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Wound healing in older adults with severe burns: Clinical treatment considerations and challenges

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Abstract

Background: The older adult population continues to rapidly expand in number, with a projection by the United States (US) Census Bureau that there will be more individuals older than > 65 years (77.0 million) than those younger than < 18 years (76.5 million) by 2034. This review provides an overview of aging as it relates to wound healing and burn injuries in older adult patients, summarizes current treatment practices, and addresses the key challenges and considerations for treating severe burn injuries in this specific patient population.

Materials and methods: A narrative literature search was conducted, focusing on recent primary literature on burns and wound healing in elderly patients.

Results: Studies showed that the aging process results in both physiologic (eg, nutritional and metabolic status) and anatomic changes (eg, thinning dermis) that contribute to a reduced capacity to recover from burn-injury trauma compared with younger patients. Owing to impaired vision, decreased coordination, comorbidities, and medication-induced side effects, older adults (ie, > 65 years) are susceptible to severe burn injury (deep-partial thickness and full-thickness), which is associated with significant morbidity and mortality.

Conclusion: A better understanding of the effects of age-related changes regarding wound healing in older adult patients who incur severe burn injuries may provide insight into clinical strategies to improve outcomes among this population.

Keywords

Aging; Burns; Burn treatment; Geriatric; Older adult; Wound healing

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Author Contributions

Both authors conceptualized this review and reviewed and revised each draft of the manuscript for important intellectual content, approved the final version for submission, and take responsibility for the final content.

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1. Introduction

The incidence of burn injuries among older adult patients is generally higher than that reported for younger adult patients [1,2]. In the United States (US), older adults (for the purposes of this review, patients aged ≥ 65 years are referred to as “older adults”) account for approximately 20% of patients who experience burn injuries, while in developing parts of the world (eg, Southeast Asia, the Middle East), older adults comprise < 5% of patients who have burn injuries [1]. However, the common types and severity of burn injuries can vary worldwide due to several factors, including lifestyle, culture, and socioeconomic status [3].

As of 2019, 16% of the US population were classified as “older adults” [4]. Moreover, the US Census Bureau projects that by 2034, for the first time in history, there will be more individuals aged > 65 years (77.0 million) than those aged < 18 years (76.5 million) [5]. In this scenario, it is likely that physicians in clinical practice in the US will encounter an increased number of older adult patients with burn injuries. The overall economic burden for adult patients aged > 60 years with burn injuries is high, as reported by the American Burn Association, National Burn Repository® between 2009 and 2018 (Table 1) [6]. Compared with younger adult patients, older adult patients have an increased risk for adverse outcomes (eg, longer hospital stays and higher costs) following burn injury [7]. Therefore, effective medical management strategies will need to consider the physiologic and anatomic differences that influence wound healing in this patient group [1,7–9].

Older adult patients harbor an increased risk of severe burn injury for several reasons, including impaired vision, decreased coordination, preexisting comorbidities, and medication-induced side effects [9]. Severe burn injuries in older adult patients may worsen preexisting comorbidities, reduce mobility, and adversely affect nutritional status and overall health [10,11]. Older adult patients with burn injuries are at a greater risk for both readmission to the hospital due to a preexisting comorbidity or chronic illness, and an increased risk of mortality within the first 2 years following hospital discharge [2,10–13]. One study found that, compared with patients aged 45–54 years, those aged 65–74 years had an adjusted odds ratio (OR) for death of 2.51 (95% confidence interval [CI], 2.03–3.09), and patients aged ≥ 75 years had an adjusted OR for death of 2.90 (95% CI, 2.36–3.55) [11]. In addition, increased size of burn injury is associated with a greater risk of complications and a higher mortality rate, especially for older adults (Fig. 1) [14]. The cutoff for burn-injury size after which patients are at an increased risk for significant complications and mortality is 40% of total body surface area (TBSA) in younger adult patients (aged ≤ 65 years) and 30% of TBSA in older adult patients (aged > 65 years) [14].

For these reasons, a greater understanding of burn-injury trauma characteristics and wound healing in older adult patients with severe burn injuries is needed to enhance treatment strategies and facilitate improved clinical outcomes in this patient group [7]. This review provides an overview of aging as it relates to wound healing, summarizes current treatment practices for severe burn injuries in older adult patients, and addresses the key challenges and considerations for treating this specific patient group.

1.1. Aging and wound healing

Wound healing is a dynamic integrated process comprised of 4 sequential phases: the first phase is hemostasis; the second phase is inflammation; the third phase is mesenchymal cell differentiation, proliferation, and migration to the wound site; and the fourth, and final, phase is tissue remodeling [15]. Several factors, including advanced age, can influence each phase, leading to impaired or delayed wound healing [15]. For example, advanced age can exacerbate impaired vascular flow and contribute to low tissue oxygenation [15]. Also, reactive oxygen species (ROS), a byproduct of cellular metabolism, accumulate with age and inflict damage upon cell membranes, enzymes, and DNA [1,16]. These changes lead to reduced epidermal proliferation, and deterioration of skin function and integrity [1]. During the normal healing process, ROS (eg, hydrogen peroxide and superoxide) act as cellular messengers that initiate some of the key processes involved in wound healing, including cell motility, cytokine action, and angiogenesis [15]. However, increased ROS production, secondary to a hypoxic microenvironment, can contribute to additional tissue damage [15].

The integrity and function of the skin deteriorates with aging, leading to diminished neurosensory perception, altered permeability, and a compromised healing response to injury and repair capability in older adults [16]. Though the number of cell layers remains constant, aging skin flattens at the dermo-epidermal junction by over one-third and becomes thinner compared with younger skin, due to reduced dermal papillae and interdigitation between skin layers (Fig. 1) [1,16]. The thinning of the dermis is associated with decreased vascularity and cellularity (ie, mast cells, fibroblasts), leading to reduced levels of glycosaminoglycans, hyaluronic acid, elastin, and interfibrillary ground substance [1,16]. Skin flattening begins around 60 years of age and leads to an increased susceptibility to injury and reduced resistance to shearing forces [1,16]. In addition, decreased surface area between the dermis and epidermis leads to reduced oxygen and nutrient delivery to the epidermis and contributes to an increased risk for dermo-epidermal separation [1]. The clinical manifestations of aging are associated with significant morbidity, with most individuals > 65 years of age having a history of at least 1 skin disorder [16,17]. For older patients with burn injuries, these changes can lead to deeper burn wounds with prolonged healing time and the potential for reduced re-epithelialization [1].

2. Challenges associated with severe burn treatment in older adult patients

2.1. Frailty

Aging is a continuous process, which is ultimately influenced by an individual's overall health, lifestyle, and preexisting comorbidities [18]. Physiologic changes associated with aging impair the capacity of a patient to fully recover after severe burn injury [19]. Given that chronologic age may not adequately predict patient outcome, a frailty score is commonly used as an outcome measure in older adult patients [20]. The term "frailty" describes the vulnerability of advanced age combined with the body's inability to maintain homeostasis and execute a normal stress response [1,19]. Frailty can be assessed by nutritional status and the activity level of a patient (ie, 5% weight loss per year, reduced muscle strength, unusual fatigue, decreased walking speed and physical activity) [1,21]. A more sedentary lifestyle, which commonly occurs with aging, can lead to organ deterioration and malfunction; reduced functional reserve capacity in muscle, heart, liver, and lung; and an impaired response to trauma [1].

Two scales that can be used to assess frailty—the Canadian Study on Health and Aging Frailty Scale (CFS) and the Burn Frailty Index (BFI)—are presented in Table 2 and Table 3 [20,22]. The CFS is a commonly used clinical-opinion scale of frailty that is not specific to disease state, but rather looks at the patient's overall activity level and independence [20,23]. Though the subjective nature of the scale could lead to over- or under-scoring a patient, it has been found to be a predictor of recovery and survival in research settings [20,23,24]. The BFI scale is specific to burn patients, and looks at overall patient comorbidities, activity, and independence, as well as patient clinical condition and % TBSA on admission [22]. While the BFI has shown high sensitivity and specificity for mortality using retrospective data, it has not been widely studied in clinical settings [22].

Although published studies assessing frailty mainly focus on those > 65 years of age, precursors to frailty likely occur long before reaching this age [20]. In a recent study, an increased CFS score at admission to a burn center was associated with increased mortality in adult patients who were as young as 50 years old [20]. Though this review focuses on patients > 65 years of age, assessing frailty may be important for treatment decisions in younger patients as well [20].

2.2. The immune response

Immunosenescence is the age-related decline in immune cell function that affects various cells of both the innate and adaptive arms of the immune system [25]. The decline in immune cell function results in a chronic inflammatory state, a process that has been called "inflamm-aging" [25]. The chronic inflammatory state in older adult patients is characterized by a marked increase in the systemic levels of various cytokines, including interleukin (IL)-1β, IL-6 (which is related to a loss of mobility and disability), IL-8, and tumor necrosis factor-alpha, which correlates with increased mortality [25]. C–C motif chemokine ligand 5 (CCL5, also known as RANTES) and epidermal growth factor are differentially regulated in response to burn injury in younger adult patients compared with older adult patients [26]. Importantly, many of these biomarkers associated with aging are also central to the inflammatory response following a severe burn injury [25]. Consequently, age-related changes to cytokines and chemokines pose significant challenges for treating older adult patients with burn injury [25].

2.3. Burn injury size and depth

Age is one of the most consistently cited factors, in addition to sex, % TBSA of burn, and concomitant inhalation injury, that influences morbidity and mortality of patients with burn injuries [1]. Lethal area 50 (LA_{50}) is the size of the burn injury that correlates with 50% mortality of a specific age group [27,28]. Smaller % TBSA burned in older adult patients leads to the same mortality rates as much greater % TBSA burned in younger adult patients. The American Burn Association reported that from 2009 to 2018, there was a 50.0% mortality rate for patients aged 5–15.9 years with burn injuries of > 90% TBSA; a

54.5% mortality rate for patients aged 16–19.9 years with burn injuries of > 90% TBSA; a 56.2% mortality rate for patients aged 70–79.9 years with burn injuries of 30–39.9% TBSA; and a 59.1% mortality rate for patients aged ≥ 80 years with burn injuries of 20–29.9% TBSA (Fig. 2) [6].

Larger burn wounds also increase morbidity in older patients. Though the authors are not aware of any studies looking at burn wound healing time in older adult patients, there are a number of studies looking at hospital length of stay and number of surgeries. The studies indicate that while older age does not impact the number of surgical procedures [29,30], older age and larger TBSA are associated with longer hospital stays [31–34]. Longer hospital stays are often due to longer healing times, complications with healing, and additional comorbidities [34].

For the acute management of severe burn injuries, the depth of burn injury dictates the extent and complexity of treatment required and also affects long-term functional and aesthetic outcomes [35–37]. Secondary burn wound progression can occur within the first several days postburn injury, leading to conversion to deep-partial thickness (DPT) or full-thickness (FT) wounds [25]. Wound progression is associated with an increased risk for hypertrophic scarring, the need for excision and grafting, wound infections, sepsis, shock, and possible mortality [25]. Burn wound conversion is initiated at the original burn injury site and involves primary tissue loss, which leads to the release of toxic proinflammatory mediators and platelet activating factors into the circulation [25]. Skin may be further damaged by oxygen radicals and proteases, causing systemic inflammatory response syndrome [25]. Older adult patients with burn injury are at increased risk for burn wound conversion due, in part, to a thinning dermis, age-related immune dysregulation, and other factors (Table 4) [25,26].

Autografting, a surgical procedure involving the harvest of healthy skin and subsequent transplantation to the burn injury site, is the standard of care for the treatment of DPT and FT burns [38,39]. Autografting provides effective wound closure; however, a donor-site wound is created that is prone to dyspigmentation, infection, pain, and scarring [39]. A thinner dermis in older adult patients complicates donor-site harvest and may result in a deeper burn wound that is more susceptible to wound conversion [2,16,26,40]. In DPT burns, the residual dermis may retain keratinocytes in hair follicles, sweat and sebaceous glands, which, given the right environment, may be recruited to repopulate the epidermis [35,39]. However, healing of a DPT burn is dependent on hair follicle density; therefore, reduced follicular density associated with aging can delay epithelial healing [27,41]. In summary, older adult patients with burns are more susceptible to burn wound conversion at the burn injury site and healing complications at the donor site.

2.4. Preexisting comorbidities

Increased patient age, independent of preexisting comorbidities or % TBSA burned, most significantly influences in-hospital mortality risk following a burn injury [7]. In addition, a higher number of preexisting comorbidities is correlated with an increased mortality risk within the first year following discharge from a burn center [7]. Reports suggest that at least 60% of US adults ≥ 50 years of age have at least 1 comorbidity (eg, hypertension, diabetes, heart disease, cancer) [42,43]. In 2013, the Pew Research Center reported that 24% of older adult patients aged > 65 years were living with diabetes; 19% had heart comorbidities; 8% had cancer; and 23% had other chronic comorbidities [43].

As the number of comorbidities increase with advancing age, they exacerbate the complexity, challenge, and burden faced by patients with severe burn injuries [19]. Neurological conditions (ie, tremors, seizures, syncope, dementia, Alzheimer's disease) can lead to impaired judgement and diminished senses, making it difficult for older adults to quickly assess the severity of a dangerous situation [13,44–46]. Mobility issues (ie, paralysis, amputation, wheelchair-dependency, arthritis) and loss of muscle strength can impede the ability to evacuate in case of a fire, and approximately 25% of older adults suffer falls during a fire, which can exacerbate the extent of the injuries sustained (eg, increased % TBSA of burn injury, deeper burn injury, and higher risk of inhalation injury) [1,13,46,47]. Diabetes mellitus can cause neuropathy that leads to an inability to sense heat; it also causes impaired resistance to infection, increases the risk of peripheral vascular disease, and may worsen the hypermetabolic response, leading to poor healing [8,45]. Pulmonary disease as a result of smoking can lead to supplemental oxygen use, and smoking while breathing oxygen may cause facial and inhalation burn injuries [45]. Chronic obstructive pulmonary disease and coronary artery disease may lead to longer hospital stays, increased ventilation requirements, and increased incidence of complications in older adult patients with burn injuries [13]. Cardiovascular disease also may worsen the hypermetabolic response associated with deeper and more-extensive burn injuries [8]. Consequently, older adult patients tend to have longer hospital stays compared with younger adult patients with comparable burn injuries [19].

2.5. Lifestyle choices

Health-related behaviors and lifestyle choices (eg, medication use, alcohol abuse, smoking) may impact treatment or recovery [15]. For example, smoking can delay wound healing and increase the risk of complications, including infection, wound rupture, necrosis, and reduced tensile strength [15]. Alcohol intake can impair wound healing and increase the risk of infection due to decreased neutrophil recruitment and phagocyte function [15]. In addition, certain medications interfere with platelet function, clot formation, inflammatory response (eg, glucocorticoids), and cell proliferation [15]. Systemic glucocorticoids not only inhibit wound repair by exerting anti-inflammatory effects, but also cause incomplete tissue granulation, decrease wound contraction, inhibit the production of hypoxia-inducible factor-1, and increase the risk of wound infection [15].

2.6. Clinical considerations for the treatment of severe burn injury in older adult patients

Although the standard of care in the US for the treatment of DPT and FT burns is excision and autografting, standardized treatment approaches for older adult patients are lacking. The optimal timing of these surgical procedures, with respect to clinical benefit, remains undefined. Because early intervention is preferable to prevent wound sepsis, surgeons face the challenge of balancing early excision and autografting with conservative management when considering a treatment approach in older adult patients. Furthermore, the thinner dermis associated with older age can complicate donor-site harvest, contribute to wound conversion, and delay healing in older patients [1]. Consequently, there is a need for well-organized, protocol-driven approaches for treating severe burns in older adult patients. In particular, the availability of clinical studies that evaluate burn treatments in older adult patients is sparse, and although some studies do include patients older than 65 years with burns, subgroup analyses for this patient group are lacking in the literature. We believe that additional prospective, controlled studies are needed to help determine optimal treatment strategies for these patients.

2.7. Fluid resuscitation

The management of older adult patients with severe burn injury is challenging from a clinical, rehabilitative perspective [2]. Severe burn injury causes multisystem stress through fluid shifts related to burn injury and subsequent fluid resuscitation, systemic inflammatory response, and increased metabolic demand [2]. Fluid resuscitation, an integral component of severe burn injury treatment, is essential for improving patient survival and preventing decreased tissue perfusion, multi-organ failure, and sepsis [1]. Furthermore, fluid titration is an important mechanism for mitigating negative outcomes; improper fluid resuscitation can contribute to burn wound conversion, pulmonary edema, abdominal compartment syndrome, and fluid overload, while avoiding hypovolemia and acute renal failure [1]. Additionally, when comparing burn injuries in older adults versus younger adults, age is significantly associated with an increased volume requirement during the first 24–48 h following a burn injury [1]. However, fluid resuscitation can be challenging in older adult patients, mainly due to preexisting cardiac dysfunction [1].

2.8. Kidney injury

Complications in older adult patients with burns are common and include pneumonia, urinary tract infection, respiratory failure, renal failure, and cellulitis (Table 5) [6]. Acute kidney injury, a major complication of burn trauma, affects 15–53% of patients who have burn injury, and is associated with poor outcomes and high mortality rates (35–70%) [48–50]. A retrospective study of 1703 burn patients found that older age and greater % TBSA involvement are both risk factors for developing acute kidney injury [51]. However, in the 51 patients who developed acute kidney injury, age did not differ significantly between patients who survived and patients who did not survive [51]. While early detection of acute kidney injury is important to facilitate optimal treatment and improve burn patient outcomes, kidney injury is difficult to detect [48,49]. Serum creatinine levels are a clinical indicator of renal function, but plasma levels may not increase until kidney function is already impaired [48,50]. Hourly urine output can also be used to evaluate renal function if affected by a reduced glomerular filtration rate; however, diuresis is influenced by neurohormonal and functional changes [50]. Therefore, urine output may appear normal, despite underlying renal injury [50].

Identifying and validating biomarkers is increasingly important to help clinicians assess kidney injury at an early stage. Following acute burn injury, renal tubules rapidly produce neutrophil gelatinase-associated lipocalin (NGAL), a 25-kDa protein that covalently binds to gelatinase, with levels readily detectable in both plasma and urine [48]. Increased plasma NGAL levels were identified as a novel biomarker for the early detection of acute kidney injury in adult patients with ≥ 20% TBSA burns [48,49]. An independent study determined that increased serum NGAL predicted acute kidney injury during the first 4 h, through the first 24 h, after hospital admission for adult patients with > 20% TBSA burns, and that serum NGAL was a superior marker to serum creatinine level and urine output, which were not indicative of acute kidney injury during the first 24 h after admission [50].

2.9. Metabolic response

Extensive burn injuries (ie, >40% TBSA) induce a hypermetabolic response (ie, increased metabolic rate, infection risk, multi-organ dysfunction, muscle protein degradation, growth attenuation, and insulin resistance), which can persist for 1 to 2 years postburn injury trauma [52]. Therapeutic approaches to mitigate the hypermetabolic response include early excision and grafting, thermoregulation, high-carbohydrate/high-protein enteral feeding, the use of growth hormone, insulin-like growth factor 1, insulin-like growth factor binding protein-3, insulin, oxandrolone, or propranolol, and exercise [52].

Adequate nutrition is a critical part of treatment for patients with severe burn injuries [27]. The older adult patient often presents with poor nutritional status and may have inadequate energy stores to meet increased metabolic demand following burn injury [13,27]. After a severe burn injury, mitochondria may lose the ability to self-repair, leading to dysfunction and negatively impacted energy availability [27]. An increased demand on energy with insufficient availability can contribute to multi-organ failure and mortality [27]. Clinical outcomes may be improved in patients with severe burn injury via intensive enteral feeding, which may help to mitigate hypermetabolic responses [52].

2.10. Quality of life

Quality of life (QoL) is another important consideration for the treatment of older adult patients with burns. Both functional and psychosocial status can be severely altered for months, and even years, following severe burn injury [9]. After incurring a severe burn injury, patients often experience depression, which had a prevalence of 13–23% in 1 study [53]. Patients may also have reduced mobility from contractures, lose their independence, feel unhappy with their appearance, and become socially isolated [9,53–55]. A study of patients ≥ 55 years old and with burn injuries found that patients aged ≥ 75 years experienced a greater loss of independence (ie, ≥ 50% were unable to perform daily activities independently), worse health-related QoL (HRQoL), and a higher level of impairment postburn injury compared with patients aged 55–74 years old [9]. Using the Functional Independence Measure, 21% of patients aged ≥ 75 years and with burns reported significant levels of impairment at 2 years postburn injury [9].

Health-related QoL factors are generally assessed via validated questionnaires and are important for determining patient burden following burn injury [56]. In a systematic review of cross-sectional studies (n = 56), cohort studies (n = 32), case-control studies (n = 3), and clinical trials (n = 3), domain scores from several validated questionnaires (ie, the Burn Specific Health Scale–Brief, the Medical Outcome Study Short Form-36, and the EuroQol 5-Dimensions questionnaire), relating to work, emotional and physical limitations, and pain/discomfort, were inconsistent across studies and did not show improvement over time, suggesting that both mental and physical support are warranted postburn injury [56].

3. Conclusions

Severe burn injuries are traumatic injuries associated with significant morbidity and mortality [44]. Older adults are more prone to burn injury [44], and the aging process is associated with both physiologic and anatomic changes that negatively influence wound healing and contribute to a reduced ability to recover from severe burn injuries compared with younger adult patients [13]. When treating older adult patients with severe burn injuries, it is important to consider that they represent a distinct patient group that responds differently to currently available therapeutic approaches. Outcomes for older adult patients with severe burn injuries are impacted by several clinical factors, including a delayed hypermetabolic response, an increased hyperglycemic and hyperlipidemic response, an inverse inflammatory response, and a compromised immune response [44]. Clinicians treating older adult patients with severe burns should consider a multimodal treatment approach, including assessing frailty [20], using fluid resuscitation if not contraindicated [1], proactively monitoring kidney function [48], providing adequate nutrition during the healing process [13], and providing mental and physical support during the follow-up phase [56]. Given that consensus treatment guidelines for older adult patients with severe burn injuries are lacking and clinical data for this patient group are sparse, clinicians should consider specialized treatment approaches and follow-up mechanisms. A better understanding of the epidemiology and potential outcomes among older adult patients with severe burn injuries may provide insight into optimal burn-management strategies for this rapidly growing patient group.

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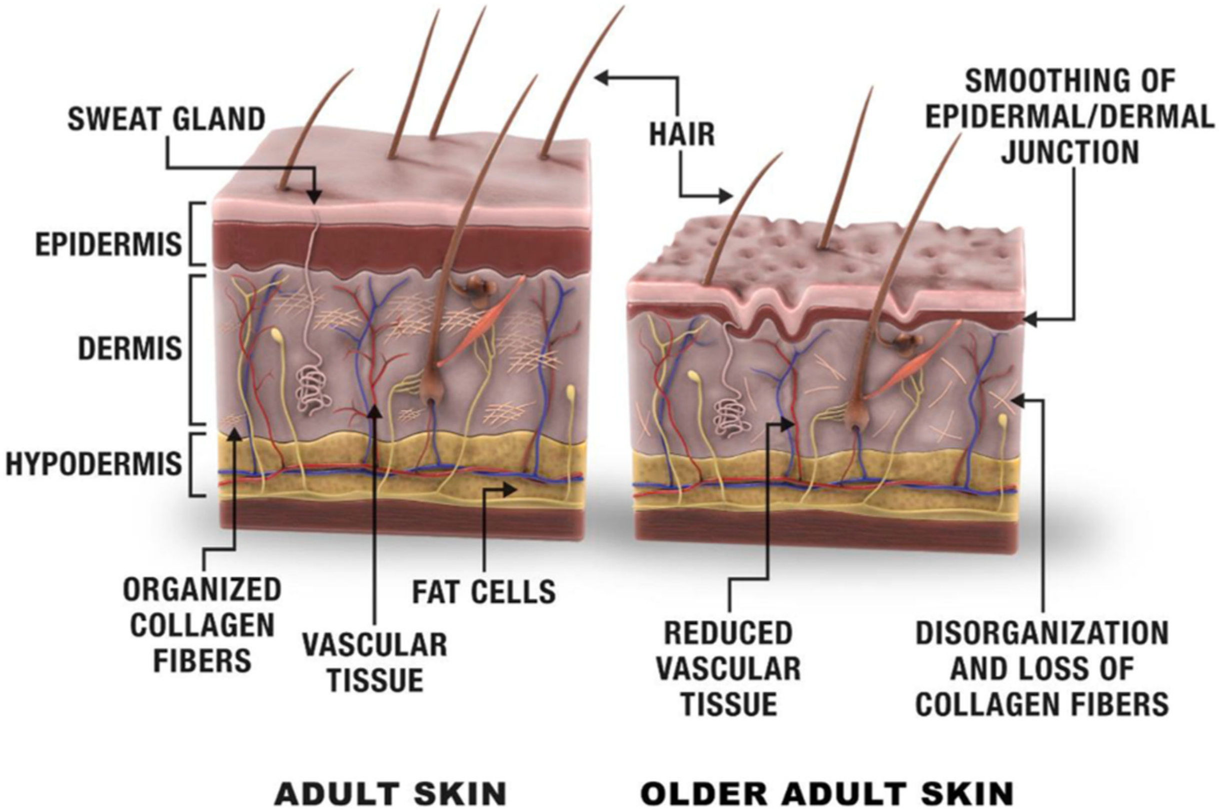
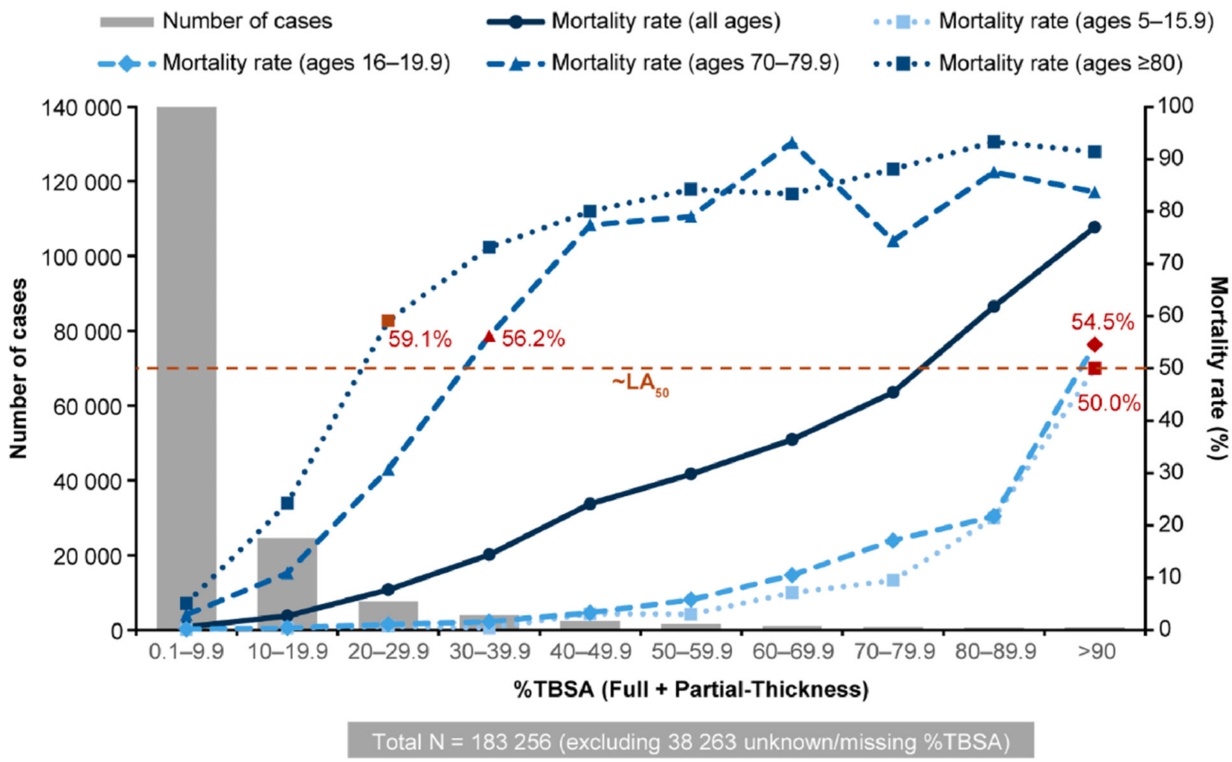


Fig. 1.

Schematic Cross-section of Skin During Aging.



LA_{50}, lethal area 50 (50% mortality); TBSA, total body surface area.

Fig. 2.

Number of Burn Cases by % TBSA Versus Mortality Rate by % TBSA From the National Burn Repository Report of Data From 2009 to 2018 [6] LA_{50}, lethal area 50 (50% mortality); TBSA, total body surface area.

Table 1

Economic Cost of Burn Injuries in Patients Aged 60 to ≥ 80 Years (2009–2018)[a] [6]

Age (Years)	MS-DRG Code	Number of Cases	Cases With Valid Charges	Average Charge (Mean ± SEM)
60–69.9 (N = 12 305)	935 - Nonextensive burns	5863	3534	$48 019 ± 1733
	928 - FT burn with skin graft or inhalation injury with CC/MCC	2680	1719	$204 543 ± 6392
	929 - FT burn with skin graft or inhalation injury without CC/MCC	2157	1133	$113 477 ± 6342
	934 - FT burn without skin graft or inhalation injury	867	575	$57 863 ± 8963
	927 - Extensive burns or FT burns with MV 96 + hours with skin graft	738	457	$623 588 ± 33 883
70–79.9 (N = 6335)	935 - Nonextensive burns	2725	1610	$50 496 ± 2382
	928 - FT burn with skin graft or inhalation injury with CC/MCC	1572	989	$197 830 ± 7 501
	929 - FT burn with skin graft or inhalation injury without CC/MCC	1098	572	$110 793 ± 8030
	934 - FT burn without skin graft or inhalation injury	525	352	$64 815 ± 7272
	927 - Extensive burns or FT burns with MV 96 + hours with skin graft	415	259	$576 321 ± 33 403
≥ 80 (N = 4105)	935 - Nonextensive burns	1549	897	$58 792 ± 5862
	928 - FT burn with skin graft or inhalation injury with CC/MCC	1073	695	$215 058 ± 9467
	929 - FT burn with skin graft or inhalation injury without CC/MCC	678	327	$124 714 ± 8576
	934 - FT burn without skin graft or inhalation injury	513	313	$60 842 ± 4806
	933 - Extensive burns or FT burns with MV 96 + hours without skin graft	292	179	$64 433 ± 8863

CC, complicating/comorbid condition; FT, full-thickness; MCC, major complication or comorbidity; MS-DRG, Medicare Severity Diagnosis-Related Group.

[a]American Burn Association, National Burn Repository® 2019.

Table 2

Clinical Frailty Scale.[a]

Frailty Score	Frailty Stage
1 – Very fit	Robust, active, energetic, well-motivated and fit
2 – Well	Without active disease, but less fit than individuals in category 1
3 – Well, with treated comorbid disease	Disease symptoms are well-controlled compared with those in category 4
4 – Apparently vulnerable	Although not frankly dependent, these individuals commonly complain of being “slowed up” or have disease symptoms
5 – Mildly frail	With limited dependence on others for instrumental activities of daily living
6 – Moderately frail	Help is needed with both instrumental and noninstrumental activities of daily living
7 – Severely frail	Completely dependent on others for the activities of daily living, or are terminally ill

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[a]From the Canadian Study on Health and Aging.

Table 3

Burn Frailty Index.[a]

Questions	Scoring					
1 – Cancer history	No (0)			Yes (1)		
2 – Diabetes	No (0)			Yes (1)		
3 – Need help with grooming	No (0)			Yes (1)		
4 – Need help with managing money	No (0)			Yes (1)		
5 – Need help doing household work	No (0)			Yes (1)		
6 – Feel sexually active	No (0)			Yes (1)		
7 – Coronary artery disease	Medication (0.25)	PCI (0.50)		CABG (0.75)	MI (1)	
8 – Dementia	None (0)	Mild (0.25)		Moderate (0.5)	Severe (1)	
9 – Need help walking	None (0)	Cane (0.25)		Walker (0.75)	Wheelchair (1)	
10 – Feel sad	Rarely (0)		Sometimes (0.5)		Most of the time (1)	
11 – Feel lonely	Rarely (0)		Sometimes (0.5)		Most of the time (1)	
12 – GCS on admission	≥ 14 (0)			< 14 (1)		
13 – Albumin level on admission	≥ 3 mg/dL (0)			< 3 mg/dL (1)		
14 – Creatinine level on admission	< 1.0 mg/dL (0)	1.0–1.49 mg/dL (1)		1.5–1.99 mg/dL (1.5)	≥ 2.0 mg/dL (2)	
15 – TBSA on admission	< 5.0% (0)	5.0–9.9% (0.25)	10–14.9% (1)	15–19.9% (1.5)	20–24.9% (1.75)	≥ 25% (2)

CABG, coronary artery bypass graft; GCS, Glasgow-coma score; MI, myocardial infarction; PCI, percutaneous coronary intervention; TBSA, total body surface area percent burned.

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[a]To determine patient score, divide sum of questions by 15. Scores range on a continuous scale from 0 (not frail) to 1.13 (extreme frailty). Scores ≥ 0.30 indicate frailty.

Table 4

Age-Related Factors That Affect Burn Injury Severity and Burn Wound Healing in Older Adult Patients.

Age-Related Factor	Consideration
Anatomical changes	
Thinning dermis	Increased risk for a deeper burn wound and for burn wound conversion; reduced capacity to recover from burn injury; prolonged wound healing and reduced re-epithelialization
Deterioration of skin integrity and function	Diminished neurosensory perception, permeability, and compromised healing response and repair capability
Impaired vision and decreased coordination	Increased susceptibility to severe burn injury (DPT, FT), and significant morbidity and mortality
Comorbidities	
Cardiovascular disease	Affects fluid resuscitation; can worsen the hypermetabolic response
COPD and coronary artery disease	Associated with longer hospital stays, increased ventilation requirements, and complications
Diabetes	May worsen the hypermetabolic response and complicate treatment
Neurological diseases	Increased risk of burn injuries
Pulmonary disease	Affects fluid resuscitation; increased risk of burn injuries
Renal disease	Affects fluid resuscitation; can contribute to increased morbidity and mortality
Physiological	
Compromised nutritional and metabolic status	Reduced capacity to recover from burn injury; increased risk of a hypermetabolic response, multi-organ failure, and mortality
Medication-induced side effects	Increased risk of severe burn injury
Immunological	
Age-related immune dysregulation	Increased risk for burn wound conversion; induction of a chronic inflammatory state

COPD, chronic obstructive pulmonary disease; DPT, deep partial-thickness; FT, full-thickness

Table 5

Complications in Patients With Burn Injuries Aged 60 to ≥ 80 Years (2009–2018)[a] [6]

Complication	Aged 60–69.9 Years (n = 20 019)[b]			Aged 70–79.9 Years (n = 10 400)[c]			Aged ≥ 80 Years (n = 6772)[d]		
	Count	**% of all complications**	**% of patients with complication**	**Count**	**% of all complications**	**% of patients with complication**	**Count**	**% of all complications**	**% of patients with complication**
Pneumonia	751	8.3	3.8	488	8.5	4.7	307	7.2	4.5
Urinary tract infection	642	7.1	3.2	453	7.9	4.4	425	10.0	6.3
Respiratory failure	431	4.7	2.2	312	5.4	3.0	225	5.3	3.3
Renal failure	367	4.0	1.8	225	3.9	2.2	154	3.6	2.3
Cellulitis	360	4.0	1.8	158	2.7	1.5	143	3.4	2.1
Wound infection	277	3.0	1.4	142	2.5	1.4	84	2.0	1.2
Septicemia	266	2.9	1.3	172	3.0	1.7	116	2.7	1.7
Cardiac arrest	260	2.9	1.3	214	3.7	2.1	191	4.5	2.8
Bacteremia	248	2.7	1.2	155	2.7	1.5	94	2.2	1.4
Deep vein thrombosis	160	1.8	0.8	N/A	N/A	N/A	N/A	N/A	N/A
Other hematologic	N/A	N/A	N/A	113	2.0	1.1	N/A	N/A	N/A
Other cardiovascular	N/A	N/A	N/A	N/A	N/A	N/A	103	2.4	1.5
Total complications	9102			5765			4255		

ABA, American Burn Association, N/A, not applicable.

[a]American Burn Association, National Burn Repository® 2019.

[b]Excludes 169 cases from non-ABA burn registry software centers.

[c]Excludes 113 cases from non-ABA burn registry software centers.

[d]Excludes 59 cases from non-ABA burn registry software centers.