Reflection

Evolution of the Field over Seven Decades

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KEYWORDS

• Burns • Fluid resuscitation • Inhalation injury • Burn wound care
• Metabolic response to injury • Organization of burn care and research

KEY POINTS

- Fluid resuscitation has moved from inadequate to excessive and is now returning to adequate.
- Reliable diagnosis and improved ventilatory management have reduced the comorbid effect of inhalation injury.
- The microbial ecology of the burn wound is constantly changing, with fungi now prominent and viruses emerging.
- Clinically effective biologic dressings require a bilaminate construction.
- Burn patients are internally warm, and the hypermetabolic response is wound directed.
- Multidisciplinary integrated clinical/laboratory research programs have provided the data that have improved burn care and significantly increased burn patient survival.

Both evolutionary and revolutionary changes have advanced the organization and delivery of burn care over the past 7 decades. Those changes have refined resuscitation, improved the diagnosis and treatment of smoke inhalation injury, virtually eliminated invasive bacterial burn wound sepsis, validated burn wound excision, defined *full service* metabolic support, expanded the goals of rehabilitation, and led to the development of a regionalized hierarchical system of burn treatment facilities.

In 1959, I was drafted after the second year of my surgical residency and reported to the US Army Surgical Research Unit (USASRU) to begin my 2 years of obligated military service as a member of the surgical staff of the Army Burn Center. I was impressed by the standard of care the burn patients received, which consisted of formulaic fluid resuscitation, prophylactic antibiotics, daily hydrotherapy and burn wound debridement, use of canine cutaneous xenografts for temporary wound

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coverage, and infusion of fat emulsions to supplement the diet of the extensively burned. The patients were nursed on rotating beds, and physical therapy consisting of functional splinting and both active and passive exercise was carried out daily. Physician-led aeromedical evacuation teams were also used to transfer patients from other military facilities and civilian hospitals.

FLUID RESUSCITATION

The historically high incidence of acute renal failure in patients with extensive burns or high-voltage electric injuries was recognized by the inclusion of a renal section within the USASRU and the presence of a Brigham-Kolff dialysis machine in that section. Even then, a greater understanding of the pathophysiology of burn injury, acquired in the first half of the twentieth century, had decreased the need for hemodialysis in burn patients. The clinical studies of Haldor Sneve[1] at the turn of the nineteenth century, the studies of Frank Underhill in patients from the Rialto Theater fire of November 1921 and in the laboratory, the clinical experience of the surgeons at the Boston City Hospital and the Massachusetts General Hospital with the patients from the Coconut Grove nightclub fire in November 1941, and earlier clinical experience at the USASRU, combined with the results of the animal studies of Henry Harkins, Alfred Blalock, and E.I. Evans had rationalized the fluid resuscitation of burn patients.[2] The analysis of those study results identified the biphasic omni-system response to burn injury (**Table 1**) and the sigmoid dose-response relationship of those changes to the extent of the burn injury (**Fig. 1**). An understanding of those relationships provided the scientific infrastructure for the research programs that have generated the data used to develop present-day burn care.

Appreciation of the relationships between the extent of burn and the volume of resuscitation fluid needed led to the development of formulae to predict burn patient resuscitation fluid needs. Arguably the first formula, based only on the extent of the burn, was recommended by the National Research Council at a meeting chaired by I. S. Ravdin in January 1942 for members of the military with burns sustained in combat in WWII.[3] Subsequently, formulae based on the extent of the burn and body weight were proposed and used as the Burn Budget Formula of Cope and Moore (1947), the Evans Formula (1952), and the Brooke Formula (1953).[2] Use of those formulae essentially eliminated burn shock and acute renal failure; but success led to excess, and the earlier complications of inadequate resuscitation were replaced by an increasing occurrence of acute pulmonary edema and compartment syndromes (**Box 1**).[4]

Table 1
Biphasic organ system response to injury

Organ System	Early Change	Later Status
Cardiovascular	Shock	Hyperdynamic
Urinary	Oliguria	Diuresis
Gastrointestinal	Ileus	Hypermotility
Musculoskeletal	Hypoperfusion	Hyperperfusion
Pulmonary	Hypoventilation	Hyperventilation
Endocrine	Catabolism	Anabolism
Immunologic	Inflammation (SIRS)	Suppression (CARS)
CNS	Agitation	Obtundation

Abbreviations: CARS, compensatory antiinflammatory response syndrome; CNS, central nervous system; SIRS, systemic inflammatory response syndrome.