Burns: pathophysiology and treatment challenges

Pathophysiology

Burn injuries result in both local and systemic responses.

Local response: The local tissue response to a burn can be characterized by three concentric zones first described by Jackson in 1947 (Figure 1): the zone of coagulation, the zone of stasis, and the zone of hyperemia.[1]

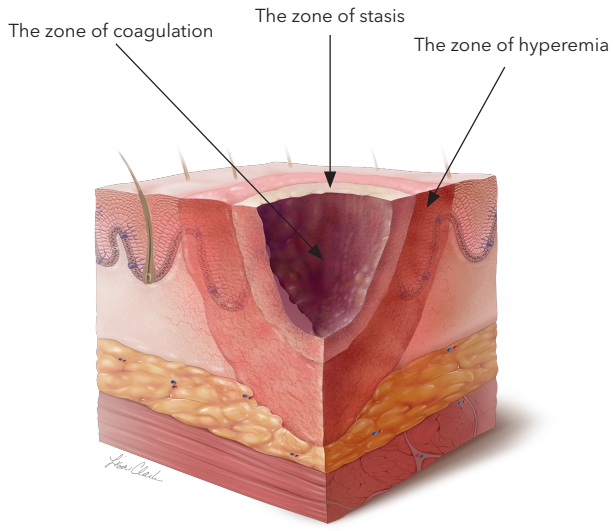
The zone of coagulation occurs at the point of maximum damage and is characterized by irreversible tissue death due to coagulation of the structural proteins.[1] The zone of stasis is characterized by decreased blood flow (perfusion) to the tissue. Tissue in this zone may be saved if perfusion can be restored; however, prolonged perfusion or infection may still result in tissue death.[2] In the outermost zone, the zone of hyperemia, tissue perfusion, edema, and inflammation are often increased, and the injured tissue has a high probability of complete recovery.[2]

These zones are three dimensional in nature and often evolve and change over the course of several days following injury, a process known as burn progression or burn conversion.[3] If perfusion is not quickly restored to injured tissue in the zone of stasis, tissue loss in the zone will lead to the burn getting deeper and wider over time. Because this additional injury can occur several hours to a few days following the initial injury, the true extent of the burn is often not known when initial treatment decisions are made.[3]

Systemic response: The release of cytokines and other inflammatory mediators at the site of injury has a systemic effect when burns reach about 30% total body surface area that can lead to severe cardiovascular changes, respiratory changes, metabolic changes, and immunological changes.[1,4] Cardiovascular changes include increased capillary permeability leading to loss of intravascular proteins and fluid into the interstitial space, decreased myocardial contractility, and possibly systemic hypotension and organ hypoperfusion.[1] Respiratory changes include bronchoconstriction from the release of inflammatory mediators, leading to respiratory distress.[1] Metabolic changes include an increase in basal metabolic rate, which may place the patient in a persistent catabolic state that decreases the rate of recovery.[5] Patients may also become more susceptible to disease following burn injury due to a general, non-specific down-regulation of the immune response, and they may suffer from evaporative fluid loss, leading to hypothermia and/or dehydration.[6]

Because the systemic response to burns involves so many different organ systems, a multi-disciplinary care team involving dermatologists, respiratory therapists, orthopedic surgeons, nephrologists, nutritionists, physical therapists, immunologists, and psychologists may be needed to support the patient's complete recovery.

Figure 1: Jackson burn zone



Note: OASIS Burn Matrix is the product name in the U.S. OASIS Extracellular Matrix is the product name outside the U.S.

Treatment challenges

Management of the severely burned patient is a long-term process that must address the local tissue response as well as the systemic, psychologic, and social consequences of the injury. Initial emergency management can be complicated by burn conversion, which may lead to underestimating the burn severity and not recognizing the need for specialized care.[7]

Burns can be complicated by concomitant major trauma, such as fractures, traumatic brain injury, or other complex soft tissue injuries due to motor vehicle accidents with associated explosions, fires with structural collapse, falls while escaping a fire, electrical injuries and falls, scald burns during assaults, or explosions with airborne fragments.[8] In these cases, the highest priority is the assessment and treatment of immediately life-threatening injuries, then the management of the burn. Delays in initial patient management may prevent early assessment of the burn extent and depth, leading to complications and resulting in prolonged morbidity, scarring, disfigurement, and decreased quality of life.[9]

Severely burned patients require a large amount of fluid during resuscitation, which can contribute to the development of ileus, compartment syndromes, respiratory complications, and generalized edema, which can all complicate general patient care.[8] Prolonged hospitalization with limited mobility and edematous tissue can result in pressure ulcer formation, further limiting recovery.

Superficial and partial-thickness burns can be extremely painful, making pain management a priority. While pharmacologic means are often used to reduce pain perception, local burn care treatment practices (e.g., debridement, antiseptic agents, dressing changes) can exacerbate or ameliorate pain depending on the methods and the dressing types used.[6] Because prolonged pain has negative physical and psychological effects on recovery, using advanced burn treatment options that cover exposed nerve ends and quiet pain receptors may ensure a more rapid healing response.[10]

Prolonged complications of burns include wound infection and sepsis, ongoing hypermetabolism, hypertrophic scarring and keloid formation, and heterotopic calcification.[2,5,6,9,10] These challenges require long-term management and rehabilitation including frequent evaluation and prompt surgical management of contractures, timely management of skin graft loss, optimization of nutritional support to avoid loss of lean body mass as the hypermetabolic response persists, and psychosocial support to adjust to scarring and disfigurement while re-immersing into society.[2,5,6,9,10]

Summary

Delayed burn healing is associated with a hyperinflammatory response characterized by increased fibroblast and myofibroblast activity that can cause increased scarring and muscle contractures leading to permanent decreases in mobility and disfigurement. Therefore, overcoming the challenges of burn treatment through aggressive early assessment, advanced specialized patient care, and advanced methods to minimize recovery time and pain can ensure the best possible outcome for the severely burned patient.

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