircaAid Thera-boot®) is an adjustable stocking with multiple Velcro straps so that the stocking can be adjusted to fit the calf. It is used for venous ulcers after edema is controlled.
Off-loading	Off-loading relieves pressure on wounds, such as neuropathic ulcers, and promotes healing. Off-loading measure include: • Half shoes to elevate the front of the foot. • Wheelchairs, crutches, walkers. • Removable cast walkers. • Total contact casts (TCC) to encase the lower leg in a walking cast and equalize pressure on plantar area of foot, sometimes with windows to expose open wounds. • Foam support and cushioning.

Control pain

One response to pain is vasoconstriction, which impairs wound healing, so pain control is an important part of wound management. Pain should be routinely assessed using the 1 to 10 scale or other scale as appropriate. Assessment includes:

- Site of pain.
- Response to activity or change of position.
- Time when pain is most acute and least acute.
- Response to dressings (pressure, changes, dryness).

Patients respond quite individually to pain. If two people have the same degree of pain, one may be very stoic and say nothing while the other moans and cries out, so it's important to ask patient's directly and look for non-verbal indications of pain, such a grimacing, tensing on movement, and increased respirations).

Pain management includes:

Hydration/nutrition	Maintaining adequate hydration and nutrition can help to reduce pain.
Analgesia	Pain medication adequate to control pain should be given before dressing changes and as needed. In some cases, such as with extensive burns, patient-controlled analgesia

	(PCA) may be used. The World Health Organization (WHO) "Analgesic Ladder" is useful as a reference. Combining two or more drugs is often more effective than just one drug. • ***Step 1 (Mild to moderate pain):*** Aspirin, acetaminophen, and NSAIDs. • ***Step 2 (Moderate to severe pain unrelieved by Step 1 medications):*** Opioids (Codeine, tramadol, or Percocet®). • ***Step 3 (Severe pain without relief from Step 1 or Step 2 medications):*** Stronger opioids (morphine, Dilaudid®, or MS-Contin®).
Topical anesthesia	• ***Lidocaine*** 2-4% can be administered 15 to 30 minutes prior to debridement or change of dressing to reduce pain. Frequently used during debridement or dressing changes. • ***Eutectic Mixture of Local Anesthetics (EMLA Cream)*** is applied thickly (1/4 inch) to the wound, extending about 1/2 inch past the wound to the surrounding tissue. The wound must be covered with plastic wrap for 20 to 60 minutes to numb the tissue. The cream is effective for about an hour after the wrapping is removed.
Regional anesthesia	• Field blocks or regional nerve blocks may be used to provide pain control for severe pain.
Positioning	Protecting the wound from pressure by correct positioning or use of foam padding can help to control pain. Off-loading also helps control pain. Direct pressure on a wound should be avoided as this can impair circulation as well.

Monitor

The wound must be monitored daily or with each dressing change to note any changes that may indicate healing, infection, or deterioration. Different methods may be used to record findings.

Flow sheet	Various flow sheets have been developed to follow the progress of the wound. Typically, they have either space to write findings, a checklist, or a combination to describe the size, shape, and condition of the wound and exudate. Special digital devices (Visitrack®), using sterile grids and electronic tracing pens, are available to outline the perimeter of a wound to show accurate measurements although this can also be done non-digitally by overlaying the wound with clear film or plastic wrap and outlining the wound with a marking pen.

Photography	One of the best methods to document changes in a wound is to take periodic photographs; however, because of liability issues, some institutions prohibit photography or have a specific protocol to direct when, how, and by whom photography can be done. The NPUAP advises that institutions that use photography have protocols in place and that photography be done by trained personnel in a consistent manner. Protocols should include: • Means of patient identification. • Date and time marking. • Sample measure (such as a 10 cm paper tape) visible in each frame. • Photographs included in permanent medical record. • Standardization of equipment, aperture settings, distance from wound. • Digital camera with ≥3 megapixels. Note that digital photographs are usually not admissible in court because of the ease of manipulation, so more permanent forms of photography (such as Polaroid® or regular film) may be used in some cases, especially if only an admission photograph is taken rather than serial photographs.
Marking	Indelible ink may be used to mark the perimeter of a wound, such as when cellulitis develops, to determine if the wound is increasing or decreasing in size. 

Protecting the skin

Avoid excessive bathing, such as every day unless skin is soiled as this can contribute to drying. Sometimes, it's better to use soap only on soiled areas, such as the perineum, and just water on other areas. Some soaps, such as Ivory, which are advertised as being "pure" are in fact very drying to the skin, so it's better to use soaps with emollients, such as Dove, Keri, or Cetaphil. Many skin cleansers are available with oatmeal or aloe vera. Skin should be patted dry rather than rubbed briskly, especially if skin is friable. Water-based lotions can be applied to damp skin. Shampooing weekly is adequate for most people, using a mild adult shampoo, as children's shampoos are usually not adequate to clean adult hair.

Dry skin is more likely to become irritated than moist skin, and some people have a tendency to dry skin, such as those with asthma, allergies, and eczema. Dry skin can be aggravated by environmental conditions, such as cold, low humidity, or exposure to air conditioning. Often the first indication of dry skin occurs on the lower extremities and the hands, progressing from rough texture to scales. Creams are thicker and more moisturizing than lotions, which contain more water.

Summary

There are many types of wounds, and management varies depending upon the type and extent of the wound. The skin provides protection and immunity, sensation, and thermoregulation and is important for metabolism of vitamin D. The four layers of the skin are the epidermis, basement membrane zone, dermis, and hypodermis. Wound assessment must include a complete history and physical examination and detailed observations about the wound. There are numerous wound classification systems, including degree (first, second, third), thickness (partial, full), NPUAP staging for pressure ulcers, Wagner's grading for foot ulcers, SAD grading for neuropathic ulcers, staging of tissue damage from irradiation, Payne-Martin classification for skin tears, Ayello's ASSESSMENTS, and the CDC categories of surgical wound infections. Healing of surgical and/or traumatic wounds may be described by the method of closure (primary, secondary, tertiary). Phases of healing include hemostasis, inflammation, proliferation, and maturation. Wound management includes maintaining perfusion, managing nutrition, cleansing, debriding, treating infection, applying dressings, managing pain, and monitoring. Special attention should be given to protect the skin and prevent excessive dryness and irritation.

References

Baranoski S.. & Ayello E.A. (2004) *Wound Care Essentials: Practice Principles.* Springhouse, PA: Lippincott.

Brown, P.A. (2008) *Quick Reference to Wound Care,* 3rd ed. Sudbury, MA: Jones & Bartlett Publishers.

Dillon, R. S. (2006). Circulator boot and topical oxygen therapy. Circulator Boot Corporation. Retrieved February 10, 2010, from http://www.circulatorboot.com/introduction/topicalO2.html

Durkin, W.T. (2005, October 4). Wound Care. *EMedicine Health.* Retrieved February 10, 2010 from http://www.emedicinehealth.com/wound_care/article_em.htm

FAQ: Photography for pressure ulcer documentation. (n.d.) NPUAP. Retrieved February 10, 2010 from http://www.npuap.org/DOCS/PhotographyFaq.doc.

Hess, C.T. (2005). *Wound Care,* 5th ed. Amber, PA: Lipincott, Williams, & Wilkins.

Pressure ulcer stages revised by NPUAP. (2007, February). *National Pressure Ulcer Advisory Panel.* Retrieve February 10, 2010, from http://www.npuap.org/pr2.htm

Latham, E, Hare, MA., & Neumeister, M. (2008, November 7). Hyperbaric oxygen therapy. *eMedicine*. Retrieved February 10, 2010, from http://emedicine.medscape.com/article/1464149-overview

Scemons, D, & Elston, D. (2008). *Nurse to Nurse Wound Care.* San Francisco, CA: McGraw Hill Medical.

Smeltzer, S.C., Bare, B., Hinkle, J.L, & Cheever, K.H. (2009). *Brunner & Suddarth's Medical-Surgical Nursing* 11th edition. Philadelphia: Lippincott, Williams, & Wilkins.

Topical Oxygen Wound Management Program. (2009). *THBO.* Retrieved May 21, 2009, from http://www.thbo.com/

Wagner ulcer classification. (2008). Family Practice Notebook.com. Retrieved February 10, 2009, from http://www.fpnotebook.com/Surgery/Exam/WgnrUlcrClsfctn.htm

Wound care product and category list. (2008). *Wound Care Information Network.* Retrieved February 10, 2010, from http://www.medicaledu.com/prodindx.htm