OUTPATIENT MANAGEMENT OF THE BURN SURVIVOR

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Introduction

Almost every book, chapter, research article, written about burn care inevitably begin with a description on how devastating burn injuries are both physically and psychologically. As a therapist at a large burn center, I see the impact of these injuries on the survivors and their families every day. Over the years, surgical techniques and medical technology have improved so that burns that were at one time not survived now are. These larger total body surface area (TBSA) burns leave in their wake physical impairments that can take years to rehabilitate. It is the job of the Physical Therapist to help these survivors regain the function that they've lost.

Objectives

- Understand burn basics including skin anatomy, wound healing, burn physiology, burn size, and surgical techniques
- Understand the role of the Physical Therapist in the burn center
- Understand the rehabilitation needs of the burn survivor including:
    - Scar management
    - Splinting
    - Therapeutic exercise
    - Modalities
    - Social, emotional, educational and vocational support

The Skin

The function of the skin is to protect the body from infection and injury, prevent the loss of body fluid, regulate body temperature, receive external stimuli, determine ones identity, and serve as an indicator of internal events. *Burn injuries cause a loss to some or all of these*.

The skin consists of the epidermis, dermis and the subcutaneous tissue beneath which lays the underlying structures such as fascia, muscles, tendons, ligaments, nerves, and organs.

The most superficial layer of the skin is the epidermis. Its thickness varies from 0.05mm to 1.5mm. There are five layers within the epidermis: stratum corneum, stratum lucidum (found only in the palms of the hand and soles of the feet), stratum granulosum, stratum spinosum, and stratum basale.[1-3]

The deepest layer of the epidermis is the stratum basale. In this layer are the cells known as keratinocytes that produce the protective protein keratin. Other important cells within the epidermis are melanocytes (produce the pigment melanin), Merkel cells (mechanoreceptors that provide information on light touch), and Langerhans' cells (dendritic cells that regulate immune responses in the skin.) [1-3,12]

Other important structures within the epidermis include: hair follicles (lined with epithelium that are continuous with the epidermis), sebaceous glands (contained within the hair follicle, it produces sebum that lubricates the skin and hair), Sudoriferous glands (secrete sweat to assist the body in dissipating heat and cooling the body) [1-3].

The basement membrane is an area of connective tissue between the epidermis and dermis. The membrane acts as scaffolding where ridges in the epidermis fit within projections in the dermis. This series of ridges are known as rete pegs. It anchors the dermis to the epidermis and prevents shearing forces. [1-3]

Beneath the epidermis is the thicker dermis. It can range in thickness from 2mm – 4mm. This highly vascularized layer provides nutrition to both the dermis and epidermis. The dermis consists of two distinct layers. The papillary dermis is the top layer and it conforms to the epidermis. The deeper layer is the

reticular dermis. This layer is a thicker layer that contains collagen bundles that provides the skin with its extensibility. [1-3]

Important structures within the dermis include smooth muscle (cause hair follicles to elevate, aka goose bumps), blood vessels (in addition to providing nutrition help in the thermoregulation of the body), lymphatic vessels, and nerves (afferent fibers that supply sensory information on temperature, pain, touch, itch, and pressure.) [1-3]

Subcutaneous layer consists of adipose tissue and connective tissue that provides energy, cushioning and insulation to deeper structures. [1-3]

Classification of burns

Burns can be classified based on the mechanism of injury, the depth of injury, and the size of the injury.

There are 6 main mechanisms of injury. They include scald, flame, contact, chemical, electrical, and radiation.

The traditional method of classifying burn depth was first, second and third degree burns. These have been replaced with the more descriptive clinical terms superficial (1st degree), superficial and deep partial thickness (2nd degree), and full thickness (3rd degree).[4]

Superficial Burn: It involves only the epidermis. The skin appears red with no blistering. It can take 3-7 days to heal as the outer epidermal cells peel away. Example: sunburn. [4,5,6]

Superficial Partial Thickness: This burn involves the entire epidermis as well as the papillary layer of the dermis. The appearance is red, moist and weepy. Blisters may be present. These are extremely painful burns as nerve endings in the dermis are exposed. As the deeper structures of the dermis are intact the wound will typically heal within 7-21 days with minimal scarring. [4,5,6]

Deep Partial Thickness: Involves the epidermis, papillary and reticular layers of the dermis. Can appear mottled white, pink or deep red. Blisters are large, and the burn is very painful as many pain receptors remain intact. As some hair follicles and sebaceous glands remain intact the wound may be able to re-epithelialize. However if the burn is large, or will take longer than 3 weeks to heal, a physician may decide to perform a skin graft to achieve wound closure. These burns are at risk for hypertrophic scarring and contracture. With poor nutrition or infection these burns run the risk of converting to full thickness.[4,5,6]

Full Thickness: Involves the epidermis, the dermis and subcutaneous tissue. Appear white, charred, leathery, yellow or brown. As all vessels have thrombosed, the wound is dry. There is little to no pain. Any remaining hairs will pull out easily. These wounds require surgical debridement and skin grafting. These wounds like deep partial thickness are at risk for hypertrophic scarring and contracture. [4,5,6]

Estimate of size: In addition to depth, the percentage of total body surface area (TBSA) of a burn is calculated. Only areas of partial thickness and full thickness are included in the calculation. Methods of calculating TBSA are the Rule of Nines and the Lund-Browder classification.[2]

Systemic effects of burn injuries

Cardiovascular System: Increased capillary permeability results in edema, fluid is lost through evaporation. This state of hypovolemia causes decreased cardiac output and can eventually lead to renal failure. Therapists must monitor patient blood pressure during activity, and manage edema.[6,7]

Respiratory System: Pulmonary failure is one of the leading causes of death for the burn patient. Inhalation injuries can cause increased airway resistance, pulmonary arterial hypertension, and reduced pulmonary compliance. Burns to the torso can cause edema, and grafts to the torso can cause a decrease in chest expansion impairing ventilation.[6,7]

Gastrointestinal System: Gastric dilation and paralytic ileus in response to shock, and increased incidence of ulcers. Hypermetabolic state causes increased muscle catabolism which can lead to muscle wasting.[6,7]

Wound Healing

Wound healing can be divided into three phases: inflammatory phase, proliferative phase, and the remodeling phase.[2]

Inflammatory phase: begins at the time of injury and can last 2-5 days. Vascular response (5-10 minutes of vasoconstriction, followed by vasodilation), cellular response (neutrophils and macrophages rid wound of bacteria and foreign debris). Wound is characterized by redness, edema, warmth, pain and decreased ROM.[2,8]

Proliferative phase: Starts around the 3rd-5th day and can last up to 3 weeks. Characterized by angiogenesis (formation of new blood vessels), granulation tissue formation (fibroblasts enter the wound and produce an extracellular matrix of collagen and elastin, appears as moist, red tissue within the wound bed), wound contraction (myofibroblasts pull the margins of the wound together), epithelialization (keratinocytes at the wound margins and within hair follicles migrate across the wound). [2,8]

Maturation phase: begins at the end of epithelialization and lasts from six months to three years. Collagen becomes more parallel in formation and creates stronger bonds. Collagen synthesis should be equal to collagen degradation during this phase. If collagen synthesis is greater than collagen degradation then hypertrophic scarring can occur. [2,8]

All phases of wound healing require oxygen. Burns develop necrotic tissue on the wound surface that impede oxygen delivery, support bacteria, encourages infection and prolongs healing.

Surgical Management

As extremities become edematous, areas of burn that are circumferential may act as a tourniquet. Decreased blood flow can cause underlying structures to die. Pts may require an escharotomy (an incision is made in the eschar to the subcutaneous tissue), or a fasciotomy (incision is made to and sometimes through the fascia.)[2,9]

Wound coverage: When it is determined that a burn wound will take more than 21 days to heal, surgical intervention is required. Burns that take longer than 21 days to heal are at an increased risk for hypertrophic scarring and contracture. Removal of eschar through tangential excision allows a surgeon to preserve underlying tissue.[5,10]

Skin grafts: Once eschar has been removed, the wound needs coverage. There are two types of skin grafts: split-thickness (contains the epidermis and a thin portion of the dermis), and full-thickness (contains the epidermis and the entire dermis.) [2,5,10]

Sometimes the excised wound bed is not healthy enough to accept the patients own skin, or with larger TBSA burns, the patient does not have enough skin to cover open wounds right away. In these instances temporary grafts may be used. Cadaver skin (known as allograft or homograft) or porcine skin (xenograft) may be used until a donor site is available, or when the wound is healthy enough to graft with the patient's own skin (autograft). [2,5,10]

Pro's and cons of meshed autograft or sheet autograft: Meshed autografts involve making incisions within the graft, allowing the graft to be stretched over a wider area. Meshing reduces the risk of fluid accumulation and clot formation under the graft. Meshed grafts, however, are prone to contract more, and they leave that meshed pattern within the scar. Sheet grafts have a much better cosmetic appearance and are not as prone to contracting as meshed grafts. Fluid may collect under the graft which could cause the graft to not attach to the wound bed. These sheet grafts require extra care during the first 3-5 days as fluid must be removed. This can be done by pricking the graft with a sterile needle and rolling a cotton swab toward the incision to remove the fluid. [2,5,10]

Other methods of wound closure and skin substitutes:

Cultured Epithelial Autografts (CEA's): Patients that have large TBSA burns and limited donor sites for harvesting may benefit from CEA's. A biopsy of the patient's healthy skin is taken. This biopsy is sent to a lab where epidermal cells from the biopsy are grown into sheets. After three weeks the cells are ready for placement on the patient. These are less durable than autografts as there is no dermis present.[5,10]

Biobrane™: Two-layer membrane with an inner layer of nylon mesh that allows fibrovascular ingrowth and an outer layer of silastic that serves as a barrier.[5] Fluid and exudate may collect beneath the membrane and will need to be removed daily.

Integra®: Used with full thickness wounds, and on areas with exposed tendons. Bilayer membrane. The top layer is silicone to control moisture loss. The bottom layer is a dermal replacement made of bovine collagen which serves as a matrix for fibroblasts. After 2-3 weeks the silicone layer can be removed and a thin autograft can be placed over the wound.[5,13]

Rehabilitation of the burn survivor

The following information was written by Kevin L. LaPratt, MS, OTR/L, David J. Lorello, PT, DPT and Anne M. Tiernan, MS, OTR/L. It will be included in their chapter entitled *Rehabilitation of the Pediatric Burn Patient*. Their chapter will be included in a new textbook, *Pediatric Burns*, edited by Bradley J. Phillips, MD.

During every phase of rehabilitation, therapy goals related to scar management include: promote optimal wound healing; minimize hypertrophic and keloid scar formation; minimize pain, pruritis, hyperesthesia, and overall discomfort caused by scars; optimize functional performance, endurance, and independence in ADLs and IADLs; provide psychosocial support to the patient and family members/support system; complete patient and family education on topics of wound healing, scar management, splint usage, home exercises and skin protection.[14]

The extent of the burn injury will dictate treatment. As the TBSA of a burn injury increases, the chance for greater loss of function leading to disability increases. Burns cause a hypermetabolic response coupled with increased resting energy expenditure which leads to loss of lean body mass from protein catabolism.[15-17] This catabolic response can last up to two years post injury. [15-17] Furthermore, studies have shown that prolonged bed rest or immobilization will result in loss of muscle mass, decreases in bone mineral density, and an increased risk for fractures, joint contractures, and deconditioning.[18-20]

Therapy is initiated the day the patient arrives in the burn center. During the first 24-72 hours when the inflammatory phase is predominant, edema reduction through patient positioning is the primary goal of the therapist. Once the patient is medically stable, the role of the therapist expands from positioning and splinting to preserving soft tissue mobility through range of motion (ROM) and exercise. *As patients with deep partial-thickness and full thickness burns are at increased risk for hypertrophic scarring that leads to contractures, therapy must focus on maintaining ROM long after their initial hospitalization*. This can become a prolonged process which is not completed until scars have fully matured. In addition to ROM, the therapist must include

strengthening and endurance activities, which can be accomplished through mobility and gait training, an exercise program, and activities of daily living (ADLs).

Throughout the rehabilitative process the foremost goal of the therapist is to preserve range of motion. Although it is always best for the patient to actively participate in exercises, the patient is often unable to because of pain, or decreased strength and endurance. Range of motion can therefore be performed passively (PROM) until the patient can either assist the therapist or fully participate themselves.

Note: In most circumstances ROM is contraindicated for patients with exposed tendons. However, in our center we continue to perform ROM despite exposed tendons in order to prevent the tendon from adhering to surrounding tissue. Typically during tendon gliding the exposed tendon is covered in petroleum impregnated gauze, which prevents desiccation and possible dehiscence.

During the proliferative phase of wound healing contraction decreases the size of the affected area, which is then repaired by scar formation. As such, the goal of therapy is to inhibit wound contraction.[14] If contraction occurs, centripetal force will pull all structures towards the wound. Joint contractures, as sometimes seen in full-thickness burns, are often the result of uncontrolled wound contraction.[21] The deeper the wound, the longer it takes to heal, resulting in increased risk of pain, infection and, ultimately, scar formation.[11,22,23]

Use of skin grafts can diminish wound contraction with the thickness of the graft correlating to the degree of wound suppression.[24] Split-thickness grafts diminish contraction of the wound by 31%, full-thickness grafts diminish contraction by 55%, and the early combined use of full-thickness grafts with splinting inhibits contraction by 77%.[21,25,26] During the proliferative phase, splinting the wound areas is an important element of scar management. Externally applied splints can provide stress to desirably orient the deposited collagen, as well as provide appropriate joint alignment positioning.[27]

Immobilization of the graft is imperative until take of the graft is seen. [28]After graft adherence has been achieved, pressure can be applied to inhibit scar contraction and hypertrophy, decrease vascular and lymphatic pooling, and avert hypersensitive, fragile skin.[29] The tensile strength and durability of the remodeled skin arises from new collagen formed after fibroblasts synthesize collagen and undergo cross-linkage. This strength is, however, less than the original skin: it will never exceed 75-80%.[30] Following grafting, there is generally enough tensile strength between the graft and the wound to permit active range of motion on the fourth day and, at least, by the sixth day. [28]

The proliferative phase is completed when epithelialization has resurfaced the wound, a collagen layer has been formed, and initial remodeling is complete.[31] This phase generally lasts two weeks. Appropriate wound care and edema management are paramount burn team concerns, with proper positioning and maintenance of functional range of motion (both active and passive now) as primary therapy goals. If possible, participation in light ADL and limited ambulation is encouraged.[32] Strengthening exercises can be introduced during the proliferative phase.[14]

The final phase of wound healing is referred to as the maturation or remodeling phase, and generally lasts a year or longer.[33] Its hallmark is the relative balance of collagen synthesis and lysis, i.e., the formation and breakdown of collagen.[27] Scar formed during fibroplasia is dense, disorganized, and different from surrounding tissue. As maturation occurs, collagen lysis increases and scar tissue becomes smoother, more elastic, and stronger. If synthesis exceeds lysis, hypertrophic scarring or keloid formation may occur. [27] Keloid scars extend beyond the boundary of the wound and appear raised. On the other hand, hypertrophic scars occur within the area of the wound and may eventually decrease in both size and shape. [27]

In their study of 59 pediatric and 41 adult patients, Deitch et al. reported that if healing took longer than 21 days, hypertrophic scarring was three times more likely to occur. [22] Pediatric patients demonstrate a greater propensity to scar than adults.[22,34-36] Deitch et al.[22] listed the feet, perineum/buttocks, chest, back, head/neck and upper extremities (in descending order) as most likely to develop hypertrophic scars, while Kraemer et

al.[35] stated that the majority of contractures occurred at the hands, axillae, head, and antecubital fossae (again, in descending order). During the maturation wound healing phase, therapy goals include all previously mentioned ones and scar management becomes a primary focus.

Prevention of raised hypertrophic scars and/or formation of keloid scars extending beyond wound boundaries can be at least partially achieved by use of pressure.[37-39] Prolonged pressure creates an ischemic condition whereby blood flow (and oxygen) is decreased in the wound tissue. With less oxygen, synthesis is curtailed while lysis is unaffected; tissue balance is achieved when scar bulk is flattened to approximate normal tissue.[21] Mechanical compression also controls the release of cytokines in a hypertrophic scar and reduces the binding of collagen fibers.[38-40]

Fitting of interim pressure garments is started as soon as the remodeling phase has become evident; patients are measured for custom garments once grafts are healed and can tolerate shearing forces.[39] Small open and granulating areas can be covered with dressings.[27,33] It has been recommended that all patients whose wounds require longer than 14 days to heal and those with split-thickness grafts receive prophylactic pressure therapy.[22,28,41] Generally, pressures ranging from 20-30 mmHg are needed for effective treatment.[42,43] Appropriate pressure produces results within a few days and notably after a few weeks of implementation.[28,44] Decreased overall edema with concomitantly reduced redness, increased pliability, softness, and flattening of scar tissue has been noted.[45,46] Garments should be worn at least 23 hours a day (except for during bathing and skin care), until scar maturation is fully achieved. Glove removal is occasionally specified for a home exercise program or for particular sensory or motor experiences.[27] Machine washing garments (versus hand washing) may be surprisingly superior for maintaining optimal pressure.[47] Garments generally last 3 months before skin blanching is no longer noted and replacements are necessary.[48] Although garments may partially protect vulnerable skin from harmful ultraviolet sun rays, application of sun block is advised for patients when outdoors.[27]

Silastic™ and elastomer conformers, as well as foam and other types of padding, can supplement pressure garments by being used over scars with irregular surfaces or concave areas.[14,27,33] Web spacers may be sewn into a glove.[27] Use of silicone gel sheeting (SGS) has been shown to be a safe and effective management tool for treatment of hypertrophic scars and keloids. Results from randomized, controlled trials and a meta-analysis demonstrate good evidence of its efficacy.[49-52] The exact mechanism is unknown. It has been shown that the surface temperature of scar tissue increases significantly following application of silicone gel sheeting, raising the possibility that temperature alteration is involved in the mechanism of action.[53,54] Alternately, friction on the silicone surface may create a static electrical field with a resultant inhibitory effect on scar tissue.[55] Lastly, increased hydration[56] and hydration with occlusion[57] have been posited as the most likely factors of the mechanism of action.

Scar management includes treating both "raising forces" and "contractile forces".[31] While application of pressure is a broadly accepted method for addressing raising forces, use of low-load, prolonged stress and other methods of supplying internal and external forces can also positively affect contractile properties. Examples of forces acting on the collagen array in order to facilitate permanent elongation of the scar are muscle tension, joint movement, passive gliding of fascial planes, soft tissue loading and unloading, temperature changes, mobilization, and splinting.[21,58] Sustained stretching is one of the most effective exercises for lengthening scar bands and increasing range of motion;[28] blanching of the scar represents appropriate stretch.[14,27,28] Progressive, judicious massage may release scar tissue from adjacent tissue and increase range of motion as well.[14]

Moist heat packs and paraffin have been used for treatment of scar contractures: using subsequent sustained stretches, Head and Helm[59] stated that increased collagen extensibility, skin pliability and joint range of motion, as well as decreased joint pain, were seen in the 20 adult and pediatric patients they treated. Paraffin is the most consistently effective modality for use with pediatric patients according to Moore and Robinson.[28] Johnson[60] demonstrated trunk and shoulder scar contracture correction following use of paraffin and manual therapy in her case study of a 6 year old boy.

Use of physical agents can be contraindicated if impaired sensation or cognition prevents the patient from accurately and consistently reporting response to the application.[61] Precautions to consider are the fragility of newly resurfaced skin and inadequate overall tolerance. Furthermore, since some patients may appear fearful of heat, gradual introduction and possible temperature reduction of hydrocollator water, paraffin wax or fluidotherapy particles is recommended.

Scars can be painful. Rest, massage, compression garment use and elevation have been found to be helpful.[62,63] Transcutaneous electrical nerve stimulation (TENS) has also been used successfully for pain control.[64] Scars also itch. Although pruritis is commonly reported by patients, medications do not appear to provide satisfactory control. In her individual case report, Whitaker[66] used TENS successfully to significantly decrease pruritis in an adult patient. Patino et al.[67] found massage reduced pruritis in pediatric burn patients. Field et al.[68] reported that adult patients receiving massage reported significantly decreased pruritis, pain and anxiety, as well as improved mood. Partial-thickness wounds without grafts, but with hypertrophic scarring, can demonstrate higher evaporative water loss and resultant extreme dryness and pruritis.[69] Hypertrophic scars have also been shown to demonstrate increased nerve density; Liang et al.[70] proposed that the debilitating itching and pain associated with hypertrophic scars implicates injured sensory nerves within the aberrant healing process. Grigsby deLinde and Knothe[27] have recommended massaging at least twice daily, and up to four times a day, using non-water based creams. Lubricants should not contain perfume or other skin irritants. Patients who require extensive grafting-with loss of hair follicles, sebaceous glands and sweat glands-should avoid high environmental heat and humidity.[28]

Scars can cause disfigurement, pain, pruritis, and functional impairment. Therapists need to be keenly aware of their patients' responses to therapeutic interventions. Subsequently, therapists can provide consistent, positive feedback, realistic goal-setting, thorough education on relevant topics, and both patient and family psychosocial support.

Optimal Positioning

Splinted Area	Desired Position
Neck/Head/Face	• neutral • slight extension • head of bed elevated 30-45 degrees
Axilla	• abduction to 90 degrees • forearm supinated (palm facing up) • horizontal adduction to 20 degrees
Elbow	• elbow in full extension • forearm supinated • elbow elevated above the level of shoulder
Hand	• wrist 15-40 degrees extension • MCP's 70-90 degrees flexion • IP's fully extended • thumb abducted and opposed • hand elevated above level of the elbow
Trunk	• midline
Hip	• abduction 15-20 degrees • hips in full extension
Knee	• full extension
Foot/Ankle	• neutral dorsiflexion

Effects of Improper Positioning

Body Part	Short Term Effects	Long Term Effects
Neck/Face	• extension contracture • side bending contractures • rotation contractures • flexion contractures • facial muscle contractures	• impaired visual gaze • increased/decreased cervical lordosis • impaired peripheral gaze • impaired eye contact • impaired swallow, articulation and mastication
Shoulder	• impaired glenohumeral rhythm • decreased scapular glide	• decreased ROM • impaired functional ability • decreased overhead movements • impingement syndrome • rotator cuff injury/tear

		• kyphosis
Elbow	• inability to fully flex and/or extend elbow • inability to fully supinate and/or pronate	• impaired hand to mouth movements • impaired functional ability/ADLs
Hand	• position of "comfort"	• decreased fine motor coordination • impaired hand to mouth movements • impaired functional ability/ADLs • impaired gross motor movements
Trunk	• side bending contractures • rotation contractures • extension contracture	• gait impairment • scoliosis • perceived leg length discrepancy • disc problems • impaired full trunk ROM • impaired rib/chest expansion • respiratory impairment
Hip	• flexion contracture • rotation contracture • adduction contracture	• impaired gait • decreased erect posture • low back pain • perceived leg length discrepancy • trochanteric bursitis • sciatica type symptoms
Knee	• flexion contracture • decreased full flexion	• impaired gait • perceived leg length discrepancy • low back pain • scoliosis
Ankle	• plantar flexion contracture • equinovarus deformity	• footwear problems • skin breakdown • deformities (bunions, calluses, etc.) • impaired gait • gait instability • need for orthotic footwear

Resources

Arizona Burn Center
2601 E Roosevelt
Phoenix, AZ 85008
(602) 344-5726
www.azburncenter.com

Foundation for Burns and Trauma
111 W. Monroe Street, Suite 1512
Phoenix, AZ 85003
(602) 230-2041
www.azburn.org

American Burn Association
625 N. Michigan Ave., Ste 2550
Chicago, Illinois 60611
(312) 642-9260
www.ameriburn.org

The Phoenix Society for Burn Survivors
1835 R W Berends Dr. SW,
Grand Rapids, MI 49519-4955
1-800-888-2876
www.phoenix-society.org

Burn survivor online links http://www.burnsurvivorsonline.com

International Society of Burn Injuries http://www.worldburn.org

Surgical burn information http://burnsurgery.org

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