Pressure Ulcers: Prevention and Management

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- **Objective:** To describe important aspects of pressure ulcer prevention and management, especially in elderly patients.
- **Design:** We reviewed pertinent published material in the medical literature and summarized effective strategies in the overall management of the elderly population with pressure ulcers.
- **Results:** Pressure ulcers are commonly encountered in geriatric patients. The development of a pressure ulcer is associated with an increased risk of death. Certain well-recognized risk factors, such as immobility and incontinence, may predispose to the development of pressure ulcers; consequently, risk factor modification is an important aspect of prevention and treatment. For existing lesions, various innovative patient support surfaces and wound care products have been developed to alleviate pressure and to facilitate wound healing. The use of a particular product should be based on the clinical setting and the limited scientific evidence available. With treatment, most pressure ulcers eventually heal.
- **Conclusion:** Pressure ulcers are often, but not always, preventable. The occurrence of such an ulcer signals the possible presence of chronic comorbid disease and should prompt a search for underlying risk factors in patients for whom ulcer treatment is considered appropriate.


HCDs = hydrocolloid dressings

Pressure ulcers are a serious and frequent occurrence among immobile and debilitated patients. Currently, an estimated 1.5 to 3 million Americans are affected. This condition involves more than $5 billion in health-care expenditures annually and causes an immeasurable amount of suffering and frustration for patients, their families, and caregivers. Pressure ulcers continue to be perceived as a consequence of suboptimal care. As a result, health-care professionals and institutions are often stigmatized, despite clearly identified and often irreversible underlying risk factors for the development of pressure ulcers. More than 17,000 lawsuits related to pressure sores are filed annually, and individual awards have been as high as $4 million. Herein we review the epidemiologic features, classification, and causes of pressure ulcers along with strategies for prevention of such ulcers and management of patients with existing lesions.

**Epidemiology**

In up to 5% of patients admitted to acute-care hospitals, a pressure ulcer will develop during their hospital stay. This figure is even higher for patients immobilized in bed or in a chair for at least a week. One study estimated that 1,692,000 hospitalized patients had pressure ulcers. At least 60% of all pressure ulcers are thought to develop in the hospital, 18% develop in nursing homes, and 18% develop at home. Approximately one in four persons in the United States who died in 1987 had a dermal ulcer at the time of death.

Pressure ulcers develop primarily in elderly patients. In almost a third of the elderly patients who undergo an operation for hip fracture, pressure ulcers develop and prolong the hospital stay; the perioperative mortality rate is 27% for those with such ulcers.

The prevalence of pressure ulcers in the long-term-care setting has been reported to be between 15 and 25% at the time of admission. The incidence of pressure ulcers in nursing home residents varies, however, the longer a patient stays in a nursing home, the greater is the likelihood that an ulcer will develop. One recent study of nursing home residents found that 13.2% had ulcers within 1 year and...
21.6% had ulcers at 2 years. Those investigators projected that, at any specified time, approximately 100,000 nursing home residents throughout the United States have a pressure ulcer.

The prevalence of pressure ulcers among non-institutionalized elderly persons is less well known. Among those who receive home health services, 7 to 12% have pressure ulcers.9

**DEFINITION**

Pressure ulcers are localized areas of tissue necrosis that tend to occur when soft tissue is compressed between a bony prominence and an external surface for a prolonged period.9 These lesions have also been referred to as bedsores, decubitus ulcers, and pressure sores. Because pressure is considered the essential factor that leads to the development of these wounds, the term “pressure ulcers” is recommended.9 Pressure ulcers commonly occur over the sacrum, greater trochanter, ischial tuberosity, malleolus, heel, fibular head, and scapula.

**CLASSIFICATION**

Over the years, numerous systems have been developed to grade or classify pressure ulcers.17-19 In 1989, the National Pressure Ulcer Advisory Panel sponsored a national consensus conference, during which several commonly used staging systems were combined in an attempt to implement a universally accepted classification system. The following staging definitions were proposed:

Stage I = nonblanchable erythema of intact skin, considered the heralding lesion of skin ulceration.

Stage II = partial-thickness skin loss that involves the epidermis or dermis (or both). The ulcer is superficial and manifests clinically as an abrasion, blister, or shallow crater.

Stage III = full-thickness skin loss and damage or necrosis of subcutaneous tissue that may extend to, but not through, underlying fascia. The ulcer manifests clinically as a deep crater, with or without undermining of adjacent tissue.

Stage IV = full-thickness skin loss associated with extensive destruction, tissue necrosis, or damage to muscle, bone, or supporting structures, such as tendons or joint capsules.

Considerable variability exists in the reported prevalence, cost, natural history, and rates of healing of pressure ulcers because of inclusion of stage I lesions in some studies and not others and because of differences in the classification systems used. The anatomic and treatment implications for stage I lesions differ from those for stage II, III, and IV lesions.

**PATHOGENESIS**

Four key factors are thought to be involved in causing skin breakdown: pressure, shearing forces, friction, and moisture.20 Pressure beneath bony prominences can impede blood flow to the skin and underlying tissues, and ischemic injury can result. Because muscle and subcutaneous tissues are more susceptible to pressure-induced injury than is the epidermis,21 pressure ulcers are frequently worse than they initially appear. Commonly, physicians tend to undertage pressure ulcers. The damaged tissue visible on the surface of a pressure ulcer may merely represent the “tip of the iceberg.” Shearing forces result from the sliding of adjacent structures, which causes a relative displacement. For example, when patients are propped up in bed more than 30 degrees or are seated and then slide down, subcutaneous tissues are stretched and angulated while the sacral skin remains stationary. Such angulation and occlusion of subcutaneous blood vessels can result in tissue ischemia.21 Friction and shearing forces can be imposed on the skin when a patient is moved across the bedsheets during transfers in and out of bed or when frequent limb movements occur in patients with restlessness, agitation, or spasticity. Moisture, often resulting from incontinence or perspiration, can lead to tissue maceration and skin breakdown when any other listed factor is present.

**RISK FACTORS**

Elderly patients and those with spinal cord injuries, traumatic brain injury, or neuromuscular disorders are high-risk populations for development of pressure sores, especially in the acute-care hospital setting.21,22 Immobility, malnutrition, fecal and urinary incontinence, and altered level of consciousness are important associated risk factors.19,10,23,24 Chronic systemic illness or the presence of a fracture may also be predictive of development of an ulcer.8,10 All these factors are more frequently found among elderly than among younger patients; thus, the risk that age itself confers is compounded.

Several changes that occur in normal skin with aging may predispose older persons to the development of pressure sores—epidermal turnover decreases, the dermo-epidermal junction flattens, and fewer dermal blood vessels are present. In addition, elderly persons have an increase in dermal collagen, a decrease in elastic fibers, a loss of cells that synthesize vessel basement membrane, and an increase in skin permeability.23 They may also experience a decrease in the perception of pain.26

Protein-calorie malnutrition is clearly associated with development of pressure ulcers, however, determining whether an elderly patient is malnourished can be surprisingly difficult. Perhaps the most useful indicator of malnutrition in elderly patients is a loss of weight from baseline. Eliciting a dietary history may also prove helpful. Because of poor sensitivity and specificity, laboratory tests such as serum albumin and total cholesterol, which may show ab-
NORTON SCALE

<table>
<thead>
<tr>
<th>Name</th>
<th>Date</th>
<th>Physical condition</th>
<th>Mental condition</th>
<th>Activity</th>
<th>Mobility</th>
<th>Incontinent</th>
<th>Total score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>4</td>
<td>Alert</td>
<td>4</td>
<td>Ambulant</td>
<td>4</td>
<td>Full</td>
<td>4</td>
</tr>
<tr>
<td>Fair</td>
<td>3</td>
<td>Apathetic</td>
<td>3</td>
<td>Walk/help</td>
<td>3</td>
<td>Slightly limited</td>
<td>3</td>
</tr>
<tr>
<td>Poor</td>
<td>2</td>
<td>Confused</td>
<td>2</td>
<td>Chair-bound</td>
<td>2</td>
<td>Very limited</td>
<td>2</td>
</tr>
<tr>
<td>Very bad</td>
<td>1</td>
<td>Stupor</td>
<td>1</td>
<td>Stupor</td>
<td>1</td>
<td>Immobile</td>
<td>1</td>
</tr>
</tbody>
</table>

Fig. 1. Norton scale for assessment of risk of development of pressure ulcers. A total score of 16 is considered the threshold for high risk and indicates that preventive strategies should be applied. (From Norton D, McLaren RS, Exton-Smith AN. Investigation of Geriatric Nursing Problems in the Hospital. London: National Corporation for the Care of Old People, 1962.)

Normally low levels in malnourished patients, are not routinely recommended.

RISK ASSESSMENT

For more than 30 years, efforts have been made to estimate the likelihood of development of pressure ulcers in individual patients, identify those at highest risk, and implement preventive strategies in those most likely to benefit. Several instruments have been developed to facilitate and standardize the process of risk assessment. Among the most widely used of these instruments, the Norton scale (Fig. 1) assesses five factors: physical condition, mental condition, activity, mobility, and continence. Each of these factors is scored on a scale of 1 to 4, a higher number indicating higher function. A total score of 16 is considered the threshold for high risk and indicative of a need for preventive strategies.

PREVENTIVE STRATEGIES

After Norton and others showed that patients at high risk for developing ulcers could be identified before ulcers occurred, clinicians soon discovered that turning high-risk patients every 2 hours resulted in a substantial reduction in the occurrence of pressure ulcers. Subsequently, various strategies for modifying or eliminating risk factors for ulcer formation were developed. These strategies have been formalized in a recent publication by the US Department of Health and Human Services, in which clinical guidelines for the prediction and prevention of pressure ulcers are enumerated (Fig. 2 and Table 1). For each patient determined to be at high risk for ulcer development, an estimated 29 to 79 minutes of nursing time per day is needed to implement these guidelines. Minimal reimbursement for preventive strategies is available from Medicare, Medicaid, or third-party payers in a fee-for-service environment. Under capitated, managed care systems, however, a strong financial incentive exists to prevent ulcers.

An essential part of prevention of pressure ulcers is education of health-care providers, patients, and family or caregivers. As enumerated in the guidelines from the Agency for Health Care Policy Research, an educational program should include information on the causes and risk factors for pressure ulcers, risk assessment tools and their application, skin assessment, selection and use of support surfaces, development and implementation of an individualized program of skin care, demonstration of positioning to decrease risk of tissue breakdown, and instructions for accurate documentation of pertinent data.

SECONDARY INFECTIONS

The development of pressure ulcers may lead to further problems, such as cellulitis, osteomyelitis, infections of adjacent structures such as joint spaces, and sepsis. Sepsis related to pressure ulcers is associated with an in-hospital mortality rate of almost 50%. Cellulitis can be difficult to diagnose because it may resemble the reactive hyperemia and erythema associated with normal healing. All pressure ulcers are colonized with bacteria, whether infection is present or not. Swab culturettes of the wound surface are virtually always positive; however, they identify only surface organisms and do not accurately identify causative organisms, even when infection is present. When an ulcer does not heal, the possibility of infection should always be considered. Typically, an infection is caused by a mixture of organisms, which may include gram-positive cocci (staphylococci and streptococci), gram-negative bacilli, and anaerobes. Clinically in-
fected ulcers and nonhealing wounds require further evaluation to rule out osteomyelitis.

Osteomyelitis has been detected in the bone underlying 26% of nonhealing ulcers. If an ulcer fails to show evidence of healing after pressure has been removed or if purulent drainage visibly extends into bone, osteomyelitis should be ruled out. Osteomyelitis can be difficult to diagnose. Even when infection is not present, findings on soft tissue cultures, radiographic studies, and nuclear imaging studies are often abnormal in areas surrounding a pressure ulcer. These tests have poor positive predictive value, but their negative predictive value is good. The "gold standard" for diagnosing osteomyelitis still remains bone biopsy, in association with microscopic examination and quantitative culture for organisms. At our institution, magnetic resonance imaging has become the procedure of choice among radiologic methods for evaluating suspected cases of osteomyelitis. Alternatively, a bone scan or a bone scan in conjunction with an indium-labeled leukocyte scan may be used. Normal findings on a bone scan rule out osteomyelitis. If the bone scan is positive, bone biopsies should be considered.

**TREATMENT**

Therapy for pressure ulcers is generally empiric, based on anecdotal experience, and borrowed from the treatment of patients with burns. Few controlled trials to evaluate specific treatment modalities have been reported. Many of the studies are hampered by their study design, the inability to control for confounding factors, or the added conflict of being performed by parties with a vested interest in the products being studied. Nevertheless, the treatment of pressure ulcers has evolved into a logical, comprehensive approach, individualized for the patient, and involving more than simple management of the wound itself. Pressure ulcers should be considered a visual manifestation of one or more underlying medical conditions, all of which may need medical attention.
Table 1.—Guidelines for Prevention of Pressure Ulcers

Mechanical loading and support surface guidelines

For bed-bound persons
- Reposition at least every 2 hours
- Use pillows or foam wedges to keep bony prominences from direct contact
- Use devices that totally relieve pressure on the heels
- Avoid positioning directly on the trochanter
- Elevate the head of the bed as little as and as briefly as possible
- Use lifting devices to move rather than drag persons during transfers and position changes
- Place at-risk persons on a pressure-reducing mattress.
  - Do not use doughnut-type devices*

For persons in wheelchairs
- Reposition at least every hour
- Have patient shift weight every 15 minutes if able
- Use pressure-reducing devices for seating surfaces.
  - Do not use doughnut-type devices*
- Consider postural alignment, distribution of weight, balance and stability, and pressure relief when positioning persons in chairs or wheelchairs
- Use a written plan

Skin care and early treatment guidelines

- Inspect skin at least once a day
- Individualize bathing schedule; avoid hot water; use a mild cleansing agent
- Minimize environmental factors such as low humidity and cold air. Use moisturizers for dry skin
- Avoid massage over bony prominences
- Use proper positioning, transferring, and turning techniques
- Use lubricants to reduce friction injuries
- Institute a rehabilitation program
- Monitor and document interventions and outcomes

*Doughnut-type devices are known to cause venous congestion and edema and may be more likely to cause pressure ulcers than to prevent them.

From the Panel for the Prediction and Prevention of Pressure Ulcers in Adults.34

The general principles of therapy for pressure ulcers are (1) relief of pressure, (2) removal of devitalized tissue, (3) optimization of the wound environment to promote granulation and reepithelialization, (4) avoidance of maceration, trauma, friction, or shearing forces, and (5) search for reversible underlying conditions that may predispose to ulcer development or impede wound healing. When the overall goals of treatment include the restoration of normal function or prolongation of life, aggressive treatment efforts may be warranted. Nevertheless, even simple measures such as frequent turning (every 2 hours) may be painful for patients or difficult for caregivers. If the primary goal of treatment is to relieve suffering or provide comfort, aggressive treatment measures may be contraindicated.37

Relief of Pressure.—The foremost goal of treatment of dermal ulcers is to relieve pressure over bony prominences. Mobilization of the patient is important whenever possible. Patients who are confined to bed should be turned every 2 hours; in addition, a support device such as a soft foam or air-waffle mattress should be used. These relatively simple measures have clearly been shown to reduce the risk of development of pressure ulcers19,25 and have consequently become standard practice in the management of patients with established ulcers as well. Pillows placed beneath the calves, foam foot protection, wheelchair cushions, or a wheelchair “push-up” device (weight shift) are also useful simple measures for patients in bed or wheelchairs.

Patient Support Surfaces.—Patients who cannot tolerate frequent turning, immobile patients, those with very large or multiple ulcers, or patients whose ulcers have not responded to treatment may require the use of a pressure support surface that is capable of lowering the surface pressure below capillary filling pressure (32 mm Hg) (Table 2). Thick foam mattresses, water mattresses, alternating-pressure air mattresses, and static multilayered air mattresses can accomplish this goal and have been found to be useful in the prevention of pressure ulcers.39,40 Their usefulness in ulcer healing is not as certain, and no one product has been shown to be clearly superior. Air-fluidized beds and low-air-loss beds, which are elaborate support surfaces, probably are the most effective for functionally dependent patients with large, deep, or multiple ulcers.

Air-Fluidized Beds.—An air-fluidized bed (Clinitron bed) is an oval space with up to 2,000 pounds (907 kg) of glass beads covered by a polyester sheet. The beads are fluidized by a flow of warm, pressurized air, which floats the polyester cover on which the patient is placed. Such beds have been available since 1969. The patient’s feces and body fluids are able to flow through the polyester sheet; thus, the skin is kept dry.41 Bowel and bladder management is still necessary to minimize incontinence. In addition to being heavy, these beds are expensive; they cost as much as $100 a day, an amount that may not be reimbursed. The circulating warm air tends to make the bed hot—a feature that may exclude its use in patients with heat intolerance, such as those with multiple sclerosis.

Most studies in which air-fluidized beds were used have shown faster rates of wound healing than with conventional treatment.21,41,42 Regardless of the method of treatment, however, severe pressure ulcers require a long healing period. In one nursing home study, the median duration of treatment was 119 days.42 Because of the need for prolonged treatment and the high cost of air-fluidized beds, they have been recommended for use primarily in medically stable patients whose prognosis is otherwise good.42 Air-fluidized beds should be used for at least 60 days before discontinuation because of no therapeutic response.42 They can also be used to treat pressure sores successfully in debilitated patients who are not surgical candidates.43 In a study of patients with...
pressure ulcers who were being treated at home, use of air-fluidized beds decreased the hospitalization days but yielded no difference in clinical outcome or cost.43

Low-Air-Loss Beds.—Low-air-loss beds, such as the KinAir bed, consist of multiple inflatable fabric pillows that are attached to a modified hospital bed frame. An electric fan maintains the buoyancy of the pillows.44 The head and foot of the bed can be elevated, similar to a regular hospital bed. The low-air-loss bed is cooler, considerably lighter, and more portable than air-fluidized beds. Unlike air-fluidized beds, urine and feces do not pass through the fabric of low-air-loss beds.

The use of low-air-loss beds for nursing home patients with pressure ulcers was associated with a threefold increase in the rate of wound healing in comparison with patients in the same facility treated with foam mattresses.44 The daily cost for the bed was $65. Similar beds were found to be useful for the prevention of pressure sores in critically ill patients in the intensive-care unit; once ulcers appeared, however, resolution was no more effective than with conventional therapy.45

Débridement.—Stage II pressure ulcers with a small amount of superficial necrotic tissue can be gently débrided mechanically with coarse mesh gauze moistened with saline (remove and reapply moist dressings every 6 to 8 hours), hydrocolloid dressings (HCDs), or enzymatic débridement agents. If allowed to dry, gauze dressings can be painful to remove. The use of enzymatic agents can also be painful; they require a skin protectant such as petroleum jelly or zinc oxide to prevent damage to adjacent normal tissues. Enzymatic agents cannot remove a hardened, black eschar or a large amount of necrotic tissue;46 however, they can loosen the eschar to facilitate sharp débridement. Whirlpool, shower cart, or pulsed-water (Waterpik) débridement may be useful adjuncts for continued débridement of large ulcers. Large stage III lesions and stage IV ulcers are usually débrided surgically. Along with surgical débridement, a soft tissue flap may be needed to ensure adequate blood flow to large deep wounds and provide cushioning over bony prominences. Surgical consultation should be considered for any wound larger than 10 cm in diameter.

The Wound Environment.—For many years, perhaps because moisture was known to cause skin maceration and lead to ulcer formation, numerous treatments focused on making the wound dry. Heat lamps were often used for this purpose. Although excessive moisture is a risk factor for ulcer formation, moisture is also vital for wound healing. A moist environment for wound healing is optimal for granulation and reepithelialization,47 and desiccation of the wound inhibits epithelialization.

Heat lamps and similar devices should not be used to treat pressure ulcers. Wound care should emphasize a clean,
Table 3.—Summary of Wound Care Products Available for the Management of Pressure Ulcers

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Advantages</th>
<th>Disadvantages</th>
<th>Indications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wet gauze</td>
<td>Woven, loose mesh cotton gauze dampened with sterile water or saline</td>
<td>Inexpensive, versatile—can cover even the largest wounds</td>
<td>Frequent dressing changes required, may dehydrate and adhere to wound, cover wrap or dressing necessary</td>
<td>Wounds covered by eschar; very large, irregularly shaped, or multiple wounds</td>
</tr>
<tr>
<td>Films (Opsite, Tegaderm, others)</td>
<td>Transparent, gas-permeable polyurethane film that mimics the function of the skin</td>
<td>Transparent, waterproof, single dressing may remain in place 5-7 days</td>
<td>Provide no cushioning of wound</td>
<td>Stage I ulcers</td>
</tr>
<tr>
<td>Foams (Allevyn, LYOFoam, others)</td>
<td>Polyurethane semi-permeable foam</td>
<td>Transparent, waterproof, cushion wound surface, maintain moist wound environment, absorb excess wound exudate</td>
<td>Cover wrap or dressing necessary</td>
<td>Noninfected stage II or III ulcers that are not completely covered by eschar</td>
</tr>
<tr>
<td>Hydrocolloids (Duoderm, Tegasorb, Confoam, others)</td>
<td>Self-adhesive semi-permeable or occlusive dressing composed of a hydrocolloid material that interacts with wound fluid and forms a gel that “sits” on the wound surface</td>
<td>Self-adhesive; create moist wound environment; promote autolysis, angiogenesis, and granulation; single dressing may remain in place 5-7 days; little nursing care required</td>
<td>May fall off highly exudative wounds, can melt and stick to clothing or bedding</td>
<td>Noninfected stage II or III wounds with light to moderate exudate; ideal for smaller, solitary ulcers</td>
</tr>
<tr>
<td>Hydrogels (Vigilon, Elasto-gel, Clear-site, Carrington gel, others)</td>
<td>Amorphous, water- or glycerin-based gel composed of a three-dimensional hydrophilic polymer</td>
<td>Highly absorbent, transparent, conform to wound surface, can be used for stage IV ulcers</td>
<td>Dehydrate easily, require additional cover wrap or dressing</td>
<td>Stage II to IV ulcers with moderate drainage</td>
</tr>
<tr>
<td>Alginates (Sorbax, Mesalt, Kaltostat, others)</td>
<td>Highly absorbent material derived from seaweed</td>
<td>Highly absorbent, conform to wound shape</td>
<td>Cause desiccation of the wound, require additional cover wrap or dressing</td>
<td>Stage III or IV wounds with copious drainage</td>
</tr>
</tbody>
</table>

moist wound environment, and maceration around the ulcer should be avoided. More than 135 different dressings and wound care products are currently available. Many of these dressings have been developed to modify the wound environment, in an effort to facilitate healing. The choice of dressing depends on the stage, size, and characteristics of the ulcer to be treated; the unique properties of individual wound care products must be considered.

**Wound Care Products.**—Products that can be used in the management of the pressure ulcer wound can be divided into six categories (Table 3): gauze, films, foams, hydrocolloids, hydrogels, and alginate dressings. Each product is discussed briefly in the subsequent material.

**Gauze.**—Moist gauze dressings are inexpensive. In one study, they cost only $0.47 per application. They must be changed at least two to three times a day, however; thus, the additional nursing time increases the overall costs. Maintaining moisture may be difficult with gauze dressings. If they become dry, they can adhere to the wound. Removing an adherent, dry dressing can cause pain and may remove healthy granulation tissue. Gauze dressings must be secured with a cover dressing or wrap.

**Films.**—Semipermeable polyurethane films allow gases to pass through but are impermeable to water. They mimic the function of the skin and may enhance healing by sequestering wound fluids. Because they are transparent, the wound can be directly visualized with the dressing in place. Such films are commonly used for treating stage I lesions. A single dressing may remain in place up to 7 days.

**Foams.**—Like films, semipermeable polyurethane foams are transparent and waterproof. Additionally, they provide cushioning to the wound and absorb excessive wound exudate. At the same time, a moist environment is maintained, and excessive autolysis or maceration is avoided. Because these foams do not adhere to the wound, they must be secured with a cover dressing or tape; hence, direct visual-
ization of the ulcer is obscured. Foams should not be used for ulcers that extend into underlying muscle, ulcers completely covered by eschar, clinically infected ulcers, or heavily exuding ulcers.40,51

**Hydrocolloids.**—HCDs contain an adhesive material that physically interacts with wound fluid. These occlusive or semiocclusive dressings encourage wound cleansing and débridement through the process of autolysis and promote the development of granulation tissue by stimulating angiogenesis.52 In several studies, HCDs have been found to be at least as efficacious as gauze dressings and may require only one-eighth the nursing care.47,49,52 Each individual dressing costs approximately $6 to $8. The dressing need not be changed for up to 7 days, although one study found that the average life span of such a dressing was only 3½ days.52 HCDs should be assessed three times a day and changed whenever any drainage or fluctuance is evident. HCDs may not adhere well to highly exudative wounds and should not be applied to clinically infected ulcers. HCDs are best for smaller, solitary stage II or III ulcers. Large or multiple lesions may not be covered by a single HCD, whereas a single moist gauze dressing may suffice. HCDs may macerate the surrounding fragile skin. Skin protectants can be used before applying the HCD to protect the surrounding skin. The dressing itself must be removed carefully, to avoid desquamation of surrounding tissue. An adhesive remover such as acetone can facilitate removal.

**Hydrogels.**—Hydrogels are three-dimensional hydrophilic polymers that interact with aqueous solutions by swelling and maintaining water in their structure. They are nonadhesive and conform to the wound surface; many are transparent. Hydrogels are very absorbent and dehydrate easily, especially when not covered properly with a dressing or wrap. Although they may be difficult to confine in large wounds, they can be used with stage IV ulcers.40,51

**Alginate Dressings.**—Alginate dressings, derived from seaweed, are highly absorbent. They have been used for ulcers with copious drainage. In one study (supported by the manufacturer), algalines dried out and adhered to the wound in a fourth of the patients and dissolved in another fourth.53 These nondherent dressings must be secured with a cover dressing or wrap. They should not be used for dry wounds.40,51

**Topical Disinfecting Agents.**—The direct topical application of disinfecting agents to the wound surface of a pressure ulcer is controversial. The use of topical antimicrobial agents such as silver sulfadiazine for treating pressure ulcers is borrowed from experience in managing patients with burns, whose wounds frequently become secondarily infected. The mechanism of ulcer formation differs considerably in pressure ulcers as opposed to thermal burns. Because the rate of infection, causative organisms, and mechanism of infection differ, one might not expect the treatment to be the same. Irrigation with saline can retard bacterial growth in open pressure ulcers.47 The topical use of disinfecting agents may actually be counterproductive. Povidone-iodine, acetic acid, hydrogen peroxide, and sodium hypochlorite are cytotoxic to fibroblasts and may impair wound healing.47,54 Topically applied antimicrobial agents such as mupirocin ointment and silver sulfadiazine can decrease bacterial counts; however, use of such agents may result in selection of resistant organisms.46,55 In general, topically applied antibiotics do not penetrate deeply into the ulcer. Hypersensitivity, contact dermatitis, and systemic toxicity from drug absorption can occur with topical antibiotic use.46 Topical application of antibiotics or antiseptic solutions is not routinely recommended. If topically applied antibiotics are used, the duration of therapy should be limited to 7 to 10 days, to prevent the selection of resistant organisms.

Odor can be a major problem with pressure ulcers, as with many other wounds. Anaerobic organisms, which may colonize the wound, are thought to have a role. Several investigators have advocated the topical use of 0.75% metronidazole gel to help control this problem.46 Before this measure is initiated, serious underlying infection should be excluded. No evidence suggests that topical application of metronidazole will hasten the rate of wound healing.

**Treatment of Osteomyelitis.**—Numerous strategies are available for treatment of osteomyelitis. Although no consensus exists about the optimal approach, most investigators agree on a few principles—elimination of all devitalized and infected tissue, delivery of vascularized tissue to the wound, and antimicrobial therapy. This management usually translates into surgical débridement, a soft tissue flap, and antibiotics. Surgical reconstruction is often necessary to repair the defect that results from adequate excision. No established guidelines indicate the duration of antibiotic treatment or the recommended intervals for parenteral and oral administration of antibiotics. Many clinicians continue parenteral therapy for 1 to 2 months and then prescribe orally administered antibiotics for another period of months.46

**Other Treatment Modalities.**—In current experimental studies, topically applied platelet-derived growth factors and fibroblast growth factor have been used to promote healing of chronic pressure sores.57,58 Although these modalities hold promise for the future, they are still investigational and consequently not yet recommended for routine use.

Various other innovative techniques and products, each with strong advocates, are also available or being developed. For example, in a randomized, double-blind, multicenter study, electric stimulation has been shown to increase the rate of healing of pressure ulcers.59 Its role as an adjunct in ulcer treatment is not yet established.
Since 1965, hyperbaric oxygen has been touted as a useful adjunctive therapy for osteomyelitis. Although several favorable reports have been published, no controlled trials have been done. Because the equipment is expensive, routine use of this therapy is impractical.

Incontinence.—Management of incontinence may be critical to the healing of pressure ulcers. Fecal contamination of the wound can lead to infection. Urinary contamination can cause continued maceration. Whenever possible, incontinence should be evaluated, in an effort to enhance management. Immobile patients may be incontinent as a result of an inability to transfer to the toilet successfully. This situation may be compounded by physical restraints, confusion, medications (such as diuretics), and hyperosmolar tube feedings (which can result in urinary or fecal urgency). Fecal incontinence, when of recent onset, may be due to fecal impaction with leakage of liquid stool around it. A digital rectal examination may identify this condition. If the impaction is beyond reach of the examining finger, rectal findings may be normal. In this instance, a plain abdominal roentgenogram (flat plate) may be useful in assessing the stool burden. When fecal incontinence results from impaired cognition (dementia), management may be difficult. Institution of a program of regularly scheduled, prompted toileting and fiber supplementation to increase stool bulk and maintain a firm stool consistency can be attempted. A rectal tube is sometimes necessary; however, this option may lead to ulceration of tissue around the tube. Urinary incontinence can be managed with a program of scheduled voiding every 2 hours and scheduled intake of fluids. Intermittent catheterization or an indwelling urinary catheter may also be necessary in some patients. Condom catheters are another option for incontinent men.

Nutrition.—Adequate nutrition is important for normal wound healing. Experts do not agree on how much patients with pressure ulcers should be fed or whether vitamin supplementation is beneficial. The effects of several nutrients on pressure ulcer development and healing have been evaluated. Zinc is a micronutrient necessary for synthesis of protein; however, the published literature presents no convincing evidence that zinc deficiency is a risk factor for development of pressure ulcers or that zinc supplementation improves healing. Ascorbic acid is necessary for the hydroxylation of proline to hydroxyproline (the form of this amino acid that stabilizes collagen). Only limited data are available on the efficacy of ascorbic acid in the treatment of pressure ulcers, although some reported results have seemed promising.

In a recent study, malnourished nursing home patients were fed up to 40 kcal/kg of body weight per day. Those patients who were fed the most had the fastest rates of wound healing in this nonrandomized trial. Patients with ulcers that are highly exudative could conceivably lose a substantial amount of protein from their wound and require additional intake of protein. Excessive feeding of malnourished patients is associated with edema and electrolyte disturbances, a potentially fatal complication. Consequently, a conservative approach seems prudent. Patients should be weighed daily, to monitor for inadequate nutrition or accumulation of fluid. Intake of calories should be recorded for at least one 24-hour period. A diet composed of 25 to 30 kcal/kg of body weight, with 1 to 1.5 g of protein per kilogram of body weight, is adequate for most patients. In addition, a standard multivitamin supplement may theoretically be beneficial and is safe for use in virtually every patient.

Mobility.—Functionally independent patients should be encouraged to be out of bed as much as possible. Patients confined to bed should perform daily range-of-motion and stretching exercises to prevent contractures. Physical therapy early during the course of a treatment can potentially increase functional mobility in patients who have pressure ulcers or who are at high risk for ulcer development.

OUTCOME

Studies have shown a clear association between development of pressure ulcers and increased mortality. Although the presence of a pressure ulcer is associated with a twofold to fourfold risk of dying, this increased mortality is generally attributable to underlying illness and poor functional status rather than the ulcer itself.

Pressure ulcers can be large and deep, involve underlying structures, and require extensive surgical débridement. Most lesions, however, are more superficial and eventually heal with nonsurgical therapies. In nursing home residents with pressure ulcers who remain institutionalized, 80% of their pressure sores eventually show improvement. A study of patients in a long-term-care hospital indicated that 42% of stage II to IV ulcers were completely healed at 6 weeks; overall, 79% showed improvement with conventional therapy.

CONCLUSION

Pressure ulcers are a common problem among elderly or immobile patients. The occurrence of a pressure ulcer increases a patient's risk of dying and stigmatizes caregivers who are responsible for elderly or immobile patients. Identification of patients at high risk for development of ulcers can direct strategies for prevention to those most likely to benefit. Once ulcers occur, treatment of underlying medical conditions, relief of pressure, creation of an optimal wound healing environment, wound débridement, and management of complications are all key aspects of healing of the ulcer.
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