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Review Article

Medicine in the Elderly. Pressure Sores - Routine and Innovation

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Abstract

Though enforced by tradition, some of the rules applied to treatment of bed sores fall short of scientific foundation. In particular, studies regarding older people with multimorbidity are wanting, despite the significant impact of comorbidities and frailty on the benefits of treatment. Priorities of care in fit older patients and those who are severely frail may differ. In fit older patients, excision of the bed sore and resurfacing the skin with pediculated flaps might be indicated. At a difference, severely frail older patients may benefit from a lenient approach to treatment. In an effort to improve management of bed sores new equipment's have been introduced and new agents were developed. The added benefit of novel topical agents, advanced dressings, nutritional supplements and topically delivered oxygen needs to be established. Few reports in the literature, if any, are controlled studies of novel methods for treatment of bed sores. Yet, an understanding by the clinician of the changing scenario is warranted. To this aim we provide an update from the point of view of the clinician and meant to support clinicians at the bedside on management of bed sores.

Keywords: Pressures Sores; Elderly; Frailty; Dressings; Topical Oxygen

Introduction

Changing demographics has resulted in the elderly constituting a more significant proportion of the population in Western countries. Many older people will develop functional impairment, disability and bed sores. Bed sores are areas of ischemic tissue necrosis caused by unrelieved pressure, shearing forces, friction and humidity at any part of the body, especially where soft tissues are compressed for prolonged periods between a bony prominence and any external surface. Measurements of tissue viability demonstrated that decubitus provokes high interstitial pressures which deform and collapse the capillaries [1]. When persisting, high tissue pressure may cause ischemia, hypoxia and finally necrosis, i.e. bed sores. Development of bed sores is favored by immobility, altered sensation, altered response to pain, impaired mental status, incontinence and malnutrition. Neurologically impaired patients often lack the sensory signal, normally arising from the buttock area, which elicits a change of the bodily position and prevents tissue injury. Sites exposed to high pressure in the supine position are the occiput, sacrum, and heels; in the sitting position the areas next to the ischial tuberosities; in the side lying position the soft tissues covering the trochanters. Elderly patients with femoral fractures are particularly vulnerable to bed sores. Long-stay nursing home residents with moderate or severe obesity are at higher odd of develop bed sores. During an acute severe illness, bed sores may form in as little as four hours [2]. Pressure sores may also develop at the site of protracted contact with a medical device, i.e. device-associated pressure injury.

Since 2002, the Association for the Advancement of Wound Care Guideline Task Force has used a systematic approach in developing the 'guidelines of guidelines' for the management of bed sores [3]. Nevertheless, pathways for bed sores management are often short of scientific foundation. Furthermore, guidelines seldom cope with the complex situations met in frail older patients and with the impact of comorbidities on the benefits of treatment [4-6]. In an effort to improve bed sores management, new equipment has been introduced and new agents were developed. Though promising, the added benefit of new topical agents, advanced dressings, nutritional supplements, topically delivered oxygen, etc. needs to be scrutinized and studied under real life conditions. An understanding by the clinician of the changing scenario is warranted. In this update we intend to focus on what is useful to be known by the clinician, not to expose the compendium of what is known.

Material and Methodology

We perused the 2013-2018 Pubmed and Embase literature for bed sore management. In the hierarchy of evidence most studies belonged to inferior categories such as case-control studies, case series and expert opinion. Were available, systematic reviews of

randomized controlled trials and individual randomized controlled trials were given priority. We omitted data from small human studies as well as *in vitro* and animal experiments.

Bed sores classification and diagnosis

In April 2016, the National Pressure Ulcer Advisory Panel redefined pressure-induced skin and soft tissue lesions: the term 'pressure injury' replaced the terms 'pressure ulcer', 'decubitus ulcer' and 'bed sores' [7]. In keeping with tradition, we used in this review the familial label 'bed sore'.

Staging

The following categories are recognized:

- Stage I bed sores are characterized by an area of intact skin with nonblanchable erythema, usually over a bony prominence. The area may be painful, firm, soft, warmer or cooler as compared with the adjacent tissue. A stage I bed sore may be difficult to detect in persons with dark skin, yet the color differs usually from the surrounding area. Notably, a purple or maroon discoloration of the skin does not suggest stage I bed sores but may imply deep tissue injury.

- Stage II bed sores are characterized by partial-thickness loss of the dermis, presenting as shallow open ulcers with a red wound-bed without slough. Stage II bed sores may also appear as intact or ruptured blisters filled with serum. Granulation tissue, slough and eschar are not present.

- Stage III bed sores are characterized by full-thickness skin loss exposing the subcutaneous adipose tissue; neither bone, tendon nor muscle are bare. Slough may be present but does not obscure the depth of tissue loss. The ulcer may comprise undermining and tunneling. The depth of a stage III bed sores may vary with the anatomical location. It is shallow at the bridge of the nose, ear, occiput and malleolus, areas which have no subcutaneous adipose tissue. In contrast, in areas of significant adiposity, deep stage III bed sores can be present.

- Stage IV bed sores are characterized by full-thickness subcutaneous tissue loss with exposed bone, tendon or muscle that is visible or directly palpable. Slough or eschar may be present on some parts of the wound bed. There is often undermining and tunneling. The depth of a stage IV bed sores varies by anatomical location. Involvement of the periost, bone or joint capsule make osteomyelitis possible.

- Unstageable are bed sores covered by slough (yellow, tan, gray, green or brown) or eschar (tan, brown or black). Staging of the sore becomes possible after removal of the slough or eschar.

- Deep tissue injury under intact skin may be difficult to detect. It might appear as a purple or maroon area of intact skin or as a blood-filled blister. The necrosis may progress quickly even with optimal treatment, exposing superficial layers of tissue and lead to ulceration. The term deep tissue injury should not be used to describe vascular, traumatic, neuropathic, diabetic or dermatologic conditions.

- Medical device–related sores may be provoked by enteral feeding tubes, nasal oxygen prongs, urinary catheters (Figure 2), tracheal cannulae, cast splints, continuous positive airway pressure/bilevel positive airway pressure mask, etc. and should be classified using the staging system used for bed sores.

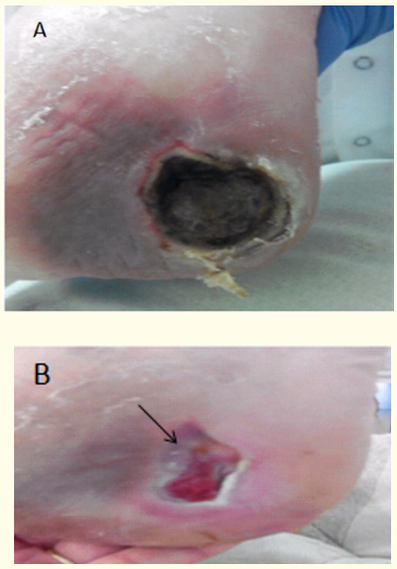

Figure 1: Stages in the evolution of the bed sore on the patient's heal. A. the 26th November 2016 the bed sore is unstageable, covered by escar; the maron color of the surrounding skin suggest deep tissue injury. B. the 6th January 2017 the bed sore has much improved, the size contracted to less than 50% of the previous, red granulation tissue is apparent on the ulcer's bottom and shallow new epithelium appears on the rim – now the lesion classified as stage III bed sore.

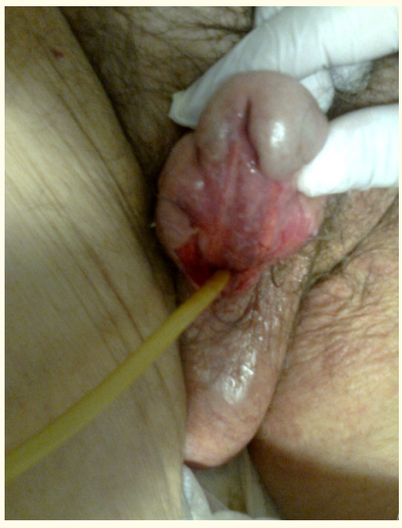

Figure 2: Device-related bed sore. Pressure from an inadvertently secured catheter caused full thickness dissection of the urethra and cleaved the penile shaft.

The practice of changing the stage of the sore as it heals (reverse staging) is not recommended. Mucosal membrane pressure injury is found on mucous membranes of patients with a medical device in present or recent use at the site of contact with the device. These ulcers cannot be staged.

Diagnosis

A bed sore is recognized in revealing the direct contact between the injured area of the skin and soft tissues with a bony prominence or device. Typical locations are the presacral area, heels, ischial tuberosities and the occiput. In unusual locations, called 'atypical bed scores', the sores may develop at the medial aspects of the knees, elbows and palms in the context of severe spasticity, and over shoulder blades and upper spine related to bony deformities. On inspection bed sores are easily distinguished from venous, ischemic and traumatic skin ulcers. Ulcers localized to the calf are usually not bed sores, but may be vasculitic, metabolic, toxic, infectious or drug-induced (Figure 3). Their appearance differs from bed sores and proper management must be adapted to the etiology [8]. Moisture-associated skin damage, skin tears, abrasions, incontinence-associated dermatitis and intertriginous dermatitis are not bed sores [7].

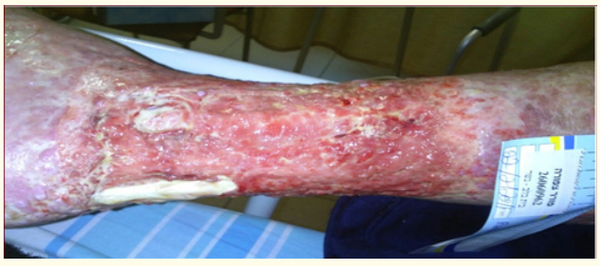

Figure 3: Extensive circumferential calf ulcer caused by longstanding hydroxyurea treatment for polycythemia vera.

Risk factors, prevention, course, time to healing

Most bed sores develop during acute hospitalizations, usually within the first 2 weeks, in spite of adoption of bed sore prevention guidelines. Bed sores may occur at a person's home or in health-care settings, including hostels and nursing homes. Among nursing homes, the incidence of bed sores is highest in institutions with lower staffing levels of nurses, showing that health-care resources are more important in prevention of bed sores than medical advice [9].

Point prevalence

A retrospective cohort study included 95 long-term care facilities participating in the National Pressure Ulcer Long-Term Care Study throughout the United States. On study entry there were 1524 residents who did not have a bed sores but were at risk of developing bed sores, as defined by a Braden Scale of 17 or less. Data were collected for each resident over a 12-week period during which 29% of residents developed new bed sores. Characteristics associated with a greater likelihood of developing bed sores were a higher initial severity of illness, history of recent bed sores, significant weight loss, eating problems, use of catheters, and use of positioning devices [10]. Another study aimed to evaluate the change in bed sore prevalence in long-term nursing home residents after the implementation of the Omnibus Budget Reconciliation Act of 1987 (OBRA '87). Included were 4679 residents who had resided in the facility for at least 100 days: 2336 during 1992-1994 and 2343 during 1997-1998. No change in bed sores prevalence was demonstrated since implementation of OBRA '87 in this nationally derived sample [11].

Patients at risk

For exposing a person's risk to develop bed sores the Braden, Waterlow and Norton scales are in common use. These are based on a combination of individual risk factors such as the person's physical and mental condition, mobility, state of hydration, continence and nutrition. However, risk assessment scales are weak predictors of the hazard to develop bed sores. The Braden Scale [12], the most widely used for bed sores risk assessment, is based on six criteria: sensory perception (a patient's ability to detect and respond to discomfort or pain), excessive and continuous skin moisture, patient's level of physical activity, mobility (the physical competency to move and willingness to move), nutritional status, friction and shear. Each category is rated on a scale of 1 to 4, except the 'friction and shear' category which is rated on a 1-3 scale. A higher score means a lower risk of developing bed sores. Very high risk totals scores of 9 or less, high risk: score 10-12, moderate risk: score 13-14, mild risk: score 15-18, no risk: score 19-23.

Multicomponent preventive intervention to avoid development of bed sores is supported by moderate-quality evidence from a systematic review of 26 studies [13]. The interventions included clinical assessment, use of a specialized support surface, repositioning, mobilization, avoiding friction and moisture, and adequate nutrition. Other features of the program were an on-site clinician to lead the program, a multidisciplinary team, audit and feedback, ongoing education, and standardization. Preventing bed sores was challenging even when facilities implement prevention programs. The 2010 consensus from the National Pressure Ulcer Advisory Panel stated that not all bed sores are avoidable, because in certain patient situations pressure cannot be relieved and perfusion cannot be improved [14].

The chance of healing bed sores depends on the lesion's characteristics, but also, greatly, on the patient's general health and comorbidities. In the acute hospital setting, the following variables were associated with poor outcomes of bed sores: severity of the patients' general condition, peripheral arterial disease, smoking, serum albumin <2.5 g/dL, antidepressant use, history of surgery, the bed sore's size, malnutrition, low Braden scale score [15]. Outcomes of bed sores treated in the community was appraised in a retrospective cohort study in the UK which comprised 209 patients: the mean time to healing for bed sores stage I was one month, 8 months for stages III and IV bed sores, and 10 months for unstageable bed sores [16]. Healing of bed sores is affected by wound colonization, wound infection and bed sore-related osteomyelitis.

Colonization and infection

Colonization of bed sores is the rule, with flora derived from the skin, the urogenital tract and gastrointestinal tract, revealing multiple organisms. Swab cultures taken from bed sores reflect surface colonization rather than infection and are not clinically useful. Guidelines recommend against using swab cultures to define the microbiology of bed sores. Only for infection control a swab culture may be useful in recognizing colonization with MRSA or other resistant bacteria. 'Critical colonization' is recognized by delay of wound improvement after 14 days of optimal treatment, though overt signs and symptoms of infection are not necessarily present. At this point antibiotic treatment becomes optional [9].

Biofilms develop within chronic wounds and delay healing. A biofilm is an aggregate of microbes which produce a protective carbohydrate matrix that allows bacteria to adhere to each other and to the wound surface. The matrix protects the bacteria from environmental factors that could lead to their eradication. Biofilms are polymicrobial. A lack of response to treatment of a bed sore with antimicrobial agents may be due to the biofilm's ability to resist antimicrobials. After debridement of necrotic tissues, application to the wound of a dedicated antibiofilm agent has been shown to promote wound healing [17].

Bed sores infection, not colonization, signifies complication. Worsening wound pain may be a valuable indication of wound infection. Edema, odor, and purulent discharge may be expressions of infection but are nonspecific findings. Erythema at wound edges and local warmth are signs of advancing cellulitis, i.e. infection. Valuable signs of infection are a lack of the wound improving for two weeks, presence of friable granulation tissue, new necrotic tissue, and lack of uniform spread of granulation tissue across the base of the wound. Fever or delirium may be associated with local signs of bed sore infection or be the only signs of bed sore infection. Hence, the diagnosis of infected bed sores is based on a combination of systemic symptoms, the look of the wound, appearance of the wound's environment, laboratory markers of inflammation, and results of cultures of targeted biopsies. Tissue or bone biopsy have long been considered the preferred methods to identify bed sore infection or osteomyelitis, but taking a biopsy is often unpractical in the clinical setting [18].

Other complications of bed sores are osteomyelitis, bacteremia with or without septic metastases, pyarthroses, joint disarticulation, extension of necrosis and infection to deep organs, heterotopic calcification, tetanus, and amyloidosis. Positioning the patient on the healthy side in seeking pressure relief over the ulcer may lead to the development other bed sores in a different location. Prolonged bed rest due to bed sores will decondition the patient. Increased pain may occur with dressing changes and surgical debridement. Bed sores are associated with a decreased quality of life. The one-year mortality rate in patients with bed sores approaches 40%. Bed sores in elderly persons with chronic diseases are an indicator of decreased survival time [3].

Principles of management bed sores

A few rules for are in general use [9].

Principles of bed sores care (Box 1)

- Clean gloves should be used for each patient.
- When multiple bed sores are present, the most contaminat ed should be attended last.
- Clean dressings are safe and should be used rather than sterile ones.
- Necrotic tissue should be removed, except dry escars on the heel that are adherent and without erythema or fluctuence.
- Yellow coatings adherent to the sore's bottom are stands of fibrin; calcium alginate or hidrofiber dressings are preferred.
- Yellow, tan or green slough consists of necrotic tissue and should be removed.
- A red and clean wound bottom means granulation tissue.
- The pink tissue covering the wound boundaries means re-epithelization.
- A moist environment promotes would healing - the dress ing should provide an adequate amount of moisture.
- Dressings impregnated with an antiseptic delay healing and should be avoided, except for short periods of time.

Basic principles of wound care comprise: 1. control of the etiology ('the patient around the wound') - emphasis is given to control glycemia, hypoxia, edema, renal failure; 2. addressing inhibitory factors of healing, such as necrotic tissue in the wound, wound infection, nutritional deficits, edema, venous and lymphatic stasis,

incontinence, certain medications (glucocorticoids, hydroxyurea), systemic disease, hypercatabolic states; 3. keeping a moist environment in the wound necessary for healing. Healing of bed sores follows the sequence of inflammation, granulation, wound contraction, re-epithelization, remodeling and scar formation.

Offloading and repositioning

A positive correlation exists between the duration of exposure to high tissue pressure and occurrence of bed sores. Patients at risk to develop bed sores should be traced; efforts should concentrate on primary prevention. Patients having one bed sore are at increased risk to develop more bed sores. Hence, emphasis should also be given to secondary prevention [6].

Measures aimed at primary and secondary prevention of bed sores (Box 2)

- Identifying patients at risk by using bed sore-risk assessment scales (e.g. Norton).
- Screening for malnutrition and monitoring dietary intake.
- Minimizing prolonged skin exposure to pressure, moisture, urine and stool.
- Cleansing the intact skin with warm water and a mild cleansing agent to minimize irritation and dryness.
- Avoidance of massaging over bone prominences.
- Use of protective padding to reduce friction and shear.
- A person in bed who is at risk should be repositioned at least every 2 hours; a written schedule should be used for systematically turning and repositioning the person.
- Mattresses and wheelchairs should be adequate for the patient's condition (consult a seating trainer or occupational therapist).
- Advanced static support surfaces (foam, gel or air mattresses and overlays) should be used in high-risk patients rather than standardized hospital mattresses.
- Checking the pressure-relieving device for 'bottoming out': the examiner's hand should slide freely when inserted with the palm up between the device and the bed under the patient's sacral area. The device is ineffective if unable to move the hand freely.
- Using pillows and foam wedges to maintain the patient's position and to keep bony prominences apart.
- Applying dressings over bony prominences to reduce the risk of injury.
- Completely immobile patients should have their heels raised from the bed by a pillow or boot and should not lie on their trochanters.
- When lying on the side, a 30° position from the horizontal should be maintained.
- The head of the bed should not be raised more than 30° from the horizontal for an extended period.
- Where possible, using lifting devices or draw sheets is recommended to reposition the patient or for transfer. For patients who are up in a chair, repositioning should be done every hour.
- While sitting on chairs or wheelchairs, the patients should be taught to shift weight every 15 minutes.
- The use of doughnuts as seating cushions is contraindicated because they increase pressure over the area of contact.

The points of highest pressure with the patient supine are at the sacrum, buttocks, heels, and occiput, all of which are subject to pressures of roughly 50-60 mmHg. When sitting, pressures up to 100 mmHg are recorded over the ischial tuberosities. Even on padded surfaces with wide load distribution, all major weight-bearing areas sustain pressures in excess of capillary pressures. The pressure on the skin over a bone is more injurious than pressure on the skin over muscles.

High levels of shear occur in the semi-Fowler's position or sliding down in a wheelchair over the lower back and buttocks. Wheelchair-bound patients may develop sacral sores if they are not sitting upright in their chair, despite the fact that theoretically the ischial tuberosities should be bearing the majority of their weight. Dragging the patient in bed or allowing patients to elevate themselves in bed by pushing with the elbows and heels cause significant shear.

Repositioning the patient to prevent bed sores is recommended in expert consensus. Yet, three randomized controlled trials found no evidence that regular manual repositioning prevented appearance of bed sores. A recent multicenter trial demonstrated no difference in pressure ulcer formation in high-risk nursing home patients turned at 2, 3, and 4-hour intervals when on a high-density foam mattress [6]. But a lack of robust proof does not mean that repositioning is ineffective, since all comparisons were underpowered.

Low-air-loss support surfaces have the ability to distribute a patient's body weight evenly, thereby minimizing pressure and tissue deformation over bony prominences. Yet, most specialty mattresses do not decrease the tissue pressure below the capillary closing pressure of 32 mm Hg; therefore, patients continue to require repositioning (every 2 hours as agreed by experts) to allow for tissue recovery. A number of reviews revealed no differences in rate of healing bed sores with use of alternating-pressure mat-

tresses or low-air-loss beds compared with standard care, while two randomized controlled trials found that use of air-fluidized beds contributed to the healing of a greater number of ulcers after 15 days compared with standard care. Several short-duration trials in hospital settings, but not in longer-duration trials of air-fluidized mattresses reported improved rates of closure of bed sores. The majority of studies had significant methodological limitations. It is recommended that the choice of a particular device should be based on patient comfort, ease of use, durability and cost [19].

Skin protection cushions are designed to reduce pressures near bony prominences. Sheepskin overlays were shown to reduce the incidence of bed sores in elderly patients recuperating from hip fracture.

Wheelchair cushions of various thicknesses are in use. In the sitting patient, the highest tissue pressure is found within 2 cm of the ischial tuberosity; it may be reduced with an 8 cm thick cushion. No data exist to recommend one type of cushion over another. Poorly fitting wheelchairs are likely to result in poor posture that will result in higher pressure on the sitting surface and an increased risk of acquiring skin ulcers. Providing a cushion that effectively protects the skin requires a properly designed wheelchair and a properly fitted sitting cushion. Such products are not routinely available to elderly wheelchair users in nursing homes [20]. Consulting a sitting trainer or occupational therapist might be indicated.

Nutrition

Nutritional deprivation and insufficient dietary intake are among the key risk factors for the development of bed sores and impaired wound healing. Critically ill patients commonly have anorexia and may be unable to feed by mouth. Unless such patients are provided with macronutrients in the form of enteral or parenteral nutrition, they accumulate an energy deficit that rapidly leads to lean-tissue wasting and bed sores [21]. High-protein oral nutritional supplements are effective in reducing the incidence of bed sores in patients at risk. From a surgical standpoint, optimizing nutritional status to achieve a plasma albumin level of at least 3.5 g/dL will minimize chances of flap failure. Hence, malnutrition should be corrected and nutritional markers, such as albumin and prealbumin, be followed. The American College of Physicians now recommends protein or amino acid supplementation in patients with bed sores [5,9]. It is usually recommended that patients with stage III and IV bed sores receive at least 30 kcal/kg/day to promote healing. Increased dietary protein intake also fosters healing of bed sores. The high protein diet promotes fibroblast proliferation, collagen synthesis, angiogenesis, and improves immune function. The protein target typically is 1.5 g/kg/day. In one study, patients receiving 1.8 g/kg/day protein demonstrated nearly a two-fold greater rate of healing than those randomized to receiving 1.2 g/kg/day.

Specific amino acids such as arginine, glutamine, and β-hydroxy β-methylbutyrate can be added to oral/enteral foods to accelerate healing [22]. Abound®, a nutritional supplement containing arginine, glutamine and beta-hydroxy beta-methylbutiric acid (HMB), has been claimed to improve wound healing: the recommended dose is arginine 3-4.5g/day. However, evidence remained inadequate in supporting the role of these agents to prevent or heal of bed sores [23]. The efficacy of vitamin C supplementation up to 200 mg/day and zinc supplementation to promote healing of bed sores has not been conclusively demonstrated.

A meta-analysis of randomized controlled trials concluded that nutritional support to prevent bed sores in high-risk hospitalized patients is cost-effective and cost saving [24]. Contrasting with this data, a 2014 Cochrane review found no clear evidence that dietary supplementation reduces the number of people who develop bed sores or help the healing of existing bed sores [5]. Surprisingly tube feedings increased the incidence of bed sores and was associated with poorer healing. This was explained by the authors by tube feeding being associated with agitation, increased use of physical and chemical restraints and worsening dementia [5].

In our practice we conform to the principle of high calorie and high-protein nutrition.

Debridement

Necrotic tissue delays wound healing and should be debrided quickly. This begins with cleansing the bed sore with saline or tap water. There is insufficient evidence to advise using one cleansing solution or technique over another [9].

Debridement of necrotic tissue (Box 3)

- Surgical debridement is indicated for infected ulcers with necrotic debris and eschars.
- Biosurgery by application of maggots is a quick and effective option for patients who cannot tolerate surgical debridement.
- Autolytic debridement using a synthetic dressing allows the devitalized tissue to self-digest from the enzymes in the ulcer fluids.
- Ulcers can be debrided with saline wet-to-dry gauze changed every 4-6 hours.

- Enzymatic debridement makes use of an enzyme to dissolve the necrotic tissue; this may be recommended when there are no signs of local infection.

Serial surgical debridement can be performed at the bedside, but major surgical debridement is performed in the operating room [9,25]. When a vulnerable older adult presents with a bed sore stage III or IV that is covered with necrotic debries or eschar then debridement should be instituted within 24 hours. An eschar on the heel should be excised only if fluctuant, draining, or surrounded by cellulitis, and if the patient is septic. Surgical debridement is the most significant method in the prevention and control of biofilm [26].

Sterile instruments should be used to debride bed sores. The use of systemic antimicrobials should be considered to prevent bacteremia during significant debridement. EMLA cream (eutectic mixture of lidocaine 2.5% and prilocaine 2.5%) reduces debridement pain. Low-dose topical morphine (diamorphine) has been used in small, randomized, placebo-controlled studies to successfully control bed sore related pain. A bone biopsy is recommended while debriding skin ulcers when bone is exposed. Tissue biopsy for culture is recommended, with parsimony, for nonhealing deep bed sores. When tissue biopsies are obtained for suspected bed sore infection the specimen should be rapidly transported to the laboratory in the appropriate anaerobic container to perform aerobic and anaerobic cultures. Information should be provided to the bacteriologist: the site where the biopsy is collected from, whether this is a surface or deep wound [9].

Biosurgery (maggot therapy) is effective in debridement of slough, densely adherent fibrinous exudates, purulent exudates, but also dry escars [27]. Comparative controlled studies evaluating the use of biosurgery for bed sores have shown a higher proportion of complete debridement by biosurgery vs. autolytic debridement, 80% vs. 48%, respectively [27]. Biosurgery is contraindicated for pyoderma gangrenosum as well as in patients receiving immunosuppressive therapy. Caution is advised in treating wounds near to large arteries and veins. Wounds heavily contaminated with pseudomonas aeruginosa may have limited benefit from biosurgery. Very dry wounds may be a relative contraindication because maggots require a moist environment.

Autolytic debridement using a synthetic dressing allows the devitalized tissue to self-digest from the enzymes found in the ulcer fluids. This method is recommended for patients who cannot tolerate surgical or biosurgical debridement, but it may take a long time to be effective. Autolytic debridement is commonly used in the palliative care setting [9].

Treatment of hypergranulation (overgranulation): Hypergranulation is defined as an excess of granulation tissue that fills the wound bed to a greater extent than required and goes beyond the height of the wound surface. Granulation tissue is red, shiny and friable. Hypergranulation prevents the migration of epithelial cells across the wound surface and impedes wound healing. Treatment of hypergranulation makes use either of topical corticosteroids, chemical cautery (with silver nitrate or hypertonic saline), laser ablation or surgical excision. These treatments are not uniformly successful [28].

Dressings

A moist environment permits wounds to re-epithelialize up to 40% faster than wounds left open to air. Hence, dressing that promote a moist wound environment should be used. The choice of a particular dressing depends on the wound characteristics, such as amount of exudate, presence of dead space, or wound infection [9,29,30].

Dressings often recommended (Box 4)

- A transparent film to cover shallow bed sores with minimal exudate or for closed sores.
- Hydrocolloid dressing for clean stage II or for shallow noninfected stage III bed sores.
- Hydrogel dressing for stage III or IV bed sores with minimal or no exudates, for granulating noninfected ulcers, for dry ulcer beds.
- Alginate for stage III and IV bed sores with moderate to heavy exudates, for ulcers with cavities.
- To obliterate dead space, deep ulcers should be filled loosely with a hydrocolloid or a hydrogel wound filler or an alginate rope before applying a synthetic dressing. This same material is inserted under the edge of the ulcer when undermining is present.
- Foams are indicated for stage II and shallow stage III bed sores with exudates.
- Silver impregnated dressings are indicated for treatment of clinically infected or heavily colonized bed sores; prolonged use should be avoided.
- Bleeding after surgical debridement can often be controlled with an alginate dressing (calcium alginate assists in the clotting pathway).
- Maceration of the adjacent skin can be avoided by using protective creams.

A review of 51 studies analyzed the effectiveness of 13 dressings, 6 topical agents and 2 supplementary interventions on the healing of bed sores. Most studies were small, with high risk of bias. As a whole, it was not clear whether any of the examined treatments was more effective than saline gauze [30]. Also, in concerning venous ulcers, an analysis of 59 studies (5156 participants, 25 different interventions) concluded that more research is needed to determine whether particular dressings or topical agents improve the probability of healing [55]. At a difference, a systematic review and network meta-analysis of 40 studies, 1757 participants, comparing 5 dressing groups found that all dressings groups ranked better than saline gauze dressing [31]. Although most synthetic dressings relieve pain, treatment for moderate to severe pain can benefit from topical lidocaine and nonsteroidal anti-inflammatory drugs.

Topical agents

For promoting wound healing, topical application of medicinal honey, flaminal and anti-biofilm solutions are popular in Western countries. Most studies addressed ischemic and venous ulcers.

Medicinal honey's effect on healing various wounds has been reviewed, based on randomized and quasi-randomized trials comprising 2987 patients. Honey dressings did not increase significantly the rates of healing venous leg ulcers when used as an adjuvant to compression. Honey delayed the healing of partial- and full-thickness burns in comparison to early excision and grafting. There was insufficient evidence to guide clinical practice in other types of wounds, including bed sores. The authors recommended that purchasers should refrain from providing honey dressings for routine use until sufficient evidence of effect is available [32]. One trial including 40 patients reported that bed sores healed more quickly with topical honey than with saline soaks, but the study was of very low quality [33].

Flaminal® (Flen Pharma, Kontich, Belgium) was introduced onto the market in 1995. Flaminal® consists of hydrated alginates polymers in a polyethylene glycol matrix embedded with a biologic enzyme system. The enzyme system forms free radicals that destroy bacterial cell walls. The wound exudates and lysed material is absorbed by the alginates. This results in continuous debridement without damaging skin cells. Two studies have indicated faster healing of partial thickness burn wounds treated with Flaminal® Forte versus comparator, but these results should be interpreted with caution due to the retrospective study design [34]. The literature is scarce in studies using Flaminal for treatment of bed sores.

Anti-biofilm agents are meant to disrupt the biofilm covering wounds and to foster healing. Anti-biofilm agents were studied *in vitro* on plates inoculated with bacterial suspensions of *Pseudomonas aeruginosa* and plates inoculated with *Staphylococcus aureous* [35]. A combination of antiseptics and proteases was tested. Antiseptics were those already utilized in clinics for wound cleaning: ProntosanR (B. Braun, Melsungen, Germany) containing 0.1% polyhexamethylene biguanide and 0.1% betaine; OctenilinR containing 0.05% octenidine dihydrochloride; BetadineR (Meda Pharma, Solna, Sweden) containing 10% povidone iodine; and chlorhexidine. The enzymes were three serine proteases [subtilisin A (Sigma, S Louis, MO), EsperaseR (Sigma) and SavinaseR (Sigma)] and an α-amylase (10065; Sigma). After 24 hours of biofilm growth the plates were exposed to the anti-biofilm agents for 24 hours. Viable biofilm bacteria were then quantified. In all experiments the load of viable bacteria decreased significantly. *In vivo,* a single-blinded randomized controlled trial assessed the efficacy of a propylbetaine-polihexanide antibiofilm solution versus normal saline in the treatment of bed sores or vascular leg ulcers in 289 patients over 28 days. There were statistically significant differences in the outcomes: BWAT (Bates-Jensen wound assessment tool), $p = 0.0248$; BWAT score for inflammatory items, $p=0.03$; BWAT scores for wound size reduction ($p = 0.049$) and granulation tissue improvement ($p = 0.043$), all in favor of propylbetaine - polihexanide. However, the observation period was too short to establish an actual rate of healing. The authors concluded that it would be useful to confirm these results during a longer observation period with comparators of different debridement methods [36].

Other topical treatments

The effectiveness of clostridial collagenase ointment for bed sore treatment was studied in 446 patients in comparison with 341 patients treated with topical honey. The majority of bed sores were stage III. The mean time to 100% granulation was 255 days for clostridial collagenase-treated sores vs. medicinal honey 282 days [37]. The efficacy of platelet-derived growth factors, fibroblast growth factor, granulocyte-macrophage colony stimulating factor, ultrasound, ultraviolet light, electromagnetic therapy, and low-energy radiation in promoting complete healing of chronic bed sores has not been established. However, claims of efficiency continue to be reported [9].

Infected bed sores

Diagnosis of bed sore infection is based on a combination of clinical symptoms (see above). Tissue or bone biopsy are the preferred methods to identify bed sore infection or osteomyelitis, but this might not be practical in the clinical setting [9,29].

Management infected bed sores (Box 5)

- Suggestive of bed sore infection are any of the following: worsening pain, erythema at wound edges, friable granulation tissue, lack of uniform spread of granulation tissue, darkening of granulation tissue, new necrotic tissue.
- Fever or delirium may be the accompanying sign or only sign of BED SORES infection.
- Consider osteomyelitis when bone is exposed
- Wound edema, odor and purulent discharge are nonspecific findings.
- A clean skin ulcer failing to show signs of healing and revealing signs of inflammation should be treated with topical antiseptics.
- Systemic rather than topical antibiotics should be used to treat an infected bed sores.

Topical antiseptic treatment is recommended in bed sores exhibiting any of the following (mnemotechnique NERDS): nonhealing, exudate increase, red friable or easily bleeding granulation tissue, new slough or debris on the wound surface, and smell [38]. Antiseptics are microbicidal to most bacteria and have a broader spectrum of antimicrobial activity than antibiotics. In comparison to most antibiotics, antiseptics reduce the likelihood of emerging resistance and should be preferred to use of topical antibiotics in the appropriate setting. A time-limited course of diluted antiseptics may be tried to control the bacterial burden, e.g. 5% mafenide acetate (Sulfamylon), 10% povidone with 1% free iodine (Betadine), 0.25% sodium hypochlorite ('half strength' Dakin solution), 3% hydrogen peroxide or 0.25% acetic acid. Topical silver sulfadiazine can also be considered. However, topical antiseptic wound treatment should be limited to 10-14 days because antiseptics are cytotoxic and delay granulation and healing [38,39]. The vast experience with antiseptic solutions in treating surgical wounds, burn wounds, diabetic foot ulcers has not been replicated by similar large studies in patients with bed sores. A Cochrane review, which included 12 studies of topical antibiotics and antiseptics for treatment of bed sores, found nil effect or unfavorable influence on wound healing. The trials were small, clinically heterogenous, generally of short duration, and at high or unclear risk of bias [40]. The quality of the evidence ranges from moderate to very low.

Systemic antibiotic treatment, if possible guided by results of tissue cultures, is indicated for patients with infected bed sores, bed sore-related bacteremia, sepsis, or osteomyelitis [9,29]. In suggesting bed sore infection the STONEES mnemotechnique [38] may be of use: size increase (for S), temperature of surrounding skin (T), os probing or exposed bone (O), new satellite areas of breakdown (N), erythema or edema (E), exudate increase (E), and smell (S). There is little data in the literature regarding the outcome of infected bed sores on antibiotic treatment. In a single-center review of spinal injured adults hospitalized for an infected bed sore or implant-free osteomyelitis the median duration of antibiotic therapy was 6 weeks; clinical recurrence was noted in 63% after a median interval of 1 year. In 86% of these recurrences, the cultures yielded a different organism than the preceding episode suggesting that recurrences were caused by reinfections. Patients with antibiotic treatment less than 6 weeks had the same failure rate as those treated longer than 12 weeks [41]. Topical metronidazole gel may eliminate the odor of an infected ulcer.

Bed sore-related osteomyelitis

The presence of osteomyelitis beneath a nonhealing deep bed sore is poorly predicted on bedside examination. Clinicians might be attempted to consider the diagnosis by analogy to the scheme used in diagnosing osteomyelitis in diabetic patients with a lower extremity ulcer. In the latter, presence of osteomyelitis is assumed based on the triad: ulcer area >2 cm^2, a positive probe-to-bone test, and an ESR greater than 70 mm/hour. Most clinicians believe that the presence of these 3 variables together would make the diagnosis of osteomyelitis certain and would treat as osteomyelitis. Nuclear scans are sensitive but not specific for diagnosing osteomyelitis beneath bed sores. Magnetic resonance imaging is successfully used to identify osteomyelitis as the cause of nonhealing bed sores but should be used judiciously [9,42]. The definitive diagnosis of osteomyelitis beneath a bed sore requires histopathological examination of bone tissue. Percutaneous bone biopsy may fail to sample the infected foci while bone infection is documented securely by intraoperative bone biopsy.

Patients who have osteomyelitis beneath bed sores are usually treated with antibiotics [9]. A retrospective cohort study comprised 220 subjects bed with sore-related pelvic osteomyelitis. Wound cultures were positive for methicillin-resistant Staphylococcus aureus (33%), Streptococci (17%), and Pseudomonas spp (18%). Most of these patients were scheduled to receive ≥6 weeks of antibiotic treatment. Fifty-five (25%) patients underwent surgery during the index admission. One third of patients had two or more readmissions because of recurrence during the subsequent year [42].

Systemic broad-spectrum antibiotics should be given immediately after debridement. Empiric antibiotic therapy is selected based on the severity of infection and the likelihood of involvement

by resistant organisms. On the basis of the available studies no single drug or combination appears to be superior to others. Initial treatment should cover for methicillin-resistant and methicillin-sensitive staphylococcus aureus until cultures are completed with susceptibilities testing. Subsequent antibiotic therapy should be tailored to culture results of bone biopsy. The duration of antibiotic therapy of osteomyelitis depends on the extent of residual affected tissue after surgery. Six weeks is an appropriate course if there is residual infected bone following debridement [9]. After infection is under control, the physician may switch the patient to an oral antibiotic for 3 to 12 months (e.g. a fluoroquinolone with or without rifampicin). Following amputation of a limb segment affected by osteomyelitis one week of antibiotic treatment is usually adequate. If necrotic bone remains, clinical cure may require several months of antibiotic therapy. The erythrocyte sedimentation rate and C-reactive protein may be useful for monitoring the response to therapy [9,42].

Negative pressure wound treatment (NPWT)

NPWT has proved to be effective in the management of diabetic foot ulcers, open fractures, mediastinal wounds and skin grafts [43]. In treatment of bed sores, however, three randomized controlled trials did not report significant benefit for wound closure or wound size diminution by 50%. A Cochrane review concluded that uncertainty remains about the potential benefits or harmful effects in using NPTW for management of bed sores [44]. It is recommended that NPWT should not be used in the presence of infected ulcers, osteomyelitis, necrotic ulcers with eschar, if there is a fistula within the ulcer cavity, or if the ulcer is bleeding more than minimally. Patients with extremity wounds and inadequate peripheral pulses should undergo noninvasive vascular testing to confirm adequate perfusion prior to instituting NPWT. This particularly applies to diabetic patients. NPWT should be used cautiously when the patient is on anticoagulants, when there is problematic wound hemostasis, or when placing the dressing along blood vessels.

Oxygen treatment

Oxygen is a key requirement for wound healing. Hyperbaric oxygen therapy (HBOT) has been used for diabetic foot ulcers, compromised flaps and large wounds. HBOT promotes wound healing by supporting neovascularisation, recruitment of stem cells, production of growth factors, and improved cell migration. Pressures applied in the chamber are usually 2 to 3 atm (equivalent to 2000 to 3000 mbars), and the patient breathes 100% oxygen. Wound healing protocols comprise 1.5 to 2 hours of daily treatments for 20 to 40 days. A Cochrane review assessed the benefits and harms of adjunctive HBOT for treating chronic ulcers of the lower limb. In subjects with diabetic foot ulcers HBOT significantly improved ulcer healing in the short term but not in the long term. The authors of the review did not find any trial concerning HBOT for bed sores [45]. The high cost of HBOT and the risk of systemic adverse effects fostered search for other modalities of oxygen treatment. Different approaches have been developed: topical delivery of pure oxygen either under pressurised or ambient condition, chemical release of oxygen via an enzymatic reaction, facilitated diffusion using oxygen binding and releasing molecules. The new sterile wound dressing and topical oxygen delivery device NATROX conveys oxygen directly to the wound at a rate of 15 mL/hour through a fine tube. The light weight and compact size of the device allows it to be portable, suitable for placement under clothing during the day and positioned comfortably for use at night. Preliminary experience in using the device is promising, particularly in diabetic foot ulcers. A study evaluated topical oxygen therapy in patients with chronic non-healing wounds in a tertiary referral specialist clinic. The mean wound duration before topical oxygen therapy was 15 months. In this previously non-healing group complete wound closure was observed in 32% of patients treated with the device. Optimal wound healing occurred when the device was used for >25 days, with an 83% wound area reduction and 47% wound closure rate seen in venous leg ulcers and a 74% reduction and a 57% wound closure rate in arterial foot ulcers [46]. There is a potential for use of NATROX topical oxygen treatment for bed sores but experience is scarce.

Surgery

The principles of surgical treatment of bed sores are essentially unchanged since they were proposed half a century ago [9]: excision of the ulcer; excision of the surrounding scar and underlying bursa; radical removal of underlying bone and heterotopic ossification; padding of bone stumps and filling dead space; resurfacing with large regional pedicled flaps; grafting the donor site of the flap if necessary. Successful surgery depends on the preoperative likelihood for wound healing, as well as the severity of the patient's frailty and disabilitiy. Therefore, appropriate patient selection for surgery and careful timing of the intervention are important. Chronic nonhealing bed sores of the heel are common among bedridden nursing home residents with lower-extremity contractures. Conservative wound care in the latter is time consuming and often ineffective. Amputation may be required for failed conservative treatment or as a definitive first-line procedure in high-risk or poor prognosis patients [47]. The worst outcomes are seen in patients with large stage heel IV ulcers, compromised peripheral arterial supply, osteomyelitis and associated morbidities. In an institutional review, out of 57 nursing home residents who had chronic infected

nonhealing heel ulcers, 43 underwent partial calcanectomy, 9 underwent total calcanectomy, and 5e underwent excision of the entire calcaneus and talus [48]. Bed sores are also common among patients with spinal cord injury and can be very challenging to treat.

Bed sores treatment in institutionalized older persons - what makes it different

The chance of healing bed sores greatly depends on the patient's general health and comorbidities. The mean time to healing bed sores can exceed the patient's life expectancy. Indeed, the mean time to healing stages III and IV bed sores in a study of older adults living in the community was 8 months [16]; the level of frailty was not mentioned in this study but probably was less than in institutionalized elders. Vulnerable adults are unlikely to experience the benefits of intensive approach to treatment but are likely to experience harmful effects from surgery. Therefore, lenient goals for bed sore treatment might be appropriate in institutionalized older persons, similarly with the agreed lenient glycemic goals in diabetic patients under similar circumstances and lenient blood pressure goals for hypertensives [49,50]. Decisions regarding the choice of treatment might be settled in agreement between the patient, apotropos and the geriatric team. Emphasis should be given to palliation and life support. Opiates for pain control, antidepressives, laxatives and enteral feeding should be given as needed. Advance directives concerning critical events should be settled. In patients with limited life expectancy the use of the equipment for offloading, methods of debridement, topicals and devices aimed at promoting bed sore healing should be used judiciously. Healing of certain stage IV bed sores might be possible only with surgical intervention. Amputation may be required for failed surgical intervention or as a definitive first-line procedure in high-risk or poor prognosis patients [47].

Conclusion

Prevention and treatment of bed sores is challenging, more so in frail older subjects affected by a number of systemic disorders. New modalities for treatment have expanded the therapeutic armamentarium and lead to conceptual changes which need to be critically integrated in practice.

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