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REVIEW ARTICLE

Definitions and Guidelines for Assessment of Wounds and Evaluation of Healing

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Background: Chronic wounds represent a worldwide problem. For laboratory and clinical research to adequately address this problem, a common language needs to exist.

Observation: This language should include a system of wound classification, a lexicon of wound descriptors, and a description of the processes that are likely to affect wound healing and wound healing end points.

Conclusions: The report that follows defines wound, acute wound, chronic wound, healing and forms of healing, wound assessment, wound extent, wound burden, and wound severity. The utility of these definitions is demonstrated as they relate to the healing of a skin wound, but these definitions are broadly applicable to all wounds.

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FEW STATISTICAL trends over the past several decades have been as consistent as those related to the increasing longevity of the American population. Though such a change appears salutary, it is not without consequences. One of the most obvious effects is the emergence of a growing segment of the population with chronic health care problems. Among the costlier sequelae of chronicity is the presence of a large number of individuals with indolent or chronic wounds. In addition to the emotional costs associated with the presence of a nonhealing sore is the escalating financial burden of the care of these wounds to patients, to families, and to society.

Pressure ulcers, or decubitus ulcers, are examples of such chronic wounds; there is an estimated 3% to 5% incidence rate in hospitalized patients.[1-4] The incidence increases to 25% to 85% in patients with spinal cord injuries.[5] Assuming that 5% of the approximately one million Americans hospitalized yearly will develop pressure sores, and using the 1977 estimate of $15 000 for cost of care per patient,[5] the total cost of treatment is a staggering $750 000 000 per year, not accounting for inflation.[1] Similar data are available for other chronic wounds.

More rapid healing of a chronic wound is significant because it could result in decreased hospitalization and earlier return of the patient to daily functions. Institutional care of such chronic wounds costs approximately $1000 per day. Because patients are increasingly cared for outside of hospitals, evaluation of wounds, availability of wound care supplies, and consistency of care vary enormously.

The consequence is that many chronic wounds last far longer than necessary. Some wounds never heal and these may indirectly be responsible for patients' deaths. As more care is rendered in the home, the need for therapies aimed at restoring and maintaining structural integrity increases.

Market expenditure of over $7 billion dollars worldwide has been projected for provision of such therapies. However, potential savings of $11 billion in health care costs have also been projected. With this background, it has become clear that confusion about wounds and healing has led to divergent initiatives and less productive approaches.[6] The Wound Healing Society, Richmond, Va, believes that definitions and guidelines for assessment of wounds and evaluation of healing are necessary to relieve this confusion.

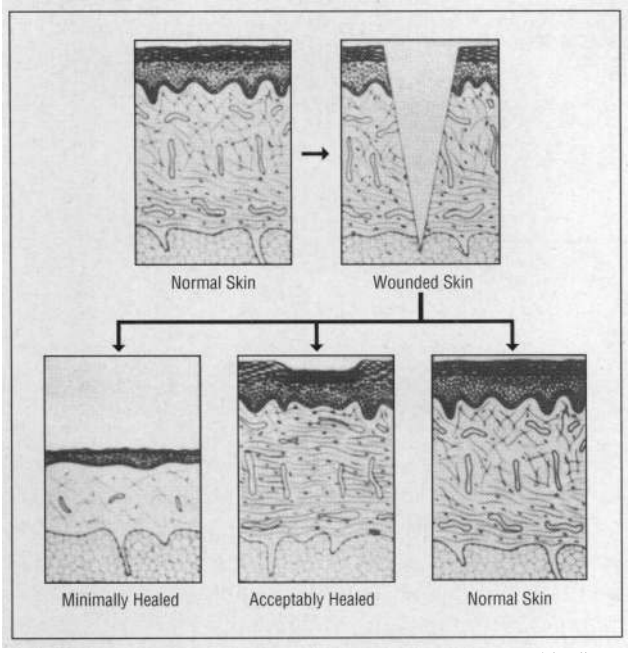

Figure 1. *A pictorial representation of prototypic forms of wound healing. An ideally healed wound results in a return to normal anatomic function, structure, and appearance. A minimally healed wound results in the restoration of anatomic continuity but without a sustained functional result. An acceptably healed wound is characterized by restoration of sustained functional and anatomic continuity.*

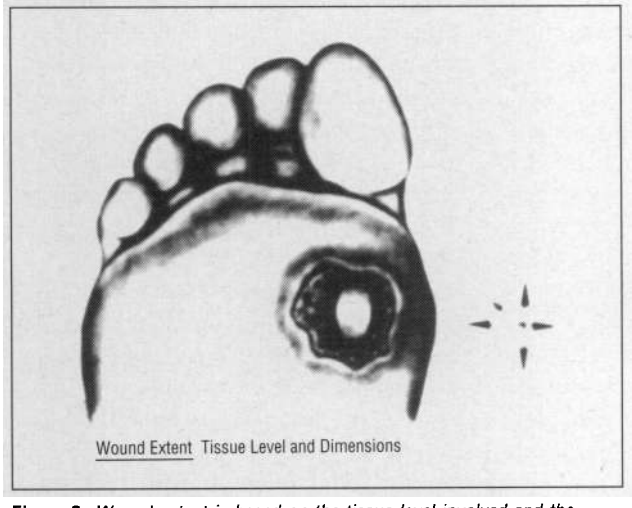

Figure 2. *Wound extent is based on the tissue level involved and the wound dimensions. The wound extent will change during wound healing and needs to be monitored.*

The purpose of this article is to initiate the creation of a common language defining a wound, healing, and the factors and processes that are important for wound healing. This language should include a system of wound classification, a lexicon of wound descriptors, and description of the processes that are likely to affect wound healing and wound healing end points. A consensus on terminology among parties interested in wound repair would greatly facilitate the ability of workers in this field to advance knowledge. The proposed definitions and guidelines are not intended as a dogmatic statement but rather as a thoughtfully prepared foundation for future discussions that will accommodate modifications over time. Although the impetus for embarking on this task was to provide basic definitions and guidelines for individuals doing research in wounds and healing, this approach will be of parallel value to clinicians, caregivers, regulators, and payers.

DEFINITIONS

A wound is a disruption of normal anatomic structure and function. Wounds result from pathologic processes beginning internally or externally to the involved organ(s). Acute wounds normally proceed through an orderly and timely reparative process that results in sustained restoration of anatomic and functional integrity. Chronic wounds have failed to proceed through an orderly and timely process to produce anatomic and functional integrity, or proceeded through the repair process without establishing a sustained anatomic and functional result. Orderliness refers to a sequence of biological events including the following: control of infection, resolution of inflammation, angiogenesis, regeneration of a functional connective tissue matrix, contraction, resurfacing, differentiation, and remodeling. Timeliness is relative, and it is determined by the nature and degree of the pathologic process, the status of the host, and the environment. The expectation of the length of time to wound repair must be clearly specified when distinguishing between an acute and chronic wound. Simply stated, wounds may be classified as those that repair themselves or can be repaired in an orderly and timely process (acute wounds) and those that do not (chronic wounds).

Healing is a complex dynamic process that results in the restoration of anatomic continuity and function. This usually involves the orderly sequence of biologic events listed previously. Healed wounds constitute a spectrum of repair and they must be defined and specified (**Figure 1**). An ideally healed wound is one that has returned to normal anatomic structure, function, and appearance. A minimally healed wound is characterized by the restoration of anatomic continuity, but without a sustained functional result and hence the wound may recur. Between these two extremes, an acceptably healed wound is characterized by restoration of sustained functional and anatomic continuity.

ASSESSMENT OF THE WOUND

Assessment of a wound in the environment in which it occurs is essential for diagnosis, treatment, management, and study. No wound can be assessed in isolation from the patient or his or her environment. Thus, complete wound assessment must include the extent of the wound, associated attributes of the wound, host factors that influence wound status, and environmental factors that impact on optimum wound management. We pro-

Table 1. Approaches Used to Determine Wound Extent

Parameter	Noninvasive	Invasive
Level	Visual, ultrasound, roentgenogram	Surgical débridement, biopsy
Perimeter/area	Linear measurement, acetate tracing, planimetry	...
Volume	Linear measurement, Kundin gauge, stereophotometry, magnetic resonance imaging, ultrasound	Liquid capacity, molds

Table 2. History and Physical Examination Findings Important in Defining Wound Attributes

Wound	Periwound
History	
Location	Spontaneous pain
Duration	Induced pain
Spontaneous pain	
Induced pain	
Positional pain	
Prior wound manipulation	
Exudate	
Odor	
Physical Examination	
Location	Erythema
Color: elevated/dependent	Induration
Odor	Edema
Fibrin	Lymphangitis
Necrosis	Callus
Undermining	Joint abnormalities
Tunnel/sinus formation	Capillary refill
Exposed tissues	Hair distribution
Instrument probe	Exposed tissue
	Function and status of surrounding organs

pose that the following terms and relationships are useful in the assessment of wounds. This relationship can be defined by the following: extent *alpha* tissue level, wound dimensions; wound burden *alpha* extent, attributes; and wound severity *alpha* wound burden, host, environment.

Assessment of any wound should begin with the extent of the wound (**Figure 2**). Because extent of a wound is a dynamic process, it requires repeated systematic assessment. The total wound extent is based on the tissue level involved and the wound dimensions. The determination of extent of a wound can include noninvasive and invasive technologies (**Table 1**). The noninvasive assessment of extent includes perimeter, maximum dimensions of length and width, surface area, volume, amount of undermining, and determination of tissue viability. Invasive methods may be necessary to quantify the extent of a wound. The tissue levels of the wound must be defined from its surface to its depth and may vary depending on the organs involved. The total wound extent should be determined by the integration of the maximal amount of available data.

A wound can be further described by various attributes, which include the following: duration, blood flow, oxygen, infection, edema, inflammation, repetitive trauma and/or insult, innervation, wound metabolism, nutrition, prior wound manipulation, and systemic factors. These attributes are clues to the cause, pathophysiology, and status of the wound. The first step is a complete and careful history and physical examination. **Table 2** presents important aspects of the history and physical examination that are helpful in defining attributes. These should be carefully monitored and documented. There are a number of noninvasive and invasive technologies that can assist in quantifying attributes (**Table 3**).

Ultimately, wounds should be assessed by their effect on the host. These factors are defined by the terms wound burden and wound severity. Wound burden is a function of the extent of the wound and its attributes

Table 3. Inventory of Technologies Used to Evaluate Wound Attributes*

Attribute	Noninvasive	Invasive
Blood flow/oxygenation	Thermography, infrared recorder, transcutaneous Po_2, transcutaneous Pco_2, laser Doppler, Doppler waveform, ankle brachial index, pulse volume recording, toe pressure, duplex waveform, magnetic resonance imaging flow profile, isotope washout, NAD/NADH fluorometry	Arteriography, subcutaneous Po_2, venography, lymphangiogram, fluorometry
Infection	Roentgenogram, bone scan, magnetic resonance imaging, indium 111 scan	Biopsy for culture, probe to bone, biopsy for histologic examination, swab culture
Edema	Organ/extremity circumference, venous plethysmography, duplex venous imaging, Doppler venous examination	Venography, lymphangiography, venous pressure
Excessive inflammation	Thermography, laser Doppler	Biopsy for histologic examination
Repetitive insult	Computer pressure profile, thermography	...
Innervation	Semmes-Weinstein filaments, two-point testing, vibration testing, sweat test	Nerve conduction, electromyography

**A number of these tests are limited in their availability. The relative merits of these technologies may still need to be evaluated.*

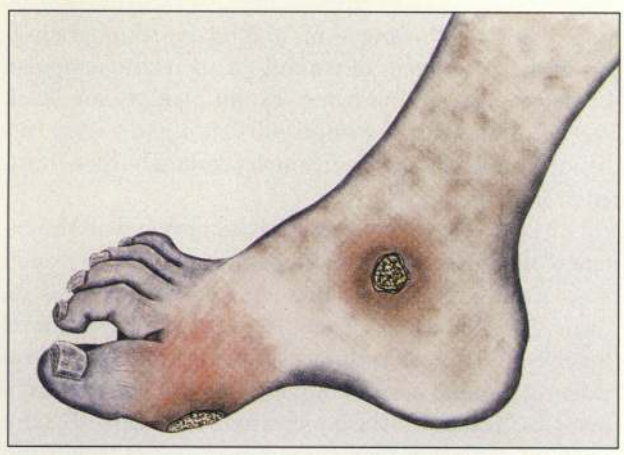

Figure 3. *Wound burden is a function of the extent of the wound and its attributes. Wound attributes are listed as follows: duration, edema, infection, inflammation, innervation, nutrition, oxygenation, trauma, and wound metabolism.*

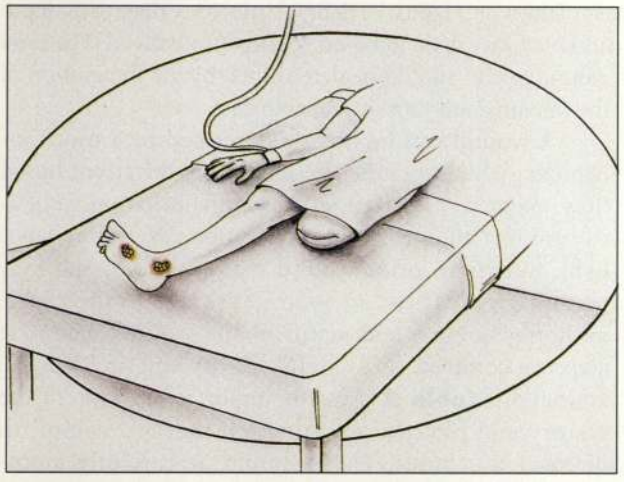

Figure 4. *Wound severity reflects wound burden, host factors, and environment. Wound severity changes during wound healing, but also when changes are made to the host and the environment.*

(**Figure 3**). Wound severity reflects wound burden, host factors, and environment (**Figure 4**). These characteristics can change during healing.

The status of the patient is essential to understanding the cause as well as evaluating the impact of systemic factors on the wound. In addition, there are environmental factors that influence the access to, and the quality of, care required to optimize the potential for wound repair. These factors include demographics, systemic agents that affect wound repair, and systemic disorders (**Table 4**).

Table 4. Demographics, Systemic Agents, and Systemic Disorders Affecting the Status of the Patient

Demographics		
Age	Occupation	Local environment
Gender	Physical activity	Geography
Habitus	Compliance	Nutritional access
Race	Self care	
Support systems	Socioeconomic status	
Systemic Agents That Affect Wound Repair		
Radiation therapy	Dialysis	Immunosuppressives
Transfusion	Immunomodulators	Corticosteroid
Cytotoxic agents	Cytostatic agents	Vasoactive drugs
Hormones	Anticoagulants	
Antimicrobials	Illicit drugs	
Nonsteroidal anti-inflammatory agents	Apheresis	
Concurrent Systemic Disorders		
Diabetes mellitus	Arteriosclerotic vascular disease	Neoplasia
Hypertension	Cardiac disease	Connective tissue disease
Venous disease	Trauma	Stress (local/systemic)
Cutaneous disease	Hypersensitivity	Musculoskeletal disease
Renal disease	Hepatic disease	Systemic infection
Gastrointestinal disease	Immunosuppression	Serum protein abnormalities
Endocrine disease	Neurosis/psychosis	
Septic shock	Pulmonary disease	

EVALUATION OF HEALING

Evaluation of healing requires the analysis of qualitative and quantitative wound assessments. The simplest method to evaluate the outcome of healing is to examine the healed wound and determine if it is minimally, acceptably, or ideally healed. This may be accomplished by history and physical examination alone, but it may require objective quantifiable measurements. The evaluation of the healing process is more difficult because it is a dynamic process: it requires ongoing, systematic, consistent evaluation. Ideally, this involves reassessment of wound extent, wound burden, and wound severity. The selection of parameters and the frequency of evaluation should be defined and appropriate to the process that is being observed. The modes of evaluating this process include assessment of changes in the following: angiogenesis, inflammation, fibroplasia and restoration of the connective tissue matrix, wound contraction, remodeling of the wound, epithelization, and differentiation (Tables 2 and 3). Synthesis of the collected information should be used to determine the progress of healing.

IMPLEMENTATION OF THESE GUIDELINES

Wounds Involving the Skin

The preceding definitions and guidelines were designed to be applicable to any wound. To illustrate the use of these guidelines, we will use wounds involving the skin as a paradigm. These wounds disrupt the epidermis and dermis and result in loss of barrier function. They may originate from forces internal or external to the skin.

To assess the extent, an accurate assessment of these wounds is based on observing structures and tissues involved. The assessment of extent includes the following: perimeter, maximum dimensions of length and width,

surface area, volume, amount of undermining, and determination of tissue viability (Table 1). Invasive methods may be necessary to quantify the extent of a wound. The tissue levels that may be involved in the wound are the epidermis, dermis, subcutaneous tissue, fascia, muscle/tendon, or bone/viscera.

Wounds involving the skin, like any wound, can be further described by various attributes. Assessment of skin wound attributes should begin with a thorough history and physical examination of the wound (Table 2). The examination includes careful description of the wound's appearance and can also include the following: wound location; description of the periwound skin and cutaneous appendages; wound color, both in a dependent and elevated wound position; capillary refill; venous filling; bruits and pulse status; varicosities; the presence of bleeding; erythema; edema; induration; fibrin; necrosis in the wound; surrounding gangrene; exudate; odor; lymphangitis; the presence of joint abnormalities; the historic origin of the wound; and a description of both spontaneous and induced pain. It is important that these parameters be quantified and recorded. There are a number of noninvasive and invasive technologies that can assist in quantifying attributes (Table 3).

Healing of Wounds of the Skin

The simplest method for evaluating healing in wounds involving the skin is to examine the wound and determine if it is minimally, acceptably, or ideally healed. An ideally healed wound of the skin results in a return to normal anatomic structure, function, and appearance that includes a fully differentiated and organized dermis and epidermis with intact barrier function. An acceptably healed wound is characterized by epithelization capable of sustaining functional integrity during activities of daily living. A minimally healed wound is characterized by the restoration of epithelial coverage that does not establish a sustained functional result and may recur.

Evaluation of wounds involving the skin requires ongoing, systematic, consistent assessment of wound burden and wound severity. This involves quantifying changes in extent (Table 1) and attributes both clinically (Table 2) and by using reproducible appropriate technologies (Table 3). These changes should always be correlated with changes in the status of the host.

SUMMARY

The escalating physiologic, psychological, social, and financial burden of wounds to patients, families, and society demands redress. The first step in the solution of this problem is agreement on definitions of wounds and wound healing, their assessment, and their evaluation. The definitions and guidelines described will enhance communication among all elements of society dealing with this problem. It is vital that the quality of clinical and technologic observations be as stringent as outlined in these guidelines. Once these uniform definitions and guidelines become standard, they can be used for determining standards of care, designing and implementing health care policy, addressing reimbursement issues, and setting end points for studies.

The broad applicability of these definitions and guidelines provides a framework for future consensus development regarding specific wound types involving hard and soft tissues, models, and technological assessment tools.

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During the preparation of the manuscript, Dr Pecoraro lost his valiant battle with cancer. His tireless efforts offered under the most adverse circumstances were an inspiration to us. We dedicate this article to his memory.

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