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Inpatient Rehabilitation Following Severe Burn Injury

MARIA TWICHELL, MD
Assistant Professor, Department of Physical Medicine and Rehabilitation
University of Pittsburgh School of Medicine

GRACE O'NEALE, MD
Resident, Department of Physical Medicine and Rehabilitation
University of Pittsburgh School of Medicine

Clinical Vignette

JD is a 50-year-old male with a past medical history of type II diabetes mellitus who presented to the emergency department after scalding oil from a fryer doused him during a workplace accident. He had 50% total body surface area (TBSA) burns predominantly over his face, torso, and bilateral upper extremities. The burns to his right arm were deep partial to full thickness, while the remaining burns were superficial partial thickness. He was admitted to the UPMC Trauma Burn intensive care unit (ICU) for acute burn management. Two days after admission, a feeding tube was placed and continuous tube feeding began for nutritional optimization. The following day, his burn wounds were excised, and he underwent the first in a series of grafting surgeries. His course included respiratory insufficiency, anxiety, hyperglycemia and cellulitis on graft donor sites. Plastic Surgery, Acute Pain Service, Psychiatry, and Endocrinology assisted in management. He received hydrotherapy and dressing changes after premedication with intravenous (IV) opioids. He was tachycardic and hypertensive in the setting of pain, pruritus and anxiety and had limited range of motion (ROM) in his joints. Physical Medicine and Rehabilitation (PM&R) was consulted at the time of admission to provide guidance on therapeutic exercise and medication optimization. At six weeks from his accident, he was medically stable but had extensive functional deficits that required comprehensive inpatient rehabilitation.

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Disclosures

Drs. Twichell and O'Neale report no relationships with proprietary entities producing health care goods and services.

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UPMC Mercy is nationally ranked #10 in rehabilitation by *U.S. News & World Report.*

Epidemiology

Approximately 489,000 burns required medical care in 2017 with three-quarters of injuries occurring at home.[1] Roughly 40,000 of these patients needed hospitalization, with 30,000 patients admitted to an American Burn Association (ABA) verified burn center. Three-quarters of burn hospitalizations result from flame or scalding injury, with the remainder due to direct contact, electrical, chemical and other causes. Inhalation injuries contribute to the risk of death; however, 96.8% of patients admitted to the burn center will survive and may require rehabilitative care.[2]

Evaluation

Initial management performed by the burn team includes resuscitation and evaluation of burn depth. Burn depth is determined by the layers of skin involved and is classified as superficial, superficial partial, deep partial and full thickness. Superficial partial thickness burns affect the epidermis while deep partial thickness burns extend into the dermis. Full thickness burns extend into subcutaneous tissue. While superficial partial burns can be managed with intensive wound care, deep partial thickness and full thickness burns require skin grafting.[3]

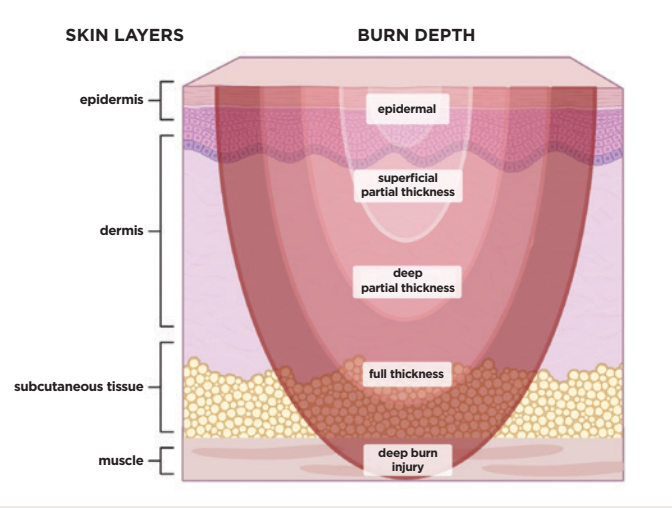

Figure 1: Burn depth. *Created with BioRender.com*

At our institution, Physical Medicine and Rehabilitation consultation occurs at admission, allowing for involvement along the patient's course. Essential elements of the history and exam include the following: how the burn occurred; pre-injury functional status and activity level; etiology, classification, and TBSA of the burn injury including the initial modified Lund-Browder chart documented by the acute care team; concomitant injuries and plans for surgical salvage versus amputation; indications for and locations of escharotomy sites; pain; need for positioning and splinting; current activities of daily living (ADLs) and mobility, psychosocial components; and short-term and long-term treatment goals. Exam should include measurement of edema, ROM, strength, sensation, and scar assessment.[3] All acute surgical interventions should be completed prior to admission to inpatient rehabilitation to minimize interruption of the comprehensive therapy program.

Burn patients should meet standard Interqual criteria to be considered for inpatient rehabilitation, including ability to tolerate and participate in greater than 3 hours of therapy daily, ongoing medical issues to be managed by a physiatrist, and care needs that cannot be coordinated in a subacute nursing facility (SNF) environment. Depending on the functional limitations of the individual patient, a typical length of stay is 2-4 weeks, followed by discharge to home. Family training and self-management of wounds and dressings is also emphasized.

Treatment

Hydrotherapy

In our institution, patients with burn injuries in inpatient rehabilitation receive daily burn wound care in hydrotherapy provided by burn certified nurses and physicians. Hydrotherapy is scheduled at the beginning of the day to minimize interruption of therapies. Prior to hydrotherapy, patients are pre-treated for anticipated procedural pain (see page 3). Dressing changes and wound care are provided once daily with emollients applied to healed areas multiple times per day by nurses or occupational therapists. Emphasis is placed on patient teaching for self-management as well as family training.

Management of Pain and Mood

An effective pain regimen should include medications that will address background, breakthrough, procedural and post-operative pain. Acutely, opiates are the foundation of pain management, but can be weaned during the rehabilitation stay. Adjuvant pain medications such as nonsteroidal anti-inflammatory drugs (NSAIDs) and acetaminophen can reduce the need for higher doses of opiates. Gabapentin may help to address neuropathic pain.[4] A typical regimen would consist of 3-4 doses per day of scheduled acetaminophen and gabapentin with opiates for breakthrough pain or prior to therapy. In addition, IV pain medications such as hydromorphone are beneficial to reduce discomfort associated with dressing changes. As part of a multimodal approach to burn pain, the ABA Guidelines on the Management of Acute Pain recommends nonpharmacologic inventions such as cognitive-behavioral therapy and virtual reality.[5] A consultation to the Chronic Pain Service may be beneficial to consider methadone, rotation of medications or dosage adjustments for patients whose pain is refractory.

Providers should also treat psychological pain modifiers such as anxiety that may exacerbate pain. In refractory cases, benzodiazepines can reduce anxiety related to dressing changes or procedures. While in inpatient rehabilitation, patients may receive neuropsychological services and be provided with outpatient resources. Psychiatry can be helpful for adjusting medications to address acute stress reaction, post-traumatic stress disorder (PTSD), anxiety and insomnia. Patients also benefit from including stress reduction and relaxation techniques.

Pruritus

Post-burn pruritus affects greater than 90% of adult burn survivors and reduces quality of life.[6] An estimated 40% of patients will continue to experience post-burn pruritus at 12 years post burn injury.[7] Pathophysiology involves both pruritogenic and neuropathic pathways. Neuropeptides secreted from nerves innervating the skin are needed to promote epidermal, connective tissue and vascular cell proliferation. These neuropeptides also increase the sensitivity of the itch receptors. The itch sensation is carried via unmyelinated C afferent fibers to the central nervous system. Antihistamines such as cetirizine, hydroxyzine, and diphenhydramine are the mainstay of treatment and can be used in combination with H2 blockers such as famotidine for greater efficacy. Gabapentin or pregabalin can also be an effective treatment option especially in chronic post-burn pruritus. Topical emollients and massage also have a role in treatment. Adjunct treatments with botulinum toxin, naltrexone, tricyclic antidepressants, selective serotonin reuptake inhibitors, and behavioral therapies have also been described but are not widely used.[7]

Nutrition

The resting energy expenditure of a person with severe burns is 1.3 to 1.5 times greater than persons without burns. The increased nutritional requirements of burn patients are due to the anabolic demands of wound healing, thermal dysregulation, adrenal hyperactivity and skeletal muscle catabolism.[3] Nutritional support is therefore an important facet of comprehensive burn rehabilitation. While PO intake is preferred, supplemental enteral feeds may be used to optimize intake initially when sufficient calories cannot be taken by mouth.

In addition to increasing caloric intake, several pharmacologic interventions may be used to mitigate the effects of the hypermetabolic state. Oxandrolone, an analog of testosterone, may be used for up to two years to promote protein synthesis and reduce muscle protein loss in burn patients. Oxandrolone is dosed at 0.1 mg/kg twice daily. Important benefits of oxandrolone include improving lean muscle mass, protein synthesis, bone density and muscle strength as well as reduced time between surgeries. The 1% risk of hepatic dysfunction and of hirsutism should be kept in mind, but overall, this medication poses minimal risk.[8] Propranolol reduces cardiac work, liver steatosis, and muscle catabolism through beta-adrenergic blockade. Metformin or insulin may be used for the hyperglycemia and insulin resistance that occur as part of the stress response to burn. In many cases, the combination of these pharmacologic interventions provides positive outcomes compared to controls.[8]

Exercise

Porter et al. described the impact of exercise on cardio-pulmonary function and skeletal muscle mass after major burn injury.[9] Patients demonstrated reduced exercise capacity and pulmonary function following burn injury, and VO_2 max significantly improved with an exercise training program. Exercise training also improves muscle lean mass, strength, and reduced requirement for contracture releases. Disseldorp et al. conducted a systematic review of 11 studies which showed that persons with severe burns scored worse on measures of physical fitness compared to burn patients participating in a 12-week exercise training program.[10] The ABA published guidelines for burn injury exercise prescription are based on 20 reports evaluating adult and pediatric patients. Adult patients who demonstrate less than normal strength should be prescribed a resistance and/or aerobic exercise program under supervision as early as discharge from acute care for 6-12 weeks.[11]

Progressive Resistive Training	Aerobic Conditioning Program
Baseline Evaluation	**Baseline Evaluation**
Instruct in correct weight lifting technique Warm up with lever arm and bar or wooden dowel Attempt to lift a weight 4 times If successful, with correct technique, 1 min rest Lift progressively increased amount Continue until unable to perform 4th repetition Final weight/load = 3RM	Standardized treadmill exercise test (modified Bruce Protocol) Oxygen consumption and heart rate measured Begin to walk on treadmill 1.7 mph 0% grade 3-minute intervals – increase speed and incline VO_{2peak} = respiratory exchange ratio ≥ 1.10 and peak volitional effort achieved
Resistance Exercises	**Aerobic Exercises**
Eight exercises: bench press, leg squats, shoulder press, leg press, biceps curl, leg curl, triceps curl, toe raises 1st week: 50-60% 3RM 4-10 reps x 3 sets 2nd - 6th week: 70-75% 3RM 4-10 reps x 3 sets 7th - 12th week: 80-85% 3RM 8-12 reps x 3 sets 1 minute rest between sets	5 minutes warm up (<50% treadmill or cycle ergometer VO_{2peak}) 30 minutes (70-85% treadmill or cycle ergometer VO_{2peak}) 5 minutes cool down (<50% treadmill or cycle ergometer VO_{2peak})
30 minutes / 3 non-consecutive days/week x 12 weeks	30 minutes / 5 days / week x 12 weeks

mph = miles per hour; RM = repetition maximum; VO_{2peak} = peak oxygen consumption

Table 1: Progressive resistive training and aerobic conditioning program evaluation and training program details in Galveston studies.[11]

Therapy

Hypertrophic Scarring

Hypertrophic scarring is defined as a raised scar above skin level but within the original burn injury that demonstrates decreased elasticity within the collagen matrix, increased cellularity and evidence of prolonged inflammation. Patients with certain individual factors, including race, age, genetic predisposition, hormone levels, atopy, and wound size may be predisposed to hypertrophic scarring. Hypertrophic scarring usually presents 1-3 months after injury and is cosmetically and functionally limiting. Treatment of hypertrophic scarring includes use of compression garments with silicone inserts worn 23 hours per day, cortisol injections, surgical release, and laser treatments.

Burn scar massage is a key component of the rehabilitation program to reduce or prevent more intensive treatments later in the healing process. A review article by Ault et al. shows that massage lessens the development of hypertrophic burn scar, including scar height, and improves skin vascularity and pliability, patient-described pain, pruritus and depression.[12] Cho et al. conducted a randomized controlled trial of individuals with completely healed burns and grafts, with one group receiving standard of care rehabilitation program and another group receiving standard of care therapy with massage. Participants in the massage group received a mean of 12 sessions (3 per week, 30 minutes per session). Those in the massage group had subjective improvements in scar pain and pruritus, and objectively improved measures such as thickness, melanin deposition, erythema, skin moisture and elasticity.[13] Another randomized controlled clinical trial assessing the effects of a 12-week massage program completed by Nedelec et al. demonstrated benefits in scar elasticity at week 2 and scar thickness at week 3, although these improvements were not maintained at the end of treatment.[14] It should be reiterated that burn scar massage is only completed over those burn and graft sites that have completely healed and epithelialized.

Contracture Prevention

Stretching is utilized to combat unopposed wound contraction and tissue shortening. Gentle, slow, prolonged stretching is

Figure 2: Hypertrophic scar after burn injury.

From personal archive used with patient permission.

preferred over high-velocity stretching to reduce injury to fragile tissue. Stretching can be maintained by splinting in the antideformity position. Stretching should begin during the post-operative phase to ensure adequate tissue length to allow for full joint range of motion. For example, shoulder positioning in abduction greater than 110 degrees post-op has a better functional outcome compared to shoulder positioned at 90 degrees or less of abduction.[15]

The adage "The position of comfort is the position of contracture" should be kept in mind during the post-op period as patients may prefer limb positions that shorten muscle length. Maintaining a more functional position while patients are in bed or immobilized should be emphasized. In the lower extremities, this includes keeping the hips at neutral, knees in extension and ankles at 90 degrees of dorsiflexion. The trunk should be straight without lateral bending or flexion. Upper limb positioning should keep the shoulders abducted, elbows in approximately 30 degrees of flexion, wrists in 20-40 degrees of extension, with metacarpophalangeal joints in 40-60 degrees of flexion. The thumb should be in radial abduction. Proximal and distal interphalangeal joints should be fully extended.

Despite efforts in acute care, some patients arrive at inpatient rehabilitation with loss of range of motion. Godleski et al. developed a 1-hour stretching protocol incorporated into the comprehensive inpatient rehabilitation program. Patients are pre-medicated with analgesia prior to therapy and are placed supine with the joint of interest stretched in one plane of motion. Once maximal stretch has been reached, it is held for 3 minutes. If there is restriction in multiple planes of movement across a joint, the stretch is repeated in all affected planes. This protocol is repeated for each joint of concern. Range of motion is measured weekly with a goniometer. Improvement in range of motion, particularly in knee flexion and shoulder abduction was demonstrated despite ongoing scar maturation and contraction. It was also noted that the time spent doing the stretching protocol did not adversely affect other rehabilitation outcomes such as Functional Independence Measure (FIM) scores. This protocol was shown to be safe and effective as part of a comprehensive rehabilitation program. [16]

Early Mobility

Early mobility in the ICU has been a long-term tenet of burn care. Burn patients may have comorbid conditions requiring immobility, such as prolonged ventilation due to inhalation or other respiratory conditions, aggressive sedation for pain management, additional traumatic injuries, or mobility and range of motion restrictions after recent grafting. Range of motion and weightbearing restrictions vary after grafting, but in our institution, these limitations are typically less than 3 days for autografts.

Early mobility therapy focuses on elongation, stretching, maintaining range of motion, contracture prevention, edema reduction, static and dynamic bracing. In addition, dynamic activities such as transferring to a chair, maintaining sitting position, and supported standing are implemented. These activities, while not conferring a mortality benefit, are associated with reduced incidence of pneumonia, deep vein thrombosis, reduced number of hospital and ICU days, and improved peripheral and respiratory muscle strength.[17]

Burn Complications

Patients with burn injuries may experience a variety of complications. Early in the acute course, inhalation injury and compartment syndrome are diagnosed and managed by the critical care and surgical teams. The incidence of inhalation injury is 7.7%, higher with increasing total body surface area up to 80-89% TBSA. Inhalation injury is a strong predictor of burn mortality.[18]

During the rehabilitation stay, physiatrists will continue to manage and diagnose complications. Approximately 10% of persons with burns are affected by peripheral neuropathies and median neuropathy is the most frequent injury but polyneuropathy is also common. Causes of nerve injury include direct thermal or electrical injury, excessive escharotomy or fasciotomy, soft tissue edema, metabolic derangements, immobilization, and heterotopic ossification. Diagnosis is made with careful neurological examination and electrodiagnostic testing. Often electrodiagnostic testing can be deferred to the outpatient setting. As in the general population, focal neuropathies may be managed with decompression, physical therapy, occupational therapy, splinting, and neuropathic pain medication.[19]

Heterotopic ossification (HO) affects 3.5% of persons with burns,[20] with the posterior elbow being the most common site.[21] Risk factors include greater than 30% TBSA burn, arm burns, arm grafts, number of ventilator days, and number of trips to the operating room. HO may be diagnosed as early as 2.5 weeks after formation on triple phase bone scan. The lesion will begin to be visible on x-ray between 3 and 8 weeks. HO is treated with NSAIDs and potentially surgical resection once the bone has matured.[20]

As patients continue to heal in the outpatient setting, hypertrophic scarring may develop, burn scar pruritus persists, and mood disturbances may progress to depression and PTSD. Following discharge from inpatient rehabilitation, the physiatrist should address ongoing rehabilitative needs including medication management, therapy prescriptions, driving assessments and return-to-work evaluations. Patients may also follow with other specialists for management of late burn complications such as scar contracture release and chronic pain management. The physiatrist serves to assist the patient in coordination of care in this phase of rehabilitation.

Clinical Vignette Outcome

While he was in inpatient rehabilitation, physical therapy provided passive stretching and worked with JD on functional mobility and occupational therapy provided ADL training, desensitization and scar massage. He progressed well completing daily hydrotherapy and weaned off IV pain medications. He benefited from an appetite stimulant that reduced his anxiety. After eighteen days in inpatient rehabilitation, he was discharged home with home health services and was instructed to follow up in PM&R burn clinic, continue hydrotherapy and see his plastic surgeon.

On his initial outpatient physiatric follow up, he was measured for pressure garments and referred to psychotherapy for adjustment to disability. Despite undergoing scar massage with physical and occupational therapy and wearing his compression garments 23.5 hours a day, he developed significant hypertrophic scarring and some areas of open wounds. He followed up with Plastic Surgery due to right upper extremity contractures and underwent staged burn scar contracture release and lasering. On subsequent PM&R follow up visits, his pain and anxiety medications were slowly weaned off. He was prescribed vehicle adaptations to resume adaptive driving and recently returned to work as a cook.

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ADDRESS CORRESPONDENCE TO:

Michael C. Munin, MD
Senior Editor and Vice Chairman
Strategic Planning and Program Development
Department of Physical Medicine and Rehabilitation

Kaufmann Medical Bldg.
Suite 201
3471 Fifth Ave.
Pittsburgh, PA 15213

T: 412-648-6848
F: 412-692-4410
Email: muninmc@upmc.edu

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