Geriatric Burns

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30.1 Epidemiology and Risk Factors for Geriatric Burn Injury

The large majority of burns sustained by elders arise from one of three general mechanisms or activities: those sustained due to smoking, those suffered from mishaps while cooking, and scald injuries. The fact that elders are uniquely vulnerable to burn injury is borne out by the National Center for Health Statistics' 2010 finding that adults 65 years of age and older accounted for 35% of all national burn deaths while accounting for 13% of the population [1].

Mobility limitation is prevalent in 44% of elders [2] and by itself has been shown to lead to a loss of independence [3], decreased quality of life [3, 4], institutionalization [5], and mortality [6, 7]. While general age-related declines in mobility are multifactorial, they tend to funnel down into a common pathway for the risk for burn injury. Patients with limitations in mobility have difficulty evacuating themselves from a burning structure. Confinement to a wheel chair is problematic, as the difficulties of navigating a chair during an emergency require both upper body strength and a structure that is chair-compatible. Additionally, limitations in mobility make it difficult for elders to quickly remove an article of clothing which has ignited. Finally, difficulties with mobility and balance put patients at risk for a ground level fall during their reaction to the event which can lead to hip fractures or head injuries both of which complicate their prognosis..

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Cognitive impairment with or without dementia is a very common comorbidity as it is seen in 3.4 million [8] and 5.4 million [9] Americans age 71 years or older, respectively. Cognitive impairment can also be iatrogenic since aging entails developing increasing numbers of chronic illnesses. Americans today are living longer with these comorbidities, and most of them are treated pharmacologically with regimens that each come with their own risk profile. Elders are known to commonly have adverse reactions due to differences in pharmacokinetics, and are at risk for poorly coordinated or duplicated care due to visiting multiple prescribers and pharmacies [10, 11]. These drug regimens can lead to episodes of hypotension, drowsiness, and impaired judgement. Alcohol and illicit drug use in the elderly is prevalent, and can by itself or in conjunction with prescribed medications exacerbate cognitive impairment [12]. Regardless of the etiology of impaired mental function, these conditions all put an elder at risk for burn injury due to their effect on the elder's ability to recognize behavior as dangerous, that hazards are present, or that certain solutions are logical or not. Additionally, a confused patient may have difficulty recognizing the severity of a given injury leading to a delay in seeking necessary medical attention.

While home oxygen therapy is common among the elderly, the proportion of those who continue to actively smoke is rarely commented upon in the literature. In the few studies that could be located which specifically addressed this issue, the proportions seen ranged from 20% [13] to 38% in the Nocturnal Oxygen Therapy Trial [14], and 43% in the British Medical Council's trial of home oxygen in COPD [15]. The risks entailed with this practice are clear, but the strength of addiction makes curtailing this activity difficult.

Age-related diminishing of sensory is a risk factor for burn injury. A decrease in auditory acuity results in an inability to hear smoke alarms, just as a loss of visual acuity increases the likelihood of not being able to see cues to the presence of a fire hazard or subtle signs of flames or smoke. Olfactory losses can make the detection of smoke or natural gas difficult. Finally, diminished sensation is a common

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finding in the elderly which can cause them to place their feet too close to heat sources or to have difficulty assessing water temperature [1].

Fixed incomes have been shown to be a risk factor for burn injury. According to the Social Security Administration's 2016 data, 21% of married Social Security Recipients and 43% of single recipients rely on Social Security for 90% of their gross monthly income [16]. Nine percent of the elderly live below the poverty line, with many more living close to it [17]. Living on a fixed income often lends itself to living in housing that is substandard with electrical and mechanical systems that are outdated or under-maintained. When central heating is absent or not dependable, the elderly will often turn to such heating sources as space heaters, fireplaces, and cooking ovens. Further, these environments may not have fire safety as a priority. A 2008 survey of homebound urban elders found that 37% had no functional smoke alarms, 82% had no access to a fire extinguisher, and 46% had hot tap water that exceeded 120 °F [18]. This association with fixed incomes is also reflected in racial and gender differences in fire-related mortality as African-American females age 85 years and older have an 11-fold increase in the relative risk of dying in a fire than the general population [1], and males 19-fold higher [1].

It is human nature to try to retain independence for as long as is possible, and for seniors maintaining independence is a significant feature of quality of life [19]. With functional adaptations, many caregivers are able to assist elders in safely staying in their own home. However, for a significant proportion despite warning signs such as escalating medical needs, caregiver strain, or concerns about safety, the stigma associated with skilled nursing facilities causes them to procrastinate on the decision to move their care to a less independent environment. Compounding this risk is the fact that as spouses die, many elders are left to live alone. In total, 28%, or 12.1 million, of non-institutionalized seniors live alone [20].

30.2 Burn Injury Prevention for the Elderly

Fire safety and burn prevention programs have historically been geared towards children and the general population [21]. This general lack of awareness regarding the importance of educating seniors is reflected in the fact that adults age 60 years and older are the least targeted demographic for burn prevention and fire safety [22]. Indeed, a 2008 survey of New York and New Jersey seniors revealed that less than 20% reported receiving fire safety within 5 years [23]. Additionally, when asked to rank where fire safety and burn prevention ranked in the order of 13 common health topics they discussed with their PCP, seniors reported fire safety and burn prevention to be last [23]. While there is a small body of literature assessing the effect of an educational program in the elderly which demonstrate an increase in seniors' burn prevention knowledge [24–28], all have a follow up.

Residential fire deaths due to unextinguished cigarettes have been addressed via an engineering solution in which a design standard has now been approved which requires that cigarettes self-extinguish when not actively being smoked. This has been accomplished by the placement of two to three thin bands of less-porous paper in the cigarette which causes an extinguish rate of 75% over 40 average cigarettes. In 2010, Wyoming became the 50th state to pass legislation requiring the use of the fire-safe cigarette design at the local point of sale. A subsequent study found that passage of the law was associated with a 19% reduction in overall residential fire mortality rates with a protective effect seen for every age, sex, race, and ethnicity strata that was analyzed [29].

Other burn injury preventions that lack evidence but which are safe, inexpensive, and possibly efficacious are to be recommended. For seniors with impaired cognition who insist on attempting to continue cooking, the use of a timer in the kitchen to remind them to turn off the stove or burners is an option. For those for whom cooking is no longer deemed to be safe by their caregiver, removal of the knobs from the stove is a solution. Special smoke alarms have been created for the hard of hearing. When activated these devices will flash, emit low-frequency audible alarms, and have bed-shaker attachments. The use of adaptive safety equipment such as bathtub stools and rails can help mitigate scald risk. Primary care physicians (PCPs) can potentially play a central role in burn prevention as these are the medical professionals with whom the elderly have the most frequent contact. Routine screening and counselling to assess fire risk and mitigation at office visits is to be recommended.

30.3 Resuscitation

Due to a lack of geriatric-specific evidence-based guidelines, resuscitation of the geriatric burn patient is treated the same as any other adult burn resuscitation. The ABA State of Science meeting identified this as an opportunity for improvement and tasked the research community with defining the special needs of the elderly population and determining the optimal instruments for measuring efficacy of resuscitation in this group [30].

The concept that geriatric burn patients may require special resuscitation is not novel. A 2009 article by Benicke et al. sought to alter the widely used Baxter-Parkland resuscitation formula in hopes of better suiting individual patient requirements. The new formula was created with the addition of several variables including inhalation injury (IHI) and high blood alcohol level (BAL), as well as a compensating

factor for advanced age [31]. This formula was found to have a superior predictive value for the true volume of resuscitation fluids administered to patients; however, the study did not look at clinical outcomes, and the impact of age on actual resuscitation requirements remains unknown.

The discussion surrounding optimal monitoring techniques is not unique to geriatric burns. Monitoring circulatory shock and hemodynamics has also been a topic of interest for the Task Force of the European Society of Intensive Care Medicine. The group constructed a list of consensus guidelines, which argue against the requirement of hypotension for a diagnosis of shock and instead emphasize the importance of perfusion markers such as lactate, mixed venous oxygen saturation, and central venous oxygen saturation. The group recommended against the use of a single variable for the management of shock as best practice. In terms of measuring response to therapy, the best practice recommendation was to use more than one hemodynamic variable. Routine measurements of cardiac output for patients responding to therapy were not recommended [32]. A paper published in Burns in 2016 reviewed the literature on critical care in burns. With respect to hemodynamic monitoring, the concept of permissive hypotension and the importance of using multiple dynamic variables were highlighted [33].

30.4 Nutrition

There is a paucity of literature on the topic of nutritional support in the geriatric burn population. In fact, the lack of progress in this area was recently highlighted at an American Burn Association (ABA) State of Science meeting where developing a nutrition protocol for elderly patients was addressed [30]. Until more targeted studies are performed on this topic, we must apply existing knowledge of burn nutrition to geriatric burn patients, albeit with caution.

The physiological response to burn injury and the natural changes in nutritional status among the elderly have been extensively studied. Interestingly, some degree of protein-energy malnutrition is present in greater than 50% of older burn victims at admission, which results in increased morbidity and mortality [34]. Nutritional deficiencies can exacerbate the complications of burn injury including muscle catabolism, delayed wound healing, and infection.

30.4.1 Glucose Control

Elderly patients often suffer from multiple comorbidities, including diabetes. While glycemic control has been greatly studied in the critical care population, ideal glucose range recommendations for burn patients have yet to be established. For now, the European Society for Clinical Nutrition and Metabolism has endorsed recommendations for nutrition in major burns to support moderate glucose control [35]. This is to avoid the complication of hypoglycemia seen with intensive glucose control for which geriatric burn patients are at increased risk given their elevated nutritional requirements and comorbid diseases.

30.4.2 Glutamine

Classified among the immunomodulating agents, glutamine has been looked at for potential benefit in the hypermetabolic population of burn patients. A 2013 meta-analysis of four randomized controlled trials comparing glutamine supplementation and non-supplementation in 155 total adult burn patients showed a significant decrease in hospital mortality and gram-negative bacteremia [36]. There was no difference found with regard to wound infection or length of stay.

30.4.3 Trace Elements

The catabolic response to burn injury known to occur in younger cohorts is also seen in the elderly at a comparable rate; however, the possibility of preexisting malnutrition or lean mass deficits may complicate the picture and require more aggressive nutritional support [34]. The administration of trace elements (Cu, Se, Zn) is often a consideration. This is especially highlighted as these elements have been found to be acutely depleted post-severe burn injury. A recent systematic review and meta-analysis on this topic in burn patients revealed that a parenterally administered combination of trace elements decreased the rate of infectious complications [37].

30.4.4 Oxandrolone

As men and women age, they undergo a decline in skeletal muscle mass and strength due to a number of likely contributing factors, including malnutrition. Muscle catabolism is a known physiological response to severe burn injury and can be of special concern in the elderly population. Oxandrolone, an anabolic steroid, has been shown to induce muscle anabolism in children [38] and older men and women [39] and may be used to combat this catabolic response.

30.4.5 Enteral Versus Parenteral Feeding

Enteral feeding is considered the preferred method for all patients when available due to the widely accepted advantage of maintaining gut mucosal integrity. The decision for

parenteral versus enteral nutritional support should be based on an individual patient's clinical picture. There is discussion in the literature of combined enteral and parenteral therapy as a means to provide adequate nutrition, considering that one of the disadvantages of enteral feeding is the sometimes frequent interruption of its administration due to surgical intervention or intolerance [40]. Again, this should be placed in the context of a patient's clinical history, course, and goals of care. There are no guidelines directed towards the feeding technique for nutritional support in the elderly burn population.

30.5 Delirium

The most recent edition of the Diagnosis and Statistical Manual of Mental Disorders (DSM-5) was published in 2013 with revisions to the criteria for delirium which is now defined as [41] a disturbance in attention and awareness, developing over a short period of time, representing a change from baseline and tending to fluctuate in severity during the course of a day. The condition may include an additional disturbance in cognition, and these changes cannot be explained by a preexisting neurocognitive disorder. There must be evidence that the disturbance is a direct physiological consequence of another medical condition, substance intoxication or withdrawal, exposure to a toxin, or multiple etiologies.

Delirium is a topic which, in general, has received much attention due to its association with poor clinical outcomes in diverse settings. The relevance of this diagnosis in elderly burn patients seems obvious; however, there has been very little work to identify and define the risk factors, optimal treatments, and outcomes in this particular population.

A 2017 study published in the Journal of Burn Care and Research aimed to address these points in 385 severely burned patients ranging in age from 18 to 65 years who underwent early escharotomy. The primary outcome was postoperative delirium (POD) as measured by the Confusion Assessment Method (CAM). The incidence of POD was 14.6% with 85.7% of those cases occurring within 24 h after surgery. Significant risk factors for developing POD included age greater than 50 years, history of alcohol consumption, preexisting pulmonary and cardiovascular diseases, larger total burn surface areas (TBSAs), intraoperative hypotension, and longer surgeries (>180 min), among others. More interesting perhaps were the findings of outcome differences between the POD and non-POD groups. The POD group exhibited increased rates of complications such as hepatic and renal impairment as well as increased lengths of stay and higher mortality rates [42].

It is important to note that patients older than 65 and those with preoperative diagnoses of cognitive dysfunction were excluded from the study described above. The incidence of delirium among these excluded patients is likely much higher and carries clinical implications. This significance was elucidated in a 2016 study of patients 65 years and older who were hospitalized for burn injury. In this population, a preexisting diagnosis of dementia was associated with a one in five chance of developing delirium or a urinary tract infection during a patient's hospitalization [43].

The development of delirium is likely multifactorial; however, medications certainly play a part. Some investigators have examined the role of postoperative pain treatment in the prevention of delirium. Lynch et al. discovered in a prospective, observational study of noncardiac surgical patients, ages 50 and up, a significant relationship between postoperative pain and the development of delirium such that patients with higher pain scores were at greatly increased risk of delirium [44]. This association persisted after controlling for other preoperative risk factors including baseline cognitive status. This study did not find significance when looking at method of analgesia, type of opioid, or cumulative opioid dose, leaving physicians to individualize pain regimens based on the clinical picture and the risks and benefits of therapy options. Adverse outcomes in mechanically ventilated patients have also been described [45], and there is literature which encourages the use of formal evaluation methods to identify delirium in these patients, and suggests changes in sedation protocols in an effort to promote better outcomes in these patients [46].

30.6 Wound Healing in the Elderly

Aging alters skin physiology and biology as well as slows the healing process [47, 48]. Due to these changes, burns which would be less severe in younger patients can have a devastating effect on the elderly patient. Aging affects all layers and components of the skin [49]. As skin ages, the epithelium in general becomes thinner, but there is also thickening of the epidermis due to sun exposure [50]. Overall the net effect is a thinning of the skin. Thinner skin means that burns which would be partial thickness in younger patients have a higher likelihood of presenting as or evolving into full thickness burns. Additionally, with aging of the skin, the junction between the epidermis and dermis flattens, reducing the size of the rete pegs. This ultimately leads to an increased risk of shearing of the skin, causing blisters of the epidermis to form. In the subdermal tissue, aging manifests as a decreased capability for angiogenesis leading to delayed revascularization [51, 52]. When revascularization does occur, the new vessels tend to have a greater tendency to leak. Both of these factors lead to impaired lymphatic drainage, predisposing the skin to increased edema, which further impairs wound healing.

For the burn victim, the most deleterious age-related skin change is the reduction in the number of skin adnexa: hair

follicles, oil glands, sebaceous glands, and other adnexa [53]. It is well established that partial-thickness wounds re-epithelize from both the epithelial edge of the wound and the skin adnexa [54]. The keratinocytes in the basal layer of the epithelium migrate towards the center of the wound, covering 1–2 cm from the wound edge. Any wound that is larger than this, or is full thickness, or lacks skin appendages attempts to heal by contraction of the wound and ultimately scar formation. In partial-thickness wounds, the hair follicles or other skin adnexa are retained so that the keratinocytes migrate from the remaining adnexa to resurface the wound. The density of the skin adnexa in the wound influences the rate of healing such that skin areas with a higher density of adnexa heal faster. For example, a wound on the scalp will heal within 4–5 days as opposed to a wound on the lower leg which can take 2–3 weeks to heal. The decrease in skin adnexa related to age therefore increases time to healing and increases scar formation. Despite the increased time to healing and the fact that prolonged healing time promotes hypertrophic scarring, it is unclear if the same holds true in the elderly [55]. Skin gets looser as it ages, therefore reducing the risk of tension on the wound which leads to contracture and hypertrophic scar.

The numerous changes that occur to the skin related to aging are well documented; however, the exact effects that these changes have on burn wounds, and how these changes should affect our treatment of these wounds are unclear. Additionally, the ultimate outcomes for elderly burn-injured patients have not been well studied. More work is needed to understand the effects of aging on the production of growth factors, stem cell biology, and the specific biological differences between elderly burn patients and their younger counterparts. It is not clear whether the tenets of early excision and grafting are beneficial in the elderly or if they are better served by waiting. Additionally, it is unknown whether surgery should be done in one stage or across multiple trips to the operating room. We as a burn community need to investigate the wounds of elderly burn patients and their management to determine the best methods of treatment.

30.7 Frailty

Traditionally, the prediction of burn outcomes has been based on patient age and %TBSA burned. Updated prediction models include more variables such as the presence/amount of full-thickness burns, inhalation injury, and gender, but still rely heavily on patient age [56]. Unfortunately, individuals with the same chronologic age vary widely in their health and functional status, making age alone a poor predictor of patient outcomes [57]. Frailty is present in 10–20% of the population over the age of 65, potentially making it a good surrogate outcome measure for elderly patients [58].

30.7.1 Importance of Frailty

Multiple studies have been conducted across a variety of clinical services that have examined frailty and its relationship to outcomes [58–60]. Conroy and Dowsing studied frailty in patients admitted to a medical unit [59]. They found that frailty predicted mortality but did not predict length of stay or readmission. In patients undergoing elective surgery, increased frailty was independently predictive of postoperative complications, increased length of stay, and discharge to a skilled nursing facility [60, 61]. In trauma patients, higher preinjury frailty predicted an unfavorable discharge (skilled nursing facility or death) [62]. In general, frailty has been associated with an increased risk of falls, delirium, cognitive decline, iatrogenic complications, and death [57].

30.7.2 Measurements of Frailty

Frailty has been defined as an age-related vulnerability related to multiple physiologic systems that can coexist with disability and chronic disease or be independent of these conditions [57]. This definition of frailty is generally well accepted; however, the issue of how to measure frailty is still up for debate. There are over 70 tools in existence for measuring frailty, and there is no consensus on which tool is best, as most have been used only within one area of medicine and have not been widely tested across patient populations or against each other to determine if there is one superior test [63].

Frailty tools can range in length from a single item to more than 90 items and can be classified as objective, subjective, or mixed. The simplest objective measures are single-item assessment tools such as gait speed measurements and the timed up-and-go test [64, 65]. These single-item tests have been found to be independently predictive of morbidity and mortality in surgical patients, as well as quick and easy to administer; however, they lack the specificity and sensitivity of full frailty assessments. The most commonly studied objective scales are those created by Brown et al. [66] and Gill et al. [67]. The Modified Physical Performance Test (MPPT) [66] examined 107 community-dwelling elderly adults on nine functional tasks (Table 30.1). Each task is scored on a four-point scale with a higher score indicating a better functional status. No single task identified frailty as well as the MPPT as a whole. Gill et al. [67] tested participants for physical frailty by conducting a rapid gait test over 10 ft (covering the distance in greater than 10 s was considered frail) and a qualitative chair stand test (an inability to stand up from a chair with arms folded indicated frailty). Subjects who were considered frail on only one test were considered moderately frail, while those who failed both tests were frail [68].

Table 30.1 Items in the Modified Physical Performance Test (MPPT)

Lift a 7-lb book to a shelf from waist height
Put on and remove a jacket
Pick up a penny from the floor
Perform a 360-degree turn
50-ft walk test
Climb a flight of stairs
Climb up and down four flights of stairs
Stand up 5 times from a 16-in. chair
Progressive Romberg Test

Table 30.2 Canadian Study on Health and Aging rules-based definition of frailty

Score	Description
0	Walk without help, perform basic activities of daily living, is continent of bowel and bladder, and is not cognitively impaired
1	Bladder incontinence only
2	One (or two if incontinent) of the following: needing assistance with mobility or activities of daily living, has cognitive impairment, or has bowel or bladder incontinence
3	Two (or three if incontinent) of the following: needing assistance with mobility or activities of daily living, has cognitive impairment, or has bowel or bladder incontinence

Table 30.3 Canadian Study on Health and Aging clinical frailty scale

1—Very fit	Robust, active, energetic, well motivated and fit
2—Well	Without active disease, but less fit than people 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 people 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 non-instrumental activities of daily living
7—Severely frail	Completely dependent on others for the activities of daily living, or terminally ill

Table 30.4 Phenotype of frailty scale

Unintentional weight loss
Self-reported exhaustion
Weakness (measured as grip strength)
Slow walking speed
Low physical activity

Each item is scored as 0 or 1. Total score: 0 = not frail; 1–2 = pre-frail; ≥3 = frail

Purely subjective frailty assessments are also available, the majority of which are products of the Canadian Study on Health and Aging (CSHA). The CSHA is a 10-year study of the epidemiology of dementia in Canada that followed patients from 1991 to 2001. The initial study was a 5-year prospective cohort trial that included 9008 people aged 65 and older [69]. While the study was aimed at studying dementia, they also developed a rules-based definition of frailty (Table 30.2). The rules-based definition was able to demonstrate a dose response relationship between frailty, institutionalization, and death. A secondary analysis of 2914 patients who were part of the initial cohort of CSHA participants was conducted. The patients were assessed for frailty using a 20-item frailty index of observed deficits [70]. The CSHA frailty index was found to be a sensitive predictor of survival in this population. On average, study authors found that the elderly without cognitive impairment accumulated functional deficits at a rate of 3% per year. In an effort to simplify the measurement of frailty, the CSHA Clinical Frailty Scale was developed [71]. It is a seven-point clinical opinion scale (Table 30.3) that was validated in the 2305 patients who participated in the second stage of the CSHA. The Clinical Frailty Scale was highly correlated with the previously developed frailty index and like its predecessors was predictive of institutionalization and death.

Many of the frailty scores that have been developed combine subjective and objective measures. The phenotype of frailty by Fried et al. is the most commonly studied scale that uses subjective and objective measures [72]. This scale looks at five variables that are scored as either 0 if absent or 1 if present (Table 30.4). The frail phenotype was independently predictive of falls, worsening mobility, or activities of daily living disability, hospitalization, and death. This scale also demonstrated that frailty is not synonymous with either comorbidity or disability, but comorbidity is a risk factor for, and disability is an outcome of, frailty. Another mixed assessment tool is the Edmonton Frail Scale [73]. This scale looks at a wide range of domains including cognition, general health status, functional independence, social support, medication use, nutrition, mood, continence, and functional performance. The benefit of this scale is the broad domains that it covers, including social support, and its ability to be administered by a non-geriatrician.

Researchers have moved beyond generic frailty indices to create scales that are designed to be used within a specific patient population. The Trauma-Specific Frailty Index (TSFI) is a 15-variable frailty index that looks at the domains of comorbidities, daily activities, health attitudes, and nutrition [62]. The TSFI has been validated in a trauma population and was found to predict unfavorable discharge (death or discharge to a skilled nursing facility). The TSFI was the only significant predictor of poor outcome in its validation study. A similar instrument has recently been created by this same group for emergency general surgery patients [74].

30.7.3 Frailty in Burn Patients

Thus far in burns the only scale that has been used in studies related to frailty and outcomes is the CSHA Clinical Frailty Scale [75–77]. These studies have demonstrated that patients who are frailer have higher mortality rates following burn injury and are more likely to be discharged to a skilled nursing facility. More research is warranted to determine the optimal scale for use in an elderly burn population to predict outcomes and for other decision-making.

30.8 Rehabilitation/Disposition

Long-term outcomes of geriatric burn patients are largely unknown as little data are available in this area. This was also discussed at the ABA State of Science meeting where the tasks of identifying elderly long-term outcomes and creating follow-up with multidisciplinary teams were prioritized [30].

30.8.1 Rehabilitation

Rehabilitation is an important part of many burn patient recoveries. In a study of patients with hand burns, a comprehensive rehabilitation program was superior to routine care in terms of physical function; more surprisingly, however, the rehabilitation arm also performed better on measures of psychological function, social function, and general health [78]. Early physical and occupational therapy, even in ventilated, critically ill patients, has been shown to improve outcomes as well [79].

Despite multidisciplinary data reinforcing the importance and impact of rehabilitation programs on patient outcomes, there is a wide variation in utilization rates of inpatient burn rehabilitation centers between states [80]. These differences persist when controlling for possible confounding factors and should be further investigated with the goal of standardizing the criteria for inpatient rehabilitation referrals.

30.8.2 Disposition

Not surprisingly, older patients often warrant higher levels of care such as skilled nursing after discharge from the hospital even when controlling for inpatient rehabilitation stay [81]. Post-hospital care for geriatric burns must be carefully planned and executed to achieve optimal outcomes. The process can prove to be complex with multiple patient factors, medical and social among others, playing a role. Some researchers are working to predict which patients would benefit from or even require a transitional facility with the goal of decreased hospital length of stay and improved patient satisfaction and outcomes.

The Comorbidity-Polypharmacy Score (CPS) has been identified as an independent predictor of need for transfer to extended care facilities in the older burn population [82]. This is useful because this variable can be measured on admission, and a treatment team may begin the planning process earlier in the patient's hospital course. The frailty score is another topic of interest in predicting outcomes and disposition in elderly trauma and burn patients. It has been found to be increased in those patients discharged to a skilled nursing facility when compared to those discharged to rehabilitation centers or to home [76, 83].

The Baux score is a tool which has been in use by burn physicians since the 1960s to predict prognosis after burn injury and has recently been applied by the Prognostic Assessment of Life and Limitations After Trauma in the Elderly (PALLiATE) Consortium to predict discharge disposition in geriatric burn patients (www.palliateconsortium.com). The authors reviewed data from the National Burn Repository on patients 65 years of age and older. Three discharge outcomes were studied in 8001 subjects, including death, discharge to home, and discharge to a non-home setting. Overall, 42.5% of patients were discharged to home with 13% transferred to a skilled nursing facility and 10% discharged to a rehabilitation center. There was an 18.9% mortality rate, and the remaining patient dispositions (15.6%) were mixed between needing home health services, being lost to follow-up, having left the hospital against medical advice, or having unavailable data. The conclusion after data analysis was that for Baux scores greater than 86, the return-to-home rate drops drastically. Additionally, mortality increases at a score greater than 93, with death almost always seen at a score greater than or equal to 130 [84]. This study's findings naturally lead into a discussion about end-of-life decisions and goals of care with patients and their families; however, this is out of the scope of the current section of text.

Of note, a 2017 study looking at discharge destination in older trauma patients found higher rates of readmission among those patients discharged to extended care facilities or rehabilitation centers, even when controlling for injury severity and comorbidities [85]. The reasons for this have not yet been elucidated.

30.8.3 Reintegration

The transition to reintegration after burn injury can be isolating and supporting resources scarce. In light of these findings, the Aftercare Reintegration Committee was formed to help burn patients, with emphasis on social skills training, peer support, and body image. While this group has ignited discussion at meetings on these topics, not much research into the interventions and implications for outcomes has been generated [86]. Any information from these discussions will likely apply, possibly in a more significant manner, to

geriatric burn patients, although we will not know for certain until data are collected and analyzed.

30.9 Long-Term Outcomes for Elderly Burn Patients

There have been many studies that look at the short-term outcomes for elderly burn patients, but there have been few significant studies that look at long-term outcomes in the elderly. As we do not have any data on long-term outcomes, it is not clear if the elderly survive acute hospitalization only to die shortly thereafter. Despite this, there is some evidence that when elderly patients are admitted to a long-term facility, or admitted to a nursing home, they have a very poor long-term outcome and usually die within 2 years [87]. For elderly burn patients, it is currently not clear what long-term outcomes should be expected.

Currently, long-term follow-up for elderly burn patients is conducted primarily by burn surgeons and not by multidisciplinary teams. In the trauma literature, there has been a movement towards creating multidisciplinary teams for the care of the elderly trauma patient. The G-60 trauma unit is a multidisciplinary trauma unit that was developed at the Dallas Medical Center in an effort to improve the care of elderly trauma patients [88]. All patients aged 60 years and older with a traumatic injury were admitted to the G-60 unit under the care of the multidisciplinary G-60 team. The team consisted of a trauma surgeon, a medical hospitalist, a physical medicine and rehabilitation physician, and representatives from PT/OT, respiratory therapy, nursing, social work, nutrition, pharmacy, and palliative care. Patients who were treated in the G-60 unit by the multidisciplinary team had a decreased length of stay from 7 to 4.8 days ($p = 0.0002$) and a decreased ICU length of stay from 5.2 to 3 days. Additionally, there was a statistically significant decrease in urinary tract infections, respiratory failure, congestive heart failure, ventilator-associated pneumonia, and acute renal failure. There was no difference seen in mortality or discharge disposition. We have long utilized multidisciplinary teams in burn care; however, we need to consider the addition of team members when caring for elderly burn patients. Additionally, it seems imperative that long-term follow-up should be conducted by a team that specializes in elderly burn care.

30.10 Outcomes Prediction/Goals of Care/Futility

Outcomes following burn injury have been steadily improving over the last 70 years, and while outcomes for the elderly have also improved, they have not done so to the degree as other age groups [89–91]. This makes the use of accurate outcome prediction scores especially important in the elderly burn patient. Jeschke et al. [92] attempted to find a cutoff age that predicted survivability of a burn injury but were unable to do so. They did, however, identify that the risk of death is linearly related to age and that the LD50 (burn size that is lethal to 50% of patients) decreases from 45% TBSA to 25% TBSA from the age of 55 to 70 years. This increase in mortality occurs despite the implementation of modern protocolized burn care. Since its development in the 1960s, the Baux score has been the traditional model for predicting outcomes among burn-injured patients [93]. This score is made up of the patient's age and their percent TBSA burned, and a total score of more than 75 portended a poor prognosis. It was developed using data sets that were inclusive of all ages and therefore not specific to elderly burn patients. The Baux score was modified in 1979 by excluding patients younger than 20 years old from the analysis, as it was determined that mortality did not increase linearly with age in this group. The resulting model demonstrated that a score of greater than 95 was equivalent to poor prognosis or mortality [94]. Because outcomes in the elderly are not the same as their younger counterparts, there has been an attempt to improve the predictive ability of the Baux score in this population. Hodgman et al. [84] used the Baux score on geriatric patients within the National Burn Repository and found that a score greater than 86 resulted in significantly fewer patients discharging to home. When the score reached 93, there was a significant increase in mortality, and death was virtually unavoidable above a score of 130. Multiple other outcome prediction models have been developed to further refine our ability to predict mortality. In addition to the modified Baux score, the scores that have been used to evaluate outcomes in the elderly are the Abbreviated Burn Severity Index (ABSI) and the score developed by Ryan et al. [95, 96]. The ABSI is calculated as the weighted sum of age, gender, %TBSA, percentage of full thickness, and presence of inhalation injury. Ryan et al. reviewed the charts of 1665 patients and identified three variables available at admission (age, TBSA burn >40%, and inhalation injury) as predictors of mortality. These were incorporated into a simple logistic regression model to objectively predict mortality. Of the scores used in the elderly, the modified Baux score has been shown to be the best predictor of survival in this population. There have been two studies that demonstrated its prognostic value. Wibbenmeyer et al. evaluated the modified Baux score and the ABSI in a cohort of 308 elderly patients and showed that the modified Baux score was superior to the ABSI (area under curve = 0.932 ± 0.02 vs. 0.815 ± 0.03, respectively) [97]. Additionally, the modified Baux score was the superior outcome score when compared with the ABSI and the Ryan et al. score in a retrospective cohort of 265 elderly patients [98].

While care for the burn-injured patient has improved significantly, there are still patients who do not respond well to treatment or have injuries that are determined to be nonsurvivable. In the elderly, it is especially important to consider having goals-of-care discussions early. Few studies have been done looking at when and how goals-of-care discussions are conducted with elderly burn patients. Madni et al. [77] examined factors associated with having goals-of-care discussions and found that in only 25% of cases were goals-of-care conversations documented. They found that a patient appearance of frailty increased the likelihood that a goals-of-care discussion occurred. Another group examined the reasons cited by decision makers for withdrawal of life-extending therapy. They found that these decisions in elderly patients (≥65 years old) were closely tied to underlying comorbidities, while in younger patients the size of the burn was a much more important factor [99]. An international survey of burn care providers assessing their feelings on end-of-life decision-making identified that these providers were more comfortable with withholding care than withdrawing care [100]. In burn patients, treatment limitations accounted for a minority of deaths. The primary reasons that they gave for either withholding or withdrawing care were severity of burn (78%), medical condition/high probability of death (68%), and unresponsiveness to therapy (68%). End-of-life care remains an area in need of both study and education among burn practitioners. In situations where survival is unlikely, we owe it to our patients and their families to have the best information possible to aid them in making care decisions.

30.11 Special Considerations

30.11.1 Specialty Consults

The complex physiologic and sociologic changes associated with advancing age have resulted in a specialty dedicated to studying and providing care for the elderly community. Geriatricians are experts in the management of the special health issues that arise in this age group, and the trauma community has begun to explore whether routine inclusion of these professionals results in better outcomes for their older patients. Olujo et al. initiated mandatory geriatric consults for all admitted trauma patients 70 years of age or older with the goal of examining do-not-resuscitate orders, rates of delirium, referral for cognitive evaluation, and patient outcomes pre- and postintervention. The rate of preintervention geriatric consults was 3.26%. This increased to 100% postintervention and resulted in improved advanced care planning and reduced ICU readmission rates from 8.26 to 1.96% ($p = 0.06$). There were no changes in 30-day hospital readmission, length of stay, or mortality, although the study was underpowered for some of these analyses [101]. Of note, an audit of a burn unit in South Australia found that the appointment of a geriatrician did not significantly reduce length of stay in patients 70 years of age and older; however, the authors asserted that the geriatrician assisted greatly in the placement of their patients, and the authors planned to make the addition permanent [102]. Speech pathology consults are also employed throughout the world, most often for patients who have experienced dysphagia as a sequela of their burn injury [103].

30.11.2 Holistic Therapy

Multimodal therapy regimens have been proposed to help with some of the challenges experienced by burn patients. For example, playing music during dressing changes can be a helpful adjunct to pharmacologic interventions [104, 105]. Additionally, aromatherapy massage and inhalation aromatherapy have been shown to reduce both pain and anxiety in burn patients [106]. Given the potential in elderly patients for polypharmacy and adverse reactions to medications, alternative therapies should be considered as part of a well-rounded treatment plan.

30.11.3 Psychologic Effects

There has been an increased interest in the psychosocial impairments seen in burn patients in the literature. A large, longitudinal, multicenter study using the National Institute on Disability, Independent Living, and Rehabilitation Research Burn Model System database found that Satisfaction With Life Scale scores were significantly lower for burn patients compared with nonburn, healthy controls. This remained true at time intervals of 6, 12, and 24 months after injury and was associated with both medical and psychological variables [107].

Emotional trauma is a recognized phenomenon in the burn patient's experience and recovery, and it is important to address as part of a complete treatment plan. Patients can suffer from pain, anxiety, mental illnesses such as depression and post-traumatic stress disorder (PTSD), and have many stressors related to reintegration into the community surrounding their scars and other factors. A qualitative study conducted in 2016 explored the concept of a "new normal" for burn patients and emphasized the importance of family closeness and empowerment through self-care [108].

Along these lines, it is noteworthy that mental disorders, particularly depression, are significant predictors of levels of functioning after burn injury [109]. This is particularly striking when one study's results revealed that 20.5% of burn patients experience clinically significant PTSD at 6 months post injury. And while the presence of burn injury has not

been found to increase the rate of mental health issues, burn patients tend to have higher rates of preexisting illness compared to controls [110].

In order to construct meaningful interventions and positively impact burn patient recovery, health care providers must continue to develop knowledge of the patient experience. A 2017 literature review focused on the postburn growth process and concluded that overall function, quality of life, social support and optimism, and new opportunities each contribute to the growth process after burn injury. The authors noted that each of these areas has potential for therapeutic intervention [111]. Interestingly, we are finding that the interventions with the most impact are not necessarily pharmacologic or medical and that teaching patients healthy, active coping strategies including positive reframing and humor may in fact improve the overall experience for the burn patient [112].

30.11.4 End of Life/Goals of Care

End-of-life conversations and goals-of-care discussions become of increased importance in elderly populations across all specialties. Communication regarding these issues between physicians and patients has become a hot topic of research in recent years. The Study to Understand Prognoses and Preferences for Outcomes and Risks of Treatments (SUPPORT) trial published in 1995 highlighted the shortcomings in care for severely ill adults. This trial found that only 47% of physicians knew when their patients preferred to avoid CPR and that 50% of patients who died while in the hospital were felt by family members to have suffered from severe pain for a large portion. The study's intervention provided physicians with estimates for 6-month survival, outcomes of CPR, and functional disability at 2 months; however, this was found to have no significant impact on patient care measures of communication [113].

Historically, surgeons have been thought to be less equipped to address these issues despite the potential morbidity and mortality inherent to surgical interventions. For this reason, an effort is being made to change the way surgeons interact with their patients during these encounters. One example is through training surgeons to use a framework which shifts the focus of conversation from isolated surgical problems to treatment alternatives and outcomes [114]. In the geriatric trauma population, prognostic indicators such as the Geriatric Trauma Outcome Score (GTOS) and Trauma and Injury Severity Score (TRISS) accurately predict probability of death [115]. Ongoing research projects will explore the utility of using newly developed frameworks along with validated outcome estimators to improve communication in both trauma and burn settings.

The impact of improved communication regarding these difficult issues extends beyond patient satisfaction. There is a recognized potential economic advantage associated with executing this interaction well. The care of burn patients is expensive in general; however, more health care dollars are spent on nonsurvivors than on survivors. Laboratory tests, imaging, nutritional support, renal support, and blood products make up a majority of these costs [116]. The identification of patients who favor comfort care measures over aggressive and life-prolonging interventions could lead to a drastic decrease in expenditures in this area and allow money to be reallocated to those patients with a potential for better outcomes.

Summary Box

Burn outcomes have improved over time for most demographic cohorts, but this cannot be said for thermal injuries in the elderly. This is especially problematic when one considers that seniors represent the fastest growing population in the United States and they possess characteristics which place them at higher risk for porr outcomes such as thinning skin, decreased sensation, mental alterations, pre-existing comorbidities and numerous other contributing factors. Despite these facts, little progress has been made over the last several decades in improving outcomes after thermal injury in the elderly as the LD50 for a burn in an elder has remained relatively constant at 30 to 35% TBSA. This chapter will review the medical and social aspects of burn care unique to seniors

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