State of Wound Care in Rhode Island

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INTRODUCTION

We are grateful to the *Rhode Island Medical Journal* (RIMJ) for encouraging this special issue on wound healing. The authors represented in this issue are active wound healing clinicians or researchers who strive to better the lives of our fellow Rhode Islanders by caring for the many among us who battle chronic or acute wounds that don't heal according to schedule or intention. One of us (PL) served as President of the Wound Healing Society (WHS) for 2013–14, an international group of clinicians, scientists, and people in industry, who are engaged in wound research and product development. One of the WHS Board members used to say that "Superman (aka Christopher Reeves, the actor) didn't die from his broken neck – it was an infected pressure ulcer that proved his undoing."

Unhealed wounds are a largely hidden epidemic, affecting 6.5 million Americans and costing about $25 billion a year.[1] Rhode Islanders are unfortunately well-represented in this population. Many of our friends, neighbors, and colleagues may be in the cohort, and far too many patients lead lives that are limited by the need to be at home for visiting nurse visits, or by odiferous wounds that prevent socialization. The incidence of chronic wounds is increased among the older population as well, and there is a clear negative impact on quality in this population. It is well established that wound healing slows with age. However, the basic molecular mechanisms underlying chronic wounds and the influence of age-associated changes on wound healing are poorly understood.[2] Despite this large socioeconomic burden, there have been only a few meaningful advances in the science of wound care. For example, there is only one pharmacologic agent approved by the FDA for use in chronic wounds: recombinant platelet-derived growth factor (becaplermin gel 0.01%, Smith and Nephew, Hull, UK), only for diabetic wounds, and it carries a black box warning.[3] A group of WHS members lobbying Congress about the lack of NIH funding for wound research pointed out that there is more funding to study several rare disorders than for all of wound healing.[4]

In this issue, we present different perspectives on this complex problem. *Mehrzad et al.* provide an overview of different types of wounds, standards of care, and recent guidelines in treating chronic and diabetic wounds – the latter being one of the most common causes of chronic wounds. *Johnston et al.*, provide a summary of some of the basic science work attempting to identify molecular cues identifying which patients may respond to hyperbaric oxygen therapy. *DosRemedios et al.*, present current concepts in caring for diabetic foot ulcers from a podiatric perspective. *Kwan et al.*, provide an overview of surgical therapies available for wound coverage, and *Ciombor et al.*, provides a glimpse into the brave new world of stem cells coupled with autologous clot that may aid in tissue regeneration and other therapies for problem wounds.

Rhode Island Dedicated Wound Care Facilities

There is no shortage of specialized centers in Rhode Island that care for chronic wounds. Rhode Island Hospital established its multidisciplinary center in 2013, which includes hyperbaric oxygen therapy (HBOT) as a treatment modality. HBOT is also available at CharterCare (Fatima Hospital in North Providence) and Kent County's Wound Recovery Center in Warwick. In addition, centers devoted to wound care exist at Newport, South County, and Westerly Hospitals. Just over the border in Massachusetts, Southcoast and Sturdy Memorial provide centers for wound healing as well. The first ever regional wound care symposium was hosted by the RIH Center in October 2015, and offered CME for physicians and nurses interested in learning the latest in techniques and materials available to speed healing.

Patient Populations and Demographics

Diabetes is a pandemic in the US. There's an estimated 22.3 million people living with diabetes in America.[5] Diabetes is one of the most common causes of wounds with approximately 10% of diabetics developing diabetic foot ulcers.[5] In RI, 7.4% of adults have diabetes.[5] However, given that 1/3 of patients with diabetes are undiagnosed, there is likely a significantly higher incidence rate of diabetes and thus chronic wound.

Different types of wounds

There are many different types of wounds. Acute surgical wounds and traumatic injury wounds will typically heal well in a healthy person (**Figure 1**). Even without a full recovery, the skin will often close and its barrier function will be re-established (so-called primary intention if repaired, secondary intention if left to contract and re-epithelialize

Table 1. The four most common causes of wounds and their characteristics.[6]

	Vascular	Neuropathic/diabetic	Pressure	Venous
Definition	Wounds caused by lack of blood supply.	Wounds exacerbated by diabetes, with damaged nerves, and blood vessels.	Wounds caused by pressure on skin tissue and resultant damage to the skin.	Wounds caused by damage to the venous valves which leads to failure to return blood to the heart → venous congestion → ulcers.
Location	Legs, feet, and toes.	Usually on the foot but could be anywhere in the leg.	Usually over a bony prominence.	Ankle to mid calf.
Size	Small, but increases in size.	Small.	Large or small.	Usually large.
Exudate (pus)	Minimal.	Minimal.	From none to heavy.	From none to heavy.
Peripheral pulses	Reduced or absent	Not reliable	N/A	Normal
Pain	Pain when limb is elevated, at night and at rest.	Either absent or severe.	Present.	Present along with edema.
Treatment	Revascularization and dressing.	Manage good blood sugar control, offloading, maintain moisture.	Remove "dead" tissue, maintain moisture, offloading.	Compression, remove "dead" tissue, offloading. Skin substitute.

over time). When skin is compromised by inadequate blood supply, presence of bacteria or related biofilm, autoimmune diseases, diabetes, or presence of nonviable tissue or contaminants from the environment wounds are less likely to heal (**Figure 2**). **Table 1** summarizes the four most common types of wounds and their specific characteristics.

Chronic Wounds

Wounds that do not heal in a timely fashion, usually defined as within three months, are considered chronic.[7] Chronic wounds are complications that are associated with the comorbidities of diabetes and obesity.[7] These wounds are classified as chronic wounds due to an interruption in the normal wound healing phases: hemostasis (blood clotting), inflammation, proliferation (new tissue growth), and remodeling.[8] Chronic wounds are in a state of constant inflammation, and the degradation of collagen is greater than the rate at which it is produced. The burden of treating chronic wounds is increasing due to an aging population, increasing prices for health-related treatments, and the rising incidence of diabetes and obesity.[9]

Chronic wounds are caused by multiple factors. Systemic illnesses such as diabetes exacerbate wounds by compromising circulation, and causing increased skin trauma due to neuropathy.[8] In general, wound healing slows with age and thus, incidence of chronic wounds increases as one gets older.[10] The incidence rate of pressure ulcers, a chronic wound, is five to seven times higher for patients older than 80 years, compared to patients between ages 65 and 70.[11]

Chronic wounds are often categorized into three groups: diabetic foot ulcers (DFU), venous leg ulcers (VLU), and pressure ulcers (PU).[7] DFU affect 10% of patients with diabetes and is a leading cause of amputations.[12] Diabetes mellitus affects the normal wound healing response, and a longer inflammation phase is common. Neuropathy, often concurrent with diabetes, indicates that the patient does not feel the pain sensation of the initial wound. Because of the location and the environment of the wound, infection of the non-healing wound would require amputation.[13] Most chronic wounds are VLUs and the exact cause is still unknown, but they are believed to be triggered by high pressure of the veins, due to improper blood flow.[14] PUs, also known as bedsores, is caused by the pressure applied to skin, often in cases of bedridden individuals.[14]

Standard of Care[2]

The treatment of diabetic foot ulcers focuses on three issues: debridement, offloading, and infection management.[13]

Debridement

Debridement entails removing callus and dead tissue from the wound and surrounding tissue, in order to minimize the chance of infection and reduce the wound pressure, which has the potential to interfere with normal wound healing.[13] After the tissue removal, saline is used to wash and clean the wound. A dressing is applied to absorb wound fluid, protect the ulcer from infection, and prevent the wound from drying out.[13]

Offloading

Offloading is the process of preventing any weight being applied to the wound.[13] It is also the most difficult issue for treatment of diabetic foot ulcers.[13] In addition to the use of crutches and wheelchairs to prevent walking directly on the wound, a cast system is used to cover and protect the foot. The total contact cast (TCC) is non-removable by the patient, and is considered the best treatment option.[16] Even though the TCC is the gold standard, a survey has found that only 2% of the centers in the United States use the TCC as the main method for treatment of DFUs.[17] Most of the ulcers were treated with removable footwear.[17]

Infection management

For infection treatment, the standard care of antibiotics is used for treating common pathogens such as Group B

Figure 1.
Venous ulcer (left), and treatment with a skin substitute (middle), as well as its post-operative result (right)

streptococci, enterobacteriaceae, and Pseudomonas aeruginosa.[15] The treatment for venous leg ulcers consists of compression therapy, and is used to decrease the blood vessel pressure.[18] It is used concurrently with leg elevation, for proper distribution of fluids and it is recommended for 30 minutes, three of four times a day.[18] The treatment for pressure ulcers is similar to the diabetic foot ulcers, focusing on debridement and dressing the wound.[19]

Recent Wound Care Improvements

In 2006, the WHS published guidelines on how to specifically approach chronic wounds. Since then, thousands of new articles have been published within the field and new evidence has emerged on recommendations for different clinical aspects of wounds. Below are some of the most relevant updates in stepwise approach.

1. Peripheral vascular disease (PAD)

PAD contributes to both the development of chronic and poor wound healing.[20] Any patient with a chronic wound should be evaluated for PAD with ankle brachial index (ABI).[20]

2. Offloading

Ulcerations on the sole of the foot, mostly secondary to diabetes, are often associated with moderate to high pressures because of foot deformity, neuropathy and limited joint mobility.[20] Different types of offloading include custom shoes, depth shoes, shoe modifications, walkers, custom inserts, custom relief orthotic walkers, diabetic boots, forefoot and heel relief shoes, and total contact casts.[20]

3. Prevention of recurrence

Recurrence rates, mainly DFU, are as high as 83% within 1 year because the underlying pathologic factors usually persist.[20] In contrast to previous recommendations, it is now unclear if good foot care and daily inspection of the feet will reduce the recurrence of diabetic ulceration.[20] However, protective footwear should be prescribed in all cases.[20]

4. Infections in the wound

The most common underlying reason for amputation and hospitalization in chronic wounds is infection. Removing all necrotic or devitalized tissue by surgical, enzymatic, mechanical, biological, or autolytic debridement is therefore essential.[20]

If there is suspected infection in a debrided ulcer, tissue biopsy or local swab cultures should be performed to determine the type and level of infection. By treating the infection by topical antimicrobial agents the bacterial load is reduced, which improves wound healing.[20] Moreover, systemic antibiotics are also effective in the treatment of acute diabetic foot infections.[20]

5. Dressing changes

There are a large number of types of dressings available for chronic wounds. In contrast to the previous suggestion to keep a wound dry, a moist wound environment physiologically favors cell migration and matrix formation while accelerating healing of wounds by promoting autolytic debridement.[20] However, dressing that maintains a moist wound-healing environment has not been shown to be more effective than other dressing approaches.[20] Topical silver dressings have not been shown to be effective to treat DFUs.[20]

6. Topical agents

Diabetic foot wounds are deficient in growth factors, therefore, *cytokine growth factors* are messengers/mediators in wound healing.[20] Furthermore, accelerated wound healing is seen with *fibroblast growth factor* and *epidermal growth factor*. Factors that have not been shown to accelerate healing are *granulocyte-colony stimulating factor (G-CSF)* and *vascular endothelial growth factor.*[20]

7. Cellular therapy

Some wounds respond well to the addition of cells, via skin substitutes or grafts. **Figure 1** illustrates the use of cultured epithelium on a collagen substrate used to heal a venous leg ulcer.

8. Surgical treatment

In patients with inadequate arterial blood flow, improvement in blood supply is associated with an increase in oxygenation, nutrition, and wound healing.[20] Therefore, these patients should be considered for a revascularization procedure. For other chronic wounds, flap coverage may be indicated. (See **Figure 6** on page 32.)

9. Devices

Negative pressure wound therapy (NPWT), hyperbaric oxygen therapy, bioengineered alternative tissues, and electrical stimulation are a few of the several devices that have more recently been shown to significantly improve wound healing.[20] NPWT improve healing by reducing edema, reducing bioburden, and increasing granulation tissue. Bioengineered dermis plays a role in wound healing for several reasons. It increases the proportion of wounds that heal; it increases the rate of wound healing; it reduces the risk of complications.[20] Electrical stimulation accelerates wound closure and the proportion of wounds that heal. Hyperbaric oxygen therapy has been shown to prevent amputation.[20]

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Disclosures

None

Conflict of interest

None

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