

BURN INJURIES

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Introduction and Definition of Burn Injuries

Burn injuries represent one of the most severe forms of physical trauma encountered in modern medicine, often resulting in profound and protracted physical, psychological, and socioeconomic consequences. Defined fundamentally as damage to the skin and underlying tissues caused by thermal, chemical, electrical, or radiation energy, these injuries initiate a complex cascade of inflammatory and systemic responses. The skin, the body's largest organ, serves as the primary barrier against infection and plays a crucial role in thermoregulation and fluid balance. When this barrier is compromised by a significant burn, the entire homeostatic system of the body is immediately threatened, leading to potential complications such as hypovolemic shock, infection, and multiorgan failure. Consequently, the management of severe burns requires specialized, multidisciplinary care, often spanning years of rehabilitation.

The scope of disability stemming from a burn injury extends far beyond the immediate wound healing process. Victims frequently grapple with extensive scarring, contractures, chronic pain, and nerve damage, which severely limit mobility and function. Furthermore, the visible nature of these injuries often precipitates significant emotional distress, including issues related to body image disturbance, **post-traumatic stress disorder (PTSD)**, and challenges related to social reintegration. Understanding the multifaceted nature of burn trauma--from the initial cellular damage to the long-term psychosocial adjustment--is critical for healthcare professionals aiming to provide comprehensive care and improve the quality of life for survivors. This entry explores the etiology, classification, acute treatment, and long-term physical and psychological interventions necessary in the field of burn care.

Classification and Severity of Burns

The clinical assessment of a burn injury relies heavily on classifying its depth, which dictates the severity and subsequent treatment protocol. Historically, burns are categorized into degrees based on the layers of tissue damaged. Accurate depth assessment is crucial because it informs decisions regarding conservative management versus surgical intervention, such as excision and grafting. The common system uses first, second, third, and sometimes fourth degrees to describe the injury penetration, directly correlating the depth of damage with the risk of complications, including infection, scarring, and functional loss.

First-degree burns are the least severe, involving damage only to the epidermis, the outermost layer of the skin. These injuries typically present with redness (erythema), mild swelling, and pain, but importantly, they blanch with pressure. A common example is a mild sunburn or a brief flash contact with a hot object. Healing usually occurs spontaneously within three to six days without scarring, as the barrier function of the skin remains largely intact. Treatment is generally symptomatic, focusing on pain relief, often utilizing over-the-counter pain medications, and

moisturizing the affected area to alleviate discomfort and support natural healing.

Second-degree burns, also known as partial-thickness burns, involve the entire epidermis and extend into the dermis. These are further subdivided into superficial and deep partial-thickness burns. Superficial second-degree burns cause blistering, weeping, and are exquisitely painful because the nerve endings in the superficial dermis remain functional. They typically heal within two to three weeks with minimal scarring if infection is prevented. In contrast, **deep second-degree burns** involve deeper layers of the dermis, may appear mottled (white and waxy), and are often paradoxically less painful due to nerve destruction at the site of injury. These injuries take significantly longer to heal, often exceeding three weeks, and carry a high risk of hypertrophic scarring and contracture formation, necessitating careful wound care and potential surgical consultation.

Third-degree burns, or full-thickness burns, are catastrophic, destroying the entire epidermis and dermis, often extending into the subcutaneous fat layer. The affected area appears leathery, dry, and may be white, brown, or charred black. Sensation is completely absent in the center of the burn due to the total destruction of nerve endings. Since all epithelial cells are destroyed, these wounds cannot heal spontaneously; they require immediate and aggressive surgical intervention, typically involving excision of the damaged tissue and **skin grafting**. Fourth-degree burns represent the most extreme classification, extending through the skin into underlying structures such as muscle, tendon, or bone, often resulting in permanent loss of function and potentially requiring amputation or extensive, complex reconstructive surgery.

Etiology: Common Causes of Burn Trauma

The causes of burn injuries are diverse, arising from exposure to excessive heat, cold, electrical currents, radiation, or specific chemicals. Identifying the mechanism of injury is vital for appropriate initial management, as different etiologies present unique physiological challenges, and for implementing effective preventative measures in public health campaigns. According to epidemiological data compiled by organizations such as the American Burn Association, thermal injuries--those resulting from flame or hot liquids--remain the most prevalent cause across all age groups, particularly in domestic and occupational settings.

Thermal burns primarily result from exposure to flame (dry heat) or scalding liquids (moist heat or steam). Fires, often originating from cooking accidents, faulty heating systems, or accidental ignition of flammable materials in the workplace, are responsible for the most extensive and life-threatening forms of burn trauma, frequently associated with dangerous **inhalation injuries** which significantly complicate patient prognosis and increase mortality risk. Scald injuries, particularly prevalent among young children and the elderly due to reduced mobility and reaction time, occur when hot liquids, such as boiling water or steam, come into contact with the skin. The duration of

contact and the temperature of the liquid are critical determinants of the injury depth; for instance, water heated to 150°F can cause a full-thickness burn in just two seconds.

Other significant etiologies include **chemical burns**, **electrical burns**, and **radiation burns**. Chemical burns are caused by contact with strong acids (which typically cause immediate, localized coagulation necrosis) or alkalis (which cause deeper, more progressive liquefaction necrosis), commonly found in industrial settings and household cleaning agents. Alkali burns are often more insidious as they penetrate tissues deeply and continue to cause damage long after initial contact, necessitating prolonged irrigation. Electrical burns, such as those resulting from faulty wiring, industrial accidents, or lightning strikes, are particularly deceptive; the superficial damage may appear minor, but the current often causes extensive, deep tissue injury along the pathway of current flow through the body. This internal damage can lead to muscle breakdown (rhabdomyolysis), cardiac arrhythmias, and kidney failure. Finally, radiation burns, ranging from severe sunburns caused by ultraviolet radiation to high-dose exposure from industrial sources or therapeutic interventions (like radiation oncology), contribute to the spectrum of burn pathology, often presenting with delayed onset and persistent damage.

The Pathophysiology and Immediate Effects

The physiological response to a major burn injury is systemic and highly complex, extending far beyond the localized wound site, initiating immediate cardiovascular instability and a long-term hypermetabolic state. The acute local damage is characterized by three concentric zones: the **Zone of Coagulation**, the central area of irreversible tissue death; the **Zone of Stasis**, the surrounding area of compromised circulation that is potentially salvageable with prompt intervention; and the Zone of Hyperemia, the outermost area of increased blood flow that typically recovers. The immediate destruction of the skin barrier leads to massive fluid losses due to increased capillary permeability and the leakage of plasma proteins into the interstitial space, resulting in burn shock, a severe form of hypovolemic shock. This fluid shift, often peaking within 8 to 12 hours post-injury, requires aggressive intravenous fluid resuscitation, carefully guided by established formulas like the Parkland formula, to prevent cardiovascular collapse and maintain essential organ perfusion.

Following the initial shock phase, the body enters a profound **hypermetabolic state**, which is characterized by significantly increased resting energy expenditure, elevated core body temperature, and systemic catabolism (tissue breakdown). This metabolic overdrive is driven by the sustained release of powerful inflammatory mediators (cytokines, prostaglandins, histamines) and potent stress hormones (cortisol, catecholamines). The hypermetabolism serves two primary purposes: to fuel the extensive wound healing process and to maintain body temperature due to the loss of the skin's regulatory function. However, if unmanaged, this persistent catabolic state ultimately leads to severe muscle wasting, profound weight loss, and chronic immunosuppression.

Managing this critical phase involves rigorous nutritional support, aggressive infection control, and specialized pharmacological interventions to modulate the inflammatory response.

Furthermore, the compromised integrity of the skin barrier renders the burn patient highly susceptible to infection, which historically remains the leading cause of morbidity and mortality in specialized burn units. The presence of necrotic tissue provides an excellent, nutrient-rich medium for rapid bacterial colonization, and the systemic inflammatory response concomitantly impairs the immune system's ability to effectively clear pathogens. Aggressive and continuous surveillance for wound sepsis and systemic infection is paramount, often requiring timely surgical debridement of dead tissue, the use of specialized topical antimicrobial agents, and the targeted administration of systemic antibiotics. The immediate pathophysiology of a severe burn injury is thus a dynamic process, requiring constant attention to hemodynamic stability, meticulous pain control, and preventing the conversion of the potentially salvageable Zone of Stasis into the irreversible Zone of Coagulation.

Medical Management and Acute Treatment

The acute medical management of severe burn injuries requires immediate, standardized, and highly coordinated care, frequently necessitating rapid stabilization and transfer to specialized burn centers equipped with the necessary expertise and technology. Initial priorities adhere strictly to the trauma protocol (Airway, Breathing, Circulation), with paramount emphasis placed on securing the airway, especially if facial burns or suspected smoke inhalation injury are present, as airway edema can progress rapidly and fatally. Once the patient is stabilized, the focus shifts to calculating the **Total Body Surface Area (TBSA)** affected, initiating precise intravenous fluid resuscitation based on TBSA and patient weight, and commencing meticulous wound care. The overall treatment regimen is intensive and multi-phased, moving systematically from initial stabilization to surgical reconstruction.

Wound care involves continuous monitoring, cleaning, and prompt surgical debridement. Necrotic tissue must be removed (excised) quickly, as it harbors bacteria, generates an inflammatory burden, and inhibits the natural healing process or successful grafting. Specialized **topical antimicrobial agents**, such as silver sulfadiazine or mafenide acetate, are routinely applied to prevent infection and promote a clean, granulated wound bed. For deep partial-thickness and full-thickness burns, surgical intervention beyond debridement is mandatory. A crucial, life-saving procedure is **escharotomy**, a surgical incision made through the leathery, non-elastic eschar, which may be required to relieve pressure and restore circulation, particularly in circumferential burns of the limbs, chest, or torso, which can otherwise lead to compartment syndrome or restricted breathing.

The definitive treatment for full-thickness skin loss is **skin grafting**. Autografts, where healthy skin

is harvested from an uninjured donor site on the patient's own body, are considered the gold standard because they provide permanent wound coverage and eliminate the risk of immunological rejection. These harvested grafts are often "meshed" to create small perforations, allowing the graft to expand and cover a larger area while facilitating drainage. Temporary biological dressings, such as allografts (from deceased human donors) or xenografts (from animals, typically porcine), may be used to temporarily cover excised wounds awaiting definitive autografting or to promote healing in indeterminate-depth burns. Following successful grafting and initial healing, physical and occupational therapy commences immediately to prevent debilitating contractures and maintain functional range of motion, establishing the foundation for long-term rehabilitation.

Long-Term Physical and Functional Outcomes

Survival of the acute phase of a severe burn injury marks the beginning of a long and challenging rehabilitation journey focused intensely on functional recovery and minimizing permanent disfigurement. The most pervasive long-term physical sequelae include pathological scarring, joint contractures, chronic pain syndromes, and peripheral nerve damage. Scarring, particularly **hypertrophic scarring** and keloid formation, results from an abnormal and prolonged wound healing response characterized by excessive and disorganized collagen deposition. These scars can be raised, rigid, erythematous (red), intensely pruritic (itchy), and significantly restrict movement, especially when they cross major joint lines, severely limiting a patient's functional independence.

Management of scarring and the prevention of contractures is central to the rehabilitation process and demands exceptional patient compliance. This often involves the rigorous, continuous use of custom-fitted **pressure garments**, silicone sheeting, and serial splinting, which must be worn consistently, sometimes for 12 to 24 months post-injury, to physically modulate collagen synthesis and flatten the scars. Physical and occupational therapy are non-negotiable, indispensable components of this phase, utilizing aggressive stretching, strengthening exercises, specialized massage techniques, and modalities to maximize joint mobility, increase muscle endurance, and restore activities of daily living (ADLs). Due to the complexity and rigidity of mature scars, many patients require multiple sessions of staged **reconstructive surgery** over several years to release contractures, improve aesthetic appearance, and enhance overall functional capacity.

Chronic pain is another debilitating long-term outcome, often stemming from underlying nerve damage (neuropathy), the persistent inflammatory state of the healing skin, or musculoskeletal issues related to altered gait and restricted movement. Patients may experience burning, shooting pain, or severe hypersensitivity (allodynia) in the scarred areas, which significantly compromises sleep and quality of life. Furthermore, the destruction of sweat glands and sebaceous glands in the burned area often leads to severe problems with **thermoregulation**, causing patients to overheat

easily in warm environments, and chronic dryness, which requires lifelong application of specialized moisturizing routines and sun protection. Addressing these complex physical issues requires a highly integrated approach involving pain specialists, dermatologists, rehabilitation therapists, and plastic surgeons.

Psychological and Emotional Impact

The psychological burden associated with sustaining a major burn injury is profound and frequently underestimated, encompassing a wide range of emotional, cognitive, and behavioral consequences that often require specialized intervention. Suffering a major burn is classified as a highly traumatic event, leading to a significant prevalence of **Post-Traumatic Stress Disorder (PTSD)**, acute stress disorder, major depressive disorder, and generalized anxiety among survivors. The intensive care environment, the painful wound care procedures, the fear of mortality, and the realization of permanent change all contribute substantially to these mental health challenges during the acute phase, while the long-term struggle with altered appearance and functional deficits fuels chronic psychological distress.

One of the most challenging psychological outcomes is the severe disturbance of **body image**. Visible scarring, alopecia, and disfigurement can lead to intense social avoidance, feelings of shame, and self-consciousness, severely impacting self-esteem, confidence, and the establishment of healthy interpersonal relationships. Many survivors experience difficulties returning to their previous roles in work or school and often face societal stigma, sometimes leading to self-isolation. Therefore, comprehensive psychological intervention, commencing as early as possible in the recovery trajectory, is absolutely essential. **Psychotherapy**, including specialized modalities such as Cognitive Behavioral Therapy (CBT) and Eye Movement Desensitization and Reprocessing (EMDR), is crucial for helping individuals process the initial trauma, manage chronic pain, and develop effective coping strategies for navigating social reintegration and appearance-related concerns.

In addition to individual therapy, the role of social support cannot be overstated in promoting long-term resilience. **Support groups** provide a vital platform for burn survivors to share their experiences candidly, validate mutual feelings, and reduce the pervasive sense of isolation by connecting them with others who genuinely understand the unique physical and emotional challenges of recovery. Furthermore, family therapy is often necessary, as the emotional strain, physical care demands, and financial burden of a severe burn injury impact the entire family unit, requiring adjustments and support for all members. Ensuring continuous access to specialized mental health services throughout the rehabilitation process is paramount for achieving holistic recovery and enabling individuals to lead satisfying and functionally integrated lives despite the physical and emotional scars.

Prevention Strategies and Public Health Initiatives

Given the significant severity, high cost, and debilitating long-term consequences of burn injuries, prevention is recognized globally as the most effective and cost-efficient public health strategy. Prevention efforts must be multifaceted, targeting high-risk environments such as the home, the workplace, and specific vulnerable populations, including very young children and the elderly, who lack the mobility or cognitive capacity to react quickly to burn hazards. Education and broad public awareness campaigns play a pivotal role, focusing intensely on reducing the incidence of the most common causes: residential fires and scalding injuries.

Key preventative measures universally recommended in the home include the mandatory installation and regular testing of **smoke detectors** and carbon monoxide alarms on every level of the residence, establishing and meticulously practicing fire escape plans, and teaching fundamental fire safety and "stop, drop, and roll" techniques to all family members. Scald prevention is critical, involving setting domestic water heater temperatures to no higher than 120°F (49°C), ensuring pot handles are always turned inward on stoves to prevent accidental tipping, and supervising children closely in kitchens and bathrooms, particularly near hot water sources.

In occupational settings, strict adherence to established safety protocols, the proper storage and handling of corrosive chemicals, and the mandatory use of appropriate **Personal Protective Equipment (PPE)** are essential to mitigate industrial, chemical, and electrical burn risks. Public health initiatives often involve legislative action, such as mandates for flame-retardant materials in children's sleepwear and furniture, and proactive community outreach programs designed to distribute essential safety devices like smoke alarms and fire extinguishers to low-income populations. By increasing public awareness regarding the inherent dangers associated with heat sources, electricity, and chemicals, and by promoting simple, actionable safety steps, the incidence and severity of burn trauma can be significantly reduced, thereby alleviating the immense burden on specialized healthcare systems and improving overall population health outcomes.

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