State of the Science Burn Research: Burns in the Elderly

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BACKGROUND

Advances in burn care have led to significant improvements in the outcomes of burn patients except in the elderly: burn patients ≥65 years of age.[1,2] This is reflected in the LD50 for elderly burn patients, which has not significantly changed over the last three decades and is around 30 to 35% TBSA burn.[4,8]

The lack of improvements is even more impactful when considering that elderly represent the fastest growing population, indicating the expected substantial increase in elderly burn patients over the next decades. Additionally, the amount of burn patients in elderly will not only grow due to the growing population of elderly but also have much higher incidence as elderly are at an increased risk for burn injuries due to thinning skin, decreased sensation, mental alterations, pre-existing comorbidities, and numerous other contributing factors.[1–6] The high risk of suffering from burns in the elderly population with the rapid growth of this population will require change to the burn treatment paradigm but, at this time, burn care providers lack treatment guidelines or protocols tailored to the special needs of the elderly burn patient. Complicating elderly burn care is the lack of knowledge about maintaining quality of life, independence, and acceptable long-term outcomes.[9,10]

As aforementioned, despite the recognition of burn care providers regarding poor outcomes of elderly burn patients, reasons for these detrimental outcomes have yet to be determined. Unfortunately, until 2016, there were no concerted or directed research efforts to improve outcomes. In 2016, past President of the American Burn Association (ABA) Dr. Tredget held the State of Science meeting in Washington, DC, with elderly burn care being one of the main areas of interest and priorities. Subsequently a white paper was published in the *Journal of Burn Care & Research* (JBCR) that briefly delineated the perceived needs of elderly burn patients and areas ripe for investigations in order to improve outcomes.[11] In addition, ABA past Presidents Dr. Peck and Dr. Tredget initiated an ad hoc Committee on Elderly Burn Care, which changed to a standing committee in 2018.

The Committee on Elderly Burn Care has met several times since its inception and has identified areas that require urgent attention and investigation by directed and extensive research. This publication reflects the committee members' expert opinion and literature review of current knowledge in elderly burn care and lists major areas for improvement along with opportunities for research. Due to the limited published data on the subject, this paper should serve as a spring board for future investigations and not as a consensus paper for specific care recommendations. The areas are structured as follows and are authored by members from the Committee on Elderly Burn Care:

PREHOSPITAL

- Burn prevention: Dr. Herb Phelan and Dr. Steven Wolf
- Frailty scores: Dr. Kathleen Romanowski and Dr. Herb Phelan

ACUTE HOSPITALIZATION

- Acute phase: Sarah Rehou and Dr. Marc Jeschke
- Infection control: Dr. Alisa Savetamal and Joan Weber
- Nutrition: Dr. John Schulz
- Wound healing: Dr. Kathleen Romanowski, Dr. John Schulz, and Crystal New
- Pain and anxiety: Dr. Arek Wiktor and Dr. Charles Foster

POSTHOSPITALIZATION/REHABILITATION

- Rehabilitation and mobilization: Dr. Lyndsay Deeter
- Delirium in elderly: Dr. Alisa Savetamal
- Long-term outcomes: Dr. Kathleen Romanowski, Dr. Alisa Savetamal, Dr. Arek Wiktor
- Posttraumatic stress disorder: Dr. Arek Wiktor and Kelly Tuohy

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It is well established that a majority of burns sustained by older adults arise from one of the three general mechanisms or activities: those sustained due to smoking, those suffered from mishaps while cooking, and scald injuries. Understanding these discrete risk factors for burn injury in the elderly, in conjunction with the finding that elders have worse outcomes than their younger counterparts following burn, the imperative for quality injury prevention measures in this cohort is clear.

CURRENT KNOWLEDGE

Association With Decreased Mobility

Mobility limitation is present in 44% of older adults,[1] which itself leads to a loss of independence,[3] decreased quality of life,[2,3] institutionalization,[4] and increased mortality.[5–7] Patients with limitations in mobility have difficulty evacuating from a burning structure or quickly removing an article of clothing that has ignited. Further, frantic and off-balance movements lead to ground level falls with increased risk for hip fractures or closed head injuries that complicate burn care.

Association With Decreased Cognitive Function

Cognitive impairment with or without dementia is observed ranging from 3.4[8] to 5.4 million[9] Americans aged ≥71 years. This can be complicated by polypharmacy as elders are known to have 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 lead to episodes of hypotension, drowsiness, and impaired judgement. Alcohol and drug use are also common among geriatric burn admissions (rates of 10% for ethanol and 29% for marijuana, cocaine, or benzodiazepines[12]).

Impaired mental function puts seniors at risk for burns due to effects on ability to recognize behaviors as dangerous, that hazards are present, or that certain solutions are illogical. Additionally, a confused patient may have difficulty recognizing the severity of a given injury leading to a delay in seeking necessary medical attention.

Association With Home Oxygen Therapy

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 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 Chronic Obstructive Pulmonary Disease.[15] A multidisciplinary algorithm for discontinuing home oxygen therapy[16] has been proposed.

Association With Decreased Sensory Function

As sensory function diminishes with age, the risk for involvement in a fire-related event increases proportionally. With loss of hearing, elders lose the ability to hear smoke alarms. Similarly, loss of visual acuity increases the likelihood of missing cues to the presence of a fire hazard or subtle signs of flames or smoke. Similarly, olfactory losses can make the detection of smoke or natural gas difficult. Finally, diminished sensation is a common finding in the elderly, which can cause them to place their feet too close to heat sources or to have difficulty assessing water temperature.[17]

Association With Fixed Incomes

According to 2016 data, 21% of married Social Security recipients and 43% of single recipients rely on Social Security for 90% of their gross monthly income,[18] and 9% of the elderly live below the poverty line. Living on a fixed income lends itself to housing with substandard electrical and mechanical systems. The fire risks associated with frayed wiring and damaged household appliances are obvious. The elderly often feel cold and, when central heating is absent or not dependable, seniors often turn to heating sources as space heaters, fireplaces, and ovens. Furthermore, these environments may not have fire safety as a priority as a survey of homebound urban elders found 37% had no functional smoke alarms, 82% had no access to a fire extinguisher, and 46% had hot tap water >120°F.[20]

Association With Attempts to Retain Independence

It is human nature to try to retain independence as long as possible, and maintaining independence is a feature of quality of life.[21] With functional adaptations, many caregivers are able to assist elders in safely staying in their own homes. 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 older adults are left to live alone.[22] A burn admission is often the red flag that independent living is no longer safe.

Evidence-Based Fire Safety and Burn Prevention Interventions

Despite the increased risk profile of seniors for burn injury, interventional prevention studies specific to this population remain frustratingly rare. Most of the published literature specific to elders has endpoints related to the efficacy of various educational efforts. No studies evaluating the effect of prevention interventions on decreasing the incidence of burn injury in older adults could be found.

Fire Safety Education

A general lack of awareness of the importance of educating seniors about fire safety[23,24] is reflected in the fact that, when polled on a list of 13 common health topics they discussed with their primary care physician (PCP), seniors reported

fire safety and burn prevention to be last.[25] Five studies were identified, which assessed the effect of an educational intervention.[26–30] All demonstrated a significant increase in seniors' burn prevention knowledge using a variety of educational programs or information, but all were notable for a very short period of follow-up as the longest postcourse survey administered was 2 weeks after the course's completion.

Four qualitative studies were identified, which sought to determine seniors' attitudes about burn prevention and fire safety education. Among the select findings, there were three factors that were associated with a successful educational program: if an established relationship with the elder community existed, if rapport was effectively established, and if the presentation was deemed relevant by the audience.[31] In another study, using semistructured interviews with eight elders, an overriding theme was that fire risks should be managed in the context of the journey to maintain independence.[32] Redlick interviewed a group of 20 elderly burn survivors and found that they articulated a preference for television, news, and poster media as a means of burn safety education.[33] Finally, interviews with a group of 10 seniors in London found that they viewed scald prevention to be a matter of personal responsibility.[34]

Fire-Safe Cigarettes

Residential fire deaths due to unextinguished cigarettes have been addressed via an engineering solution in which two to three thin bands of less-porous paper have been placed along a cigarette, which cause 75% of unattended cigarettes to extinguish. In 2010, Wyoming became the 50th state to require the fire-safe cigarette design at the point of sale. Subsequent to this legislation, Yau demonstrated 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.[35] While these results include but are not specific to the elderly, the sophistication of the analysis and the striking magnitude of the signal for this prevention measure warrant inclusion here.

Nonevidence-Based Fire Safety and Burn Prevention Interventions

No published studies were located for the following older adult-specific fire safety interventions. Nevertheless, these are interventions that are safe, inexpensive, possibly efficacious, and are to be recommended. The use of a timer in the kitchen as a reminder to turn off the stove or burners is simple. When cooking is no longer deemed safe by a caregiver, removal of the knobs from the stove is an easy solution. Special smoke alarms have been created for the hard of hearing, which 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 can potentially play a central role in burn prevention as these are the medical professionals with whom the elderly have the most frequent contact and they are well positioned to conduct routine screening and counseling to assess fire risk and mitigation at office visits. Primary care physicians are well positioned to order a home care agency to perform a home safety evaluation. Finally, when prescribing home oxygen, primary care physicians should educate both the patient as well as the primary caregiver about the necessity for smoking abstention. The role of the caregiver is central to these discussions because, more often than not, it is the caregiver who is providing the cigarettes. The caregiver should be educated of the importance of notifying the prescribing MD for noncompliance with smoking on home oxygen. Finally, the caregiver plays a key role in home care, for example, smoke detector installation and maintenance and hot water heater settings.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

In the State of the Science open forum discussion, it was agreed that interventional studies that seek to demonstrate a reduction in the incidence of elder burn injury should be the gold standard. The realities behind the paucity of such studies were acknowledged (namely, the methodological difficulty in demonstrating a statistically significant reduction in events that are usually multifactorial), and it was the group's consensus that interventional studies that seek to demonstrate changes in behavior as a primary endpoint will continue to be the mainstay in the field.

In considering the prioritization of future research, a consensus emerged during the open forum discussion that the area that had the greatest potential impact on future prevention efforts was increasing the role of primary care physicians. The rationale for this strategy was based on these physicians' pre-existing relationships with the subjects of the intervention, the size of their workforce, their clinical mindset that generally values prevention efforts, and the resources that they can bring to bear should screening efforts raise areas of concern. Additionally, paradigms already exist for similar efforts with pediatricians and child safety, which could inform attempts to forge relationships between burn providers and nonsurgical community physicians. The presumed familiarity of the primary care physician with the patient would also allow for interventions to be tailored to a given risk factor as opposed to "one-size-fits-all" education. Finally, collaboration with these community physicians was felt to be a factor that would be viewed favorably by extramural funding agencies in future applications for support of these efforts. At the conclusion of the discussion, there was agreement that this intervention was the primary recommendation of the State of the Science Symposium's elder burn prevention efforts. Action items to this end were: investigating methods used by child safety experts to forge partnerships with community physicians; determining the most efficient and effective methods to gauge Primary Care Physician interest; and determining clinically significant endpoints that can be practically studied.

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Frailty Scores for Burn Surgery

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As the elderly population grows, so does the number of elderly burn victims. Traditionally, prediction of burn outcomes has been based on patient age and %TBSA burned. Updated models include presence/amount of full thickness burns, inhalation injury, and sex in their predictions.[1,2] Unfortunately, individuals with the same chronological age vary widely in their health and functional status making age alone a poor predictor of patient outcome.[3]

CURRENT KNOWLEDGE

Frailty is present in 10 to 20% of the population over the age of 65, potentially making it a good surrogate outcome measure for elderly patients.[4] Despite its potential to predict outcomes, there are questions that still remain about frailty. Why is frailty important? How is frailty measured? Which frailty measure should we use as burn surgeons to risk stratify our patients? Many studies across a variety of clinical situations examined frailty and its relationship to outcomes.[4–6] Conroy and Dowsing examined frailty in patients who were admitted to a medical unit[5] and found frailty scores were able to predict mortality but did not predict length of stay or readmission. In those undergoing elective surgery, they found frailty independently predicted postoperative complications, increased length of stay, and discharge to a skilled nursing facility.[6–7] In trauma patients, a higher preinjury frailty index predicted an unfavorable discharge (skilled nursing facility or death).[8] In general, frailty has been associated with increased risk of falls, delirium, cognitive decline, iatrogenic complications, and death.[3]

How is Frailty Measured?

Frailty has been defined as age-related vulnerability related to multiple physiologic systems that can either coexist with or be independent of disability and chronic disease.[3] While the definition of frailty is well accepted, how to measure frailty is still a matter for debate. There are over 70 tools in existence for measuring frailty, but there is no consensus on which tool is best since most have been used only within one area of medicine and have not been widely tested across patient populations.[9] Additionally, they have not been tested against each other to determine which is best able to predict outcomes.

Frailty tools range in length from a single item to more than 90 items and can be classified as objective, subjective, or mixed. Perhaps, the simplest objective measures are single-item assessment tools such as gait speed measurements and the timed up-and-go test.[10,11] These are included in some of the longer frailty assessments and have been found to be independently predictive of morbidity and mortality in surgical patients. They are easy to administer but lack the specificity and sensitivity of full frailty assessments. The most commonly studied objective scales are those presented by Brown et al[12] and Gill et al.[13] The Modified Physical Performance Test (MPPT)[12] examined 107 community-dwelling elderly adults on nine tasks (Table 1). Each item is scored on a four-point scale and a score of less than 32 denotes at least some amount of frailty, with a score less than 17 indicating dependence on a caregiver. They found no single item identified frailty as well as the combined tool. Gill et al[13] tested participants in their intervention study for physical frailty by conducting a rapid gait test over 10 feet (greater than 10 seconds considered frail) and a qualitative chair stand test (inability to stand up from a chair with arms folded). Subjects who were considered frail on one of these criteria were considered moderately frail, and those considered frail on both criteria were considered severely frail.[14]

Table 1. Items in the Modified Physical Performance Test (MPPT)

Lift a 7-pound book to a shelf from waist height
Put on and remove a jacket
Pick up a penny from the floor
Performance of a 360° turn
50-foot walk test
Climb on flight of stairs
Climb up and down four flights of stairs
Stand up five times from a 16-inch chair
Progressive Romberg test

Most of the purely subjective scores are products of the Canadian Study on Health and Aging (CSHA). CSHA is a 10-year study of the epidemiology of dementia in Canada that followed patients from 1991 to 2001. The first part of the study was a 5-year prospective cohort study that included 9008 people aged ≥65.[15] In addition to their findings related to dementia, they developed a rules-based definition of frailty (Table 2). The rules-based definition showed a dose-response relation between frailty, institutionalization, and death. In a secondary analysis of the initial cohort of CSHA participants, 2914 patients assessed frailty using a 20-item frailty index of observed deficits.[16] The CSHA frailty index was found to be a sensitive predictor of survival and the average accumulation of deficits in those who do not have cognitive impairment was 3% per year. To simplify the measurement of frailty and ease implementation, the CSHA Clinical Frailty Scale was developed.[17] It is a seven-point clinical opinion scale (Table 3) that was validated in the 2305 patients who participated in the second stage of CSHA. The Clinical Frailty Scale was highly correlated with the previously developed Frailty Index and, like its predecessors, was predictive of institutionalization and death.

While the scales and indices previously discussed are either subjective or objective, many scales combine both elements. The Phenotype of Frailty by Fried et al[18] is the most commonly cited mixed scale. The phenotype of frailty is a scale looking at five variables that are scored as either a 0 if absent or a 1 if present. (Table 4) The frailty phenotype was independently predictive of falls, worsening mobility or Activities of Daily Living (ADL) disability, hospitalization, and death.

Table 2. Canadian Study on Health and Aging (CSHA) rules-based definition of frailty

Score	Description
0	Walk without help, perform basic activities of daily living, are continent of bowel and bladder, and are 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 3. Canadian Study on Health and Aging (CSHA) 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 life
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 terminally ill

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. The five-item "Fatigue, Resistance, Ambulation, Illness, and Loss of Weight" (FRAIL) scale was designed to be a screening tool that looks at similar variables to the Phenotype of Frailty scale.[19] It is supposed to take less than 5 minutes to administer and examines fatigue, ability to climb a flight of stairs, ability to walk one block, the presence of greater than five comorbid conditions, and a greater than 5% weight loss. Another mixed assessment tool is the Edmonton Frail Scale.[20] 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 benefits of this scale over some others are the broad domains that it covers, including social support and its ability to be administered by a nongeriatrician.

Table 4. Phenotype of Frailty Scale

Unintentional weight loss
Self-reported exhaustion
Weakness (measured as grip strength)
Slow walking speed
Low physical activity
Scored 0 or 1; 0: not frail; 1–2: prefrail; ≥3: frail

Some researchers have started to move 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.[8] The TSFI has been validated in a trauma population of 200 patients over 2 years 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 their validation study. A similar instrument has recently been created by this same group for emergency general surgery patients.[21] Each of these frailty scores has pros and cons, which are summarized in Table 5.

Which Frailty Measure Should We Use As Burn Surgeons to Risk Stratify Our Patients?

In choosing a frailty scale to be used in burn surgery, there are several factors that come into play. Many of the previously described tools were designed for community-dwelling seniors and are not applicable for elders admitted after injury where wounds may impede the physical performance of some of the diagnostic tasks. The optimal scale chosen to be used in the burn community must be independent of wound burden, predictive of outcomes, easy to administer, validated, and reproducible across a wide variety of hospitals. Thus far, in burns, the only scale that has been used in research related to frailty and outcomes is the CSHA Clinical Frailty Scale.[22,23]

Table 5. Comparison of frailty scores

Frailty score	Pros	Cons
Single-item objective measures (5-m walk; get up and go)	• Easy to administer • Minimal training required to administer	• Lacks both sensitivity and specificity of more complex scales • Only tests physical frailty • Requires patient be able to participate in test
Modified Physical Performance Test	• Objective measure of physical abilities • Tests fine and gross motor abilities	• Time to administer • Requries training to administer • Only measures physical frailty • Patient must be able to participate in tasks
CSHA Frailty Index	• Comprehensive examination of frailty using 70 items	• Large number of items • Time consuming to administer • Purely subjective
CSHA Clinical Frailty Score	• Easily administrated as part of standard patient encounter • May be used retrospectively if the data on functional status is collected	• Purely subjective • Clinical opinion scale
Phenotype of Frailty	• Short (requires 10–15 min to conduct) • Subjective and objective measurements	• Requires more than a simple questionnaire • Need to know the norms in order to score the scale
FRAIL scale	• Created as a screening test	• Is a screening test; therefore, further confirmatory tests would need to be done
Edmonton Frail Scale	• Combination of objective and subjective measures	• Time to administer
Trauma-Specific Frailty Index	• Includes cognition • Only 15 variables • Fast and easy to administer •Minimal training needed to administer	• Requires training to administer • Requires an albumin level • Largely subjective • Generalizability as it was designed for trauma patients

These studies have demonstrated that patients who are more frail have higher mortality rates following burn injury and are more likely to be discharged to a skilled nursing facility.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

Creation of a working group to fully examine the available frailty scales and determine which one will be the most useful for the elderly burn-injured patient may require a study of multiple scales or the creation of burn-specific frailty score/index to find the one that best serves our needs as an organization. It may be possible to look at the already accumulated data about the scales that are in existence and make a decision. Given its use in previous burn studies, its ability to be used retrospectively, and its ease of use, the CSHA Clinical Frailty Scale may be the best option, but this should be fully examined. Once a scale is chosen, it should be included in the Burn Quality Improvement Program (BQUIP) and the National Burn Repository (NBR).

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Acute-Phase Response Postburn in Elderly Patients

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Elderly burn patients do not respond to stress in the same way that adult burn patients respond in terms of inflammation and metabolism. Elderly patients have delayed inflammatory and metabolic responses compared with younger adults.[1] This was confirmed in a study by Stanojcic et al showing that elderly burn patients express an altered and reversed inflammatory response, indicating that elderly patients likely do not have the resources to adequately respond to stress.[2] The unique pathophysiologic responses to burn in the elderly are only being realized in recent times. The impact of these responses on burn outcomes has not yet been fully investigated.

CURRENT KNOWLEDGE

There is little information or studies delineating the acute-phase and inflammatory response in elderly burn patients. Swanson et al showed that 75% of burn deaths can be attributed to failure or decompensation in the resuscitation phase.[3] We conducted a cohort study to investigate whether elderly respond differently to the initial burn in terms of clinical parameters, such as fluid resuscitation requirements, and their systemic response compared to adults.[4] Our study identified differences in the acute-phase response to burn injury in adult and elderly patients with a burn ≥20% TBSA. We confirmed that elderly do have worse outcomes

and increased mortality. We found that 50% of elderly patients died in hospital in comparison to 5% of adult patients. The greatest difference between adult and elderly burn patients was impaired and reduced cardiac function in elderly burn patients. Elderly burn patients have decreased cardiac efficiency, associated with increased preload and increased resistance. This leads to decreased output and hypoperfusion as found by decreased mean arterial pressure and diastolic blood pressure. This impaired cardiovascular function led to organ hypoperfusion likely resulting in organ failure. Elderly patients had a significantly decreased PaO_2/FiO_2 ratio upon admission associated with an increased lung water content, indicating that elderly patients have decreased or impaired lung function.[4] Additionally, we were able to confirm previous study results by Stanjocic et al[2] as elderly were hypoinflammatory during the acute-phase response with significantly lower interleukin (IL)-6, monocyte chemotactic protein (MCP)-1, MCP-3, and granulocyte-colony stimulating factor (G-CSF) compared to adults.[4]

Key Takeaways From Study

In this study, we suggested clinicians consider use of non-invasive cardiac monitoring, use of dobutamine if a patient has a low cardiac index or low cardiac output, recognition that impaired cardiac function and hypotension can lead to overresuscitation, and initiation of early hemofiltration if overresuscitation occurs.[4] However, there are elderly burn patients who might have prior cardiac comorbidities that cannot be ideally managed.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

There has only been a glimpse into how the elderly respond to the burn stress acutely. Although there is reasonable evidence that these alterations impact acute hospitalization outcomes, there is no direct causality. We, therefore, propose to further study the effects of the acute phase on various physiologic and biological systems during acute hospitalization. Areas requiring further investigation include: 1) determine molecular and cell organelle functions in elderly and compare these to adults; 2) determine how changes during the acute phase alter outcomes at a later time point, and 3) identify and predict outcomes including organ failure. Overall trajectories of elderly burn patients must also be determined to facilitate outcome prediction of elderly burn patients.

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Infection Control in the Elderly Burn Patient

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Injury to the skin leaves burn patients particularly at risk for infectious complications. Elderly patients, who often have thinner skin, relatively compromised immune systems, and chronic medical problems, are particularly vulnerable after burn injury, with high mortality if sepsis occurs within 2 weeks. Compounding the infectious risks for this group is the possibility of pre-existing colonization or even active infection with multidrug-resistant organisms (MDROs) at the time when burn injury occurs, particularly if patients have been residents of a long-term care facility (LTCF).

CURRENT KNOWLEDGE

The Center Disease Control, in recognizing that LTCF residents carry a higher risk of harboring MDROs as well as a higher risk of increased complications with MDRO infection (including length of stay, hospitalization and readmission, and mortality), suggests developing and implementing protocols for active surveillance cultures for MDROs in at-risk patients, including burns. While no large-scale data exist for infection control in the elderly burn patient, it is important to be particularly vigilant to the danger of MDRO infection in this vulnerable population. To that end, we advocate the following measures for infection control in the elderly burn patients:

Routine Surveillance of Elderly Patients

Burn centers will have different microbial profiles for their patients based on geographical location and the types of patient populations they serve. It is important for each to determine the baseline microbiology of the local geriatric population. Discerning whether MDROs are common in the local population and what those organisms are will allow a targeted, early response. Nasal and wound cultures should be obtained on admission. If MDROs are found during this period, then routine admission surveillance cultures for all elderly patients should be continued. If no MDROs are found, then reassessment of this risk should occur periodically.

Weekly Surveillance Cultures

If MDROs are found, control of the spread of these organisms, particularly to other elderly burn patients, is of paramount importance. Weekly surveillance cultures (nasal and wound) of all elderly patients should be undertaken to determine any cross colonization. Along with contact isolation for patients with MDROs, heightened awareness and staff education should be reinforced for all activities, particularly Physical Therapy/Occupational Therapy, where shared facilities could facilitate spread of MDROs.

Contact Isolation

Patients transferred from another hospital or from a long-term care facility are at risk for having acquired MDROs. Infection control measures, including contact isolation, have been shown to decrease rates of colonization and infection with MDROs. Contact isolation should be instituted for patients arriving from a LTCF *until* admission surveillance cultures document that no MDROs are present.

Indwelling Device Management

Indwelling devices are associated with significant complications in elderly patients in particular. Elderly patients with Foley catheters carry a 3 to 7% daily risk of urinary tract infections as well as a greater adjusted odds ratio of rehospitalization and death if discharged with a catheter. Central venous catheters in elderly patients are also associated with bacteremia and death. Endotracheal tubes, rectal tubes, and nasogastric/nasojejunal feeding tubes also present potential risks to the patient. Daily assessment of need for indwelling devices and *early removal* where clinically appropriate. Use of peripheral venous catheters is preferred to central catheters if possible.

Antibiotic Stewardship

Antibiotic stewardship is important in the elderly population as these patients have potentially been exposed both to multiple organisms and multiple antimicrobial treatments. Infections may have unusual presentation in elderly patients, with equivocal clinical findings and laboratory studies. As a result, many practitioners may find themselves using a "low threshold" for treatment, and possibly overtreating rather than using a "high threshold" and possibly delaying treating a clinically indolent infection. Daily reconsideration of need for antibiotics in elderly patients will allow early treatment of suspected infection but encourage appropriate cessation of antibiotic coverage once the patient has clinically cleared an infection. Where available and appropriate, this decision should be made in conjunction with a geriatrician, an infectious disease specialist, or a geriatric ID specialist.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

While we believe that these approaches to infection control in the elderly will be beneficial to our older patients, the fact remains that there is a wide disparity of practice in the burn community regarding infection control. Despite our belief that elderly burn patients are more likely to be colonized with MDROs, we do not have a good sense of either the prevalence of the problem or whether colonization with MDROs in elderly patients translates into increased burn wound complications and mortality. There are likely geographic differences as well that would be interesting and important to elucidate.

We would propose to begin with a study of practices in burn centers to determine 1) if and how elderly patients are screened for MDROs; 2) what percentage of elderly patients arrive to burn units with MDROs or develop them while in hospital; and 3) mortality rates among the elderly, particularly deaths due to burn wound sepsis from MDROs. With these data in hand, we will be able to make stronger evidence-based recommendations for managing elderly burn patients and their infections.

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Nutrition in Elderly Burn Patients

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Among those aged ≥65, undernutrition and protein malnutrition are much more prevalent than among younger cohorts.[1,2] The reasons for this are multifactorial, ranging from poor dentition and attenuated senses of taste and smell to dementia, immobility, depression, and poverty. Independent of preinjury nutritional status, older adults also present with lower lean body mass than younger patients of similar weight. Beginning as early as age 40, humans lose an average of 0.6% of lean body mass per year as they age, producing a "sarcopenia" of aging. Consequently, the older patient is already suffering from a relative lean body mass decrement at the time of presentation with a burn injury.[3] How these relate to burn injury is not yet known.

CURRENT KNOWLEDGE

Older adults have a blunted anabolic response to dietary protein, requiring a greater serum amino acid concentration than younger patients to initiate muscle protein synthesis.[4] Age is a mortality risk factor in burn injury

and it seems reasonable to posit that malnutrition, senescent sarcopenia, and altered protein anabolic response have some impact on the prognostic significance of older age. Evidence for this, however, is lacking and, in the near term, it may be that premorbid nutritional status is best subsumed in an overall frailty assessment. Going beyond initial assessment, there is scant data to support any particular nutrition intervention in the burned elder except for provision of nominally adequate protein and calories with the understanding that older patients may need more exogenous protein to support muscle protein synthesis than younger patients. Additionally, there is evidence that pharmacologic intervention with oxandrolone can support lean body mass gains in older adult subjects[5] and there is good evidence that oxandrolone is beneficial for adult burn patients.[6] For those interested in current recommendations for burn nutrition with a discussion of the supporting evidence, please see an excellent recent review article by Clark et al.[7]

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

Besides having to deal with the frailty and comorbid illnesses and prolonged inflammation after injury of the old patient, burn centers need to determine the best way(s) to adequately nourish a patient that starts with a lean body mass deficit and takes more of a stimulus to build muscle protein than do younger patients. Where do we start? Given the lack of evidence available to suggest best practices in the elderly (other than providing nutrition and oxandrolone, previous observational studies on nutrition practices have focused on critically ill patients and have not specifically looked at older adults[8]), the ad hoc committee agreed that the place to start is to define current practice by a survey of burn center practices in North America.

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Elderly Wound Healing

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Aging alters skin physiology and biology and alters the healing process.[1,2] Consequently, burns which would be less severe in younger patients can have a devastating effect on the elderly patient. Elderly patients experience not only changes in skin physiology that leads to deeper burns, but prolonged healing and differences in scarring are well established. While the numerous changes that occur to the skin with aging are well documented, the exact effects that these changes have on burn wounds, our treatment of these wounds, and the ultimate outcomes of elderly burn-injured patients is unclear at this time.

CURRENT KNOWLEDGE

Aging affects all components of the skin.[3] As the skin ages, the epithelium becomes thinner, but there is also some thickening of the epidermis due to sun exposure.[4] Despite this, the overall effect is a thinning of the skin. In the burn-injured patient, thinning skin means that burns, which would only be partial thickness in younger patients, are full thickness in the elderly. Another change in the skin of the elderly is that the junction between the epidermis and dermis flattens, reducing the size of the rete pegs that leads to an increased risk of shearing of the skin leading to blisters of the epidermis. In the subdermal tissue, aging manifests as a decreased capability for angiogenesis leading to delayed revascularization.[5,6] Additionally, the new vessels tend to have a greater tendency to leak. All of this leads to impaired lymphatic drainage, predisposing the skin to increased edema that impairs wound healing.

Perhaps 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. In particular, the decreased number of hair follicles throughout the body is critical to the changes seen in wound healing of the elderly.[7] It is well established that partial-thickness wounds re-epithelize from both the epithelial edge of the wound and the skin adnexa.[8] The cells in the basal cell layer of the epithelium at the edge of the wound migrate toward the center of the wound covering 1 to 2 cm from the wound edge. Any wound that is too large, is full thickness, or lacks skin appendages attempts to heal by contraction of the wound and scar formation. If the wound has hair follicles or other skin adnexa (and, therefore, is partial thickness), the keratinocytes migrate from the remaining adnexa to resurface the wound. The greater the density of skin adnexa in the wound, the more rapid the rate of healing of the wound. For example, a wound on the scalp will heal within 4 to 5 days as opposed to a wound on the lower leg, which can take 2 to 3 weeks to heal. Therefore, a decrease in the density of hair follicles and other skin adnexa slows the resurfacing of a wound and leads to an increased risk of scarring.

Despite the increased time to healing and the fact that it is known that prolonged healing time promotes hypertrophic scarring, it is unclear if the same holds true in the elderly.[9] Because skin gets looser as it ages, the risk of contracture producing tension is lower. It is this tension that leads to hypertrophic scarring and, therefore, patients with loose skin can contract a wound without producing a hypertrophic scar. 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.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

At this time, there is no definitive data to suggest how practitioners are treating elderly patients. It is not known whether early excision and grafting is 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. It is not clear whether excision is beneficial to be more or less aggressive in the care of the elderly. We, as a burn community, need to investigate the wounds of elderly burn patients and their management. The first step is a nationwide and international survey with the assistance of the ABA, the International Society for Burn Injuries (ISBI), and their memberships assessing the current practices used in treating elderly burn patients. Ultimately this should lead to a prospective phase 3 multidisciplinary multicenter trial to determine the optimal excision and grafting practices in elderly burn patients.

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Pain and Anxiety Management

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One of the most challenging aspects of burn care is the implementation of a sound and efficacious pain and anxiety treatment regimen. Pain control in the burned elderly patient is especially problematic given the added layers of complexity of treating a painful burn wound, performing daily physical and occupational therapy, while also accounting for pre-existing medical comorbidities, pre-existing chronic pain,[1] diminished organ function, and polypharmacy issues.

CURRENT KNOWLEDGE

Barriers to optimal geriatric pain control include underreporting of pain[2] and misconceptions by providers that treating pain too aggressively may cause deleterious effects such as overdose, diversion, or dependence.[3,4] Optimal pain/anxiety care in the elderly require both an appreciation to the subtleties of how elderly patients present and express their pain, along with medical therapies that must take into account comorbidities, other medications, and baseline level of cognition and function.

In one of the only studies to explicitly study pain management in the elderly burn population, Honari et al showed that opioid administration decreased as age increased, despite a larger percentage of total surface area burned.[5] The reasons for this were unclear, and the authors postulated that it could be a result of less pain (actual or reported), differences in metabolism, patient refusal, or a bias toward undermedicating in the elderly.[5] Even less is known about anxiety in the elderly burn population as there are no studies that specifically address this. Notwithstanding, it is well recognized that pain and anxiety go hand in hand and can exacerbate each other.[6] Higher levels of anxiety have been linked with increased pain following burn injury.[7] The lack of evidence in these areas highlights the urgent need for further investigation of this vulnerable patient population.

A variety of pain assessments have been used to study the elderly, including the Verbal Descriptor Scales (VDS), the Numerical Rating Scales (NRS), and the Visual Analogue Scales (VAS),[1] while the Beck Anxiety Inventory has been used to study anxiety.[8] None of these assessments have been specifically studied in the elderly burn population. Multiple excellent consensus guidelines have been developed as useful tools for pain management in the elderly population, including those from the American Geriatrics Society[9] and the American Pain Society.[10] However, these tools do not specifically address pain control in the geriatric burn patient. This categorization is important considering their unique needs in daily wound care, physical therapy sessions, and postsurgical periods when compared with other geriatric patients.

Treatment Considerations

There are several key points to consider when caring for the elderly. Pharmacologic treatment of pain and anxiety in the elderly burn patient should be focused on adequately managing symptoms while limiting unwanted adverse effects. As individuals age, pharmacokinetic and pharmacodynamic changes may occur that should be considered when selecting and dosing pharmacologic agents. A natural decline in all organ functions over time may lead to variability in the absorption, distribution, metabolism, and elimination of drugs and their metabolites; however, there are minimal pharmacokinetic analyses to provide specific recommendations. Elderly patients may be prone to a reduction in first pass metabolism

of enteral medications, leading to an increase in systemic exposure, while also having a propensity for lower renal excretion of active metabolites, such as those from morphine and midazolam. Clinical studies have shown that elderly patients are more sensitive to opiates, both from an efficacy and safety perspective. As a result, elderly patients often require much lower doses for a comparable effect and are at higher risk of respiratory depression. Lastly, it should be noted that all medications that are utilized to treat pain or anxiety cross the blood–brain barrier and will contribute to the potential for an increased risk of falls in elderly patients. To complicate things further, nearly all of the medications used for pain or anxiety are listed on the Beers Criteria for Potentially Inappropriate Medication Use in Older Adults.[11,12]

In general, it is assumed that nonopiate medications, such as acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), and nonpharmacologic strategies, be optimized and given alongside opiates. A broad approach should be to use acetaminophen for mild-to-moderate pain and short courses of low-dose NSAIDs with close monitoring. However nonopiate analgesics are not without their risks. Products containing acetaminophen are present in more than 600 over-the-counter and prescription medications, resulting in unintentional overdose as the leading cause of acetaminophen-related hepatic toxicity.[13] NSAIDs also can have profound renal, gastrointestinal, and cardiovascular adverse effects including acute kidney injury, gastrointestinal bleeding, and increased risk of heart attack and stroke, all of which the geriatric population are at higher risk of experiencing.

In most consensus guidelines, opiates are described as a first-line agent for pain control. In elderly patients, decreasing the dose by 25 to 50% due to pharmacodynamic changes is recommended.[3] The side-effect profile of opiates in the elderly is particularly concerning, encompassing respiratory depression, constipation, sedation, sleep disturbance, nausea, and vomiting.[14] Benzodiazepines should also be avoided due to their side-effect profile as they show an increased risk of delirium, somnolence, dizziness, and respiratory depression, especially when used concomitantly with opiates. Ironically, benzodiazepines are also the mainstay for treatment of anxiety in burns.[15] As such, their use in this patient population needs to be further studied. Other medications given alongside opiates methadone, gabapentin, pregabalin, and clonidine; however, again, these have not been studied with regards to the geriatric burn patient. Synthetic cannabinoids, such as dronabinol, have also been used for pain but have not been studied in the elderly.[10] Topical therapies, such as lidocaine and NSAIDs, are additional adjuncts that require further evaluation in the burn population, especially in the elderly.

Challenges for Pain Control

Perhaps the greatest unknown is what is the most efficacious and safe pain control regimen to use during tub-room wound care sessions. Agents such as ketamine, dexmedetomidine, ketamine + dexmedetomidine, and ketamine + midazolam have been tried with varying degrees of success,[16] but no trial has been performed in the elderly population. Fundamental questions, such as how much premedication should be given prior to undergoing wound care, what sorts of agents should be given during wound care, and at what doses, remain unanswered in the elderly burn patient.

Nonpharmacologic approaches for pain and anxiety therapy, such as cognitive-behavioral therapy (distraction techniques), cooling therapy, hypnosis, virtual reality, acupuncture, meditation, massage/therapeutic touch, video games, and self-education, have also been explored.[13, 14] Most of these have been trialed in the pediatric and adult burn populations with some success,[14] but there have been no studies specifically targeting elderly patients. Finally, optimization of sleep at night with reduction in vital sign frequency and access to hearing aids and eye glasses has been helpful in reducing delirium and anxiety in elderly patients. Whether this intervention alongside others can optimize pain and anxiety in the geriatric burn patient is still unknown though.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

Treatment of pain and anxiety in the geriatric burn patient is complex and, as of yet, an uncharted area of research. Reduced organ function, reduced functional and cognitive status, medical comorbidities, and polypharmacy all contribute to the difficulty in optimizing treatment for these patients. Research into both pharmacologic and nonpharmacologic therapies is necessary. Pain and anxiety management protocols need to be developed that are specifically geared to the geriatric burn patients, addressing not only baseline pain but also wound care pain, postoperative pain, and chronic pain. The relationship between dementia, delirium, anxiety, and pain must be explored in the geriatric burn patient. Finally, research into nonpharmacologic approaches must incorporate geriatric needs.

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Delirium in the Elderly Burn Patient

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Delirium is an alteration of mental status sometimes called "brain failure" colloquially; it is characterized by inattention and a broad global cognitive dysfunction. A fuller description of it would be that delirium is "a transient, reversible syndrome that is acute and fluctuating, and [that] occurs in the setting of a medical condition."[1] While delirium is often thought of in its hyperactive form, where a patient may be agitated or uncooperative, it is important to note that it is probably more common in its hypoactive form, where it can manifest as lethargy or slowed cognition; it also exists in a mixed form, compounding the difficulty in diagnosis. In the elderly burn population, delirium may be particularly difficult to diagnose. The incidence of delirium in this patient population remains unclear and will be the focus of further investigation by this workgroup.

CURRENT KNOWLEDGE

Delirium can affect patients of all ages but is generally rare, affecting 1 to 2% of the general population but 14 to 24% of hospitalized patients.[1] The elderly, however, are particularly susceptible to developing delirium. Estimates of incidence range widely between 15 to 53% of surgical patients over the age of 65; elderly patients in the intensive care setting fare even worse with 70 to 87% experiencing delirium.[2] The diagnosis of delirium can be elusive, with one study suggesting that between 32 and 66% of these cases are unrecognized.[3] This may be due to underrecognition of hypoactive delirium, which may be difficult to separate from depression or dementia in the older population.

The costs of delirium are significant, both to the individual patient and to the health care system. Mortality increases 25 to 33% with in-hospital delirium in elderly patients.[2] Elderly patients who develop delirium experience more in-hospital complications, persistent functional and cognitive losses, and the "unmasking" of dementia that might have been previously well compensated.[1] The financial cost of delirium in the elderly is significant as well, adding between $16,303 and $64,421 per patient to each hospitalization; this translates to costs of $38 to $152 billion per year in the United States, roughly similar to the cost of treatment for diabetes mellitus ($91.8 billion).[2] Preventing, detecting, and treating delirium in the elderly would have a significant impact on the individual and systemic levels.

Risk Factors

Risk factors for developing delirium in the elderly are myriad. A meta-analysis of elderly burn patients undergoing elective surgery shows that 18.4% will develop postoperative delirium, with a history of delirium, frailty, and cognitive impairment being the most important predictors of delirium.[4] Fong et al describe several risk factors for delirium and categorize these into nonmodifiable and potentially modifiable,[1] and many of these are common to the elderly burn population. The nonmodifiable risk factors include:

- dementia or cognitive impairment;
- advancing age (>65);
- a history of delirium;
- multiple medical comorbidities;
- male sex;
- chronic renal or hepatic disease.

The potentially modifiable risk factors include many that are applicable to elderly burn patients:

- medication use, particularly narcotics, and in the setting of polypharmacy;
- metabolic derangement;
- surgery;
- pain.

A separate meta-analysis of postoperative delirium in the elderly found other risk factors, including: American Society of Anesthesiologists grade III or above; body mass index; low albumin level; intraoperative hypotension; perioperative blood transfusion; and a history of alcohol use.[5] The development of delirium in burn patients has been studied but remains to be more fully investigated. A study of a mixed-age cohort of ICU patients (age range: 38–62) suggests that 80% of patients in a burn intensive care setting will develop at least one episode of delirium; 71% of these cases were thought to represent hypoactive delirium.[6] Benzodiazepine exposure strongly predicted development of delirium (Operating Room [OR] 6.8), which was reduced by opiate exposure (OR 0.5 for IV fentanyl equivalent, OR 0.7 for methadone). More specific data on elderly burn patients, however, is lacking.

Prevention

Currently, the best approach to delirium in the elderly appears to be prevention. Certain simple interventions—ensuring that patients have access to assistive devices (eyeglasses, hearing aids); removing restraints and catheters; restoring the sleep/wake cycle—can help to normalize a patient's environment and potentially prevent the development of delirium. Of the potentially modifiable risk factors mentioned by Fong et al (above), perhaps the most crucial interventions are the limitation of polypharmacy and the control of pain.

Pain management, while critical to the care of the burned patient, can be particularly challenging in the elderly population, as noted in a separate section. Pain management in the elderly burn patient is complicated by a number of factors that exacerbate the potential for delirium. The elderly often already engage in polypharmacy, sometimes related to chronic pain. Even without chronic pain, elderly patients on average take more than five prescription medications per day.[7] When

physiological changes associated with aging such as slowed metabolism of medications and renal dysfunction are added to the medications necessarily administered for pain control, the potential for delirium inevitably increases. The American Society of Anesthesiologists recommends a multimodal approach to perioperative pain management,[8] but many of the recommended medications (gabapentin; ketorolac; tramadol) are considered inappropriate for use in the elderly or are to be used with caution as per the American Geriatrics Society's updated 2015 Beers Criteria.[9] Benzodiazepines are highly correlated with the development of delirium, are on the Beers list of potentially inappropriate medications, and are not recommended for the elderly. Most opiates, however, are not on the list, and it appears that the judicious use of oral and intravenous narcotics may be the safest option for pain control in the elderly burn patient, particularly if the dosing is decreased by 25 to 50% to account for slowed metabolism.[10]

The opposite consideration, the undertreatment of pain, is relevant as well as pain itself is a contributor to the development of delirium. The study by Honari et al of burn patients over the age of 55 demonstrated that burn patients in the eldest group (aged 76–92) received significantly less pain medication than patients in the youngest group (55–65).[11] The authors speculated that a generational stoicism might account for some of this discrepancy. While the development of delirium was not specifically addressed in this study, it is possible that, if elderly patients are less inclined to express pain, the development of delirium in some may in part be related to undertreatment of pain.

Recognition of Delirium

Currently, the Confusion Assessment Method (CAM) is widely used for diagnosing delirium. It is relatively straightforward, requiring evidence of acute onset and fluctuation in mental status as well as inattention and either disorganized thinking or altered level of consciousness.[12] It has a reported sensitivity of 94% and specificity of 89% with high interrater reliability.[13] There can be challenges in using this tool in the burn population, however, and results for burn patients using CAM have anecdotally been mixed.

It is important as well to differentiate between delirium and withdrawal. Patterson and Jeste note that, far from being rare, substance abuse is common in the elderly and is in fact increasingly common in the "baby-boomer" generation.[5] An "agitated" elderly patient, therefore, may be experiencing hyperactive delirium or may be withdrawing from alcohol, prescription medications, or nonprescribed pharmacologic agents, and there should be a heightened vigilance for this possibility.

Treatment

Current treatments for delirium are relatively limited. Nonpharmacologic interventions, such as distraction, with or without augmented reality, are preferred to pharmacologic ones. When needed, however, haloperidol and the atypical antipsychotics may be used. There are reports of successful use of Aricept use as well for hyperactive delirium. The treatment for hypoactive delirium, however, is still unclear. For many patients, resolution of delirium comes with time rather than with medication.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

For elderly burn patients, the incidence of delirium is likely high—but the number is not known with certainty. It is assumed to be high because of the high number of risk factors associated with this patient population. Prevention of delirium requires an understanding of the true incidence of delirium in the elderly burn population and improved recognition of delirium, either using the CAM method or another agreed-upon modality. Areas for further research include an understanding of how the elderly perceive pain and whether it is the perception of pain and/or the verbalization/notification of pain that is different. Various nonpharmacologic techniques and nonpsychotropic medications need to be investigated in the context of the elderly burn patient.

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Rehabilitation and Mobilization of Elderly Burn Patients

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By 2025, more than 60 million of the U.S. population will be ≥65 years; this approaches 20% of the population.[1] As these

patients age, it poses a significant shift in the dynamics of health care. The burn patient population has noted these changes as the number of elderly burn patients, defined as those being ≥60 years of age, reached 28,704 in 2016.[2] This patient population poses an increase in complexity of their care as mortality of burn patients increases with age; it begs the question how much quality of life providers can bring to these patients in their recovery as they frequently present with suboptimal baseline functional status.[2]

CURRENT KNOWLEDGE

Overall, burn centers have demonstrated an improvement in survival in all comers, yet there have been fewer improvements in the elderly burn patient population and a greater percentage are placed on comfort care or have therapeutic care withdrawn.[3] For those who do survive, physical function has been directly linked to quality of life.[3] Yet, there are few guidelines delineating when and how to mobilize the elderly burn patient population.

The ABA State of Science meeting that occurred in 2006 addressed burn rehabilitation. Primary attention was focused on medical and psychological complications and outcomes, community integration, and general outcomes. Overall, individual body parts were discussed, as was the pediatric and adult patient population; however, no formal mention of the geriatric patient population was noted.[4]

In 2008, representatives from 16 burn centers in the United States, Canada, and Australia gathered in San Antonio, TX, to again examine burn rehabilitation at a consensus summit. Focus on positioning, head and neck burns, exercise in burn patient management, and perioperative rehabilitation management in burn patients was addressed in patients as all comers and did not designate any specific recommendations for the elderly.[5] Suffice to say, as the elderly burn population increases, attention needs to be directed toward specific rehabilitation strategies that most are beneficial to geriatric patients during acute hospitalization and rehabilitation, transitional care, and postdischarge.

Rehabilitation Approaches

Though there are many recommendations for the mobility and therapy of burn patients, there are no guidelines by which all centers abide. Clinical focus has shifted to include an emphasis on early mobilization to mitigate the effects of hyper metabolism and prolonged bed rest after burn injury; however, the benefits have not been shown specifically with the elderly burn population. Examining the efficacy of this trend has expanded to include the geriatric patient population; however, Ljungqvist and his group sense that more can be done hospital wide to improve outcomes. They developed a plan internationally in the 1990s for patients undergoing coronary bypass with a focus on a surgical fast track called the Enhanced Recovery After Surgery program (ERAS).[6] The program focused on a multidisciplinary team encompassing the preadmission, preoperative, intraoperative, and postoperative settings. Preadmission team members addressed medical optimization, nutrition, and cessation of alcohol and tobacco use.[6] Preoperatively patient care was focused on carbohydrate treatment, Venous Thromboembolism prophylaxis, infection prevention, and nausea and vomiting prophylaxis.[6] Intraoperative focus encouraged minimally invasive techniques, standardized anesthesia, strict maintenance of fluid administration, nonnarcotic pain management, minimization of tubes/lines and drains, and thermal control.[6] Postoperative management demonstrated early mobilization, oral intake, removal of tubes/lines/drains, protein rich nutrition, multimodal pain management, and an audit of outcomes.[6] Granted, while all facets cannot apply to burn patients, this program has started to be implemented in the emergency general surgery population and may lend some guidance to developing protocols for the burn patient population. They noted that with continued auditing and follow-up visits, there were multiple benefits to the program, including decreased length of stay, less complications, and significant cost savings. One facility noted a significantly lower mortality rate for patients undergoing hip and knee replacements.[6] These improved outcomes could potentially translate to the geriatric burn population and warrant investigation.

As patient survival improves, more emphasis is given to the quality of that survival, specifically functional status after discharge from the hospital. Burn patients of all ages admitted to acute rehabilitation programs have demonstrated lower Functional Independence Measure (FIM) scores than those admitted for other etiologies.[7] Seventy-nine percent of burn survivors admitted to acute rehabilitation in one study demonstrated cognitive-communication deficits on admission, with memory scores being particularly low. Of note, cognitively impaired patients have poorer recovery of instrumental activities of daily living tasks at 6 months. Hendricks et al investigated the use of speech therapy in the inpatient rehabilitation setting to help mitigate these cognitive deficits, and their results were favorable. They referred 77 patients to receive speech therapy and 40% improved from a dependent level, while 10% persisted with their low admission score.[7] Referral for early cognitive evaluation and persistent interventions could be the best way to identify at-risks patients and jump start treatment to correct these underlying cognitive issues that compromise independence at discharge of the geriatric patient population.

Discharge Considerations

Rehabilitation facilities and skilled nursing facilities accounted for 2.9 and 2.3% of all hospital dispositions for burn patients of all ages in 2016.[2] However, delineating where patients who are >60 years are managed after acute hospitalization is less clear. It is widely accepted that elderly patients can have functional decline as soon as 2 days following admission and approximately one-third will have reduced function by discharge; therefore, this population may account for a larger portion of those discharged to acute rehabilitation or a skilled nursing facility.[8] Nehra et al evaluated the effects of inpatient rehabilitation in all ages of the trauma population. After investigating 933 patient rehabilitation admissions, they concluded a significant increase in FIM scores, chance of disposition to home, and increased 1-year mortality.[9] In conjunction with this, Schneider et al conducted a pilot study of 11 burn patients, mean age of 52, admitted to inpatient rehabilitation following their acute admission for burn management. Patients demonstrated significant improvement with respect to range of motion, hand function, and balance, which could translate to increased independence and overall function.[10] Though neither of these studies relate specifically to the

geriatric burn population, it is encouraging that more intensive postacute care results in better outcomes for patients and that could translate to the geriatric burn population. Minimal research has been completed that focuses on the geriatric burn population. However, this patient population has an increased chance of presenting with pre-existing comorbidities that will complicate their care and, perhaps, a multimodal approach may improve outcomes. Further investigation is warranted.

Timing of Discharge

If there is to be a focus on discharging elderly burn survivors to inpatient rehabilitation, it begs the question when is it best to initiate that transfer. It is widely accepted that the larger the burn, the longer the patient length of stay. Yet there is no standard marker that delineates when exactly patients should be transferred. One study examined 138 burn survivors being admitted to a geographically separate inpatient rehabilitation facility versus an on-site facility.[11] This study demonstrated that those being discharged to an on-site facility were discharged with a significantly shorter length of stay with no increase in readmissions.[11] They also demonstrated lower initial FIM scores, yet had quicker improvement in scores and a greater overall improvement in FIM scores.[11] This study demonstrated the safety, improved functional status, and cost savings associated with an earlier discharge. Though this was not examined specifically in elderly patients, it warrants investigation in this patient population.

While mobility is arguably one of the most important aspects of a burn patient's care, the topic is so vast that research has not provided us with clear cut treatment algorithms, in particular for the geriatric patient population. This patient population is more complex as they present with pre-existing conditions that may increase needed monitoring while mobilizing and cause them to present at a lower functional level than other burn patients. However, an early emphasis on mobility improves outcomes in adult burn and other nonburn patient populations. Extrapolating the rehabilitative interventions that can be used in the preoperative, operative, postoperative, rehabilitation, and postdischarge phases of care can help form standard treatment algorithms for the geriatric burn population and improve outcomes significantly. Mobility research needs to focus on extrapolating best practice for this particular patient population.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

For elderly burn patients, rehabilitation standards vary from institution to institution and patient to patient based on pre-existing limitations. A survey of burn centers to evaluate rehabilitation standards for elderly patients can be vital in gaining knowledge on this population's needs and obstacles. Timing and location of discharge (inpatient rehabilitation vs skilled nursing facility vs home vs maintain inpatient until ready for outpatient rehab) all require investigation. Finally, implementation of an ERAS type fast track in the elderly would be useful to evaluate if such measures improve outcomes.

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Elderly Long-Term Outcomes

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While there have been several studies that look at the short-term outcomes for elderly burn patients, there have been few studies that look at the long-term outcomes in the elderly. Without data on long-term outcomes, it is not clear if the elderly survive the acute hospitalization only to die shortly thereafter. There is evidence that, when elderly in general 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.[1] They were also found to be more likely to be readmitted and have increasing mortality with age at 2 years of follow-up as well.[2] For elderly burn patients, it is currently not clear what long-term outcomes should be expected or if these are changing over time as the population ages and we become more accustomed to caring for elderly patients.

CURRENT KNOWLEDGE

The National Institute on Disability and Rehabilitation Research (NIDRR) Burn Model System (BMS) program conducted a study where older burn patients were followed for their functional and psychosocial outcomes for 2 years.[3] They found that burn injury affected both functional outcomes and quality of life in an age-related manner and suggests that long rehabilitation programs (up to 1 year after

injury) might prove beneficial in achieving maximal recovery. There are multiple studies conducted by the BMS that include elderly patients[4–6]; however, not all of these conduct a subgroup analysis of the elderly patients, which limits our ability to draw further conclusions about the long-term outcomes of elderly burn patients.

Long-Term Follow-up

Currently, the long-term follow-up for elderly burn patients is being conducted primarily by the burn surgeon and not as a multidisciplinary team. There has been a movement described in the trauma literature to create 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.[7] All patients aged ≥60 with a traumatic injury less than 48 hours old were admitted to the G-60 unit under the care of the multidisciplinary G-60 team. The G-60 team consisted of a trauma surgeon, a medical hospitalist, a physical medicine and rehabilitation physician, Physical Therapy/Occupational Therapy, respiratory therapy, nursing, social work, nutrition, pharmacy, and palliative care. They found that patients who were treated in the G-60 unit had a decreased length of stay from 7 to 4.8 days (P = .0002) and a decreased ICU length of stay from 5.2 to 3 days. Additionally, they found a statistically significant decrease in urinary tract infections, respiratory failure, congestive heart failure, ventilator associated pneumonia, and acute renal failure. They did not see a statistically significant difference in mortality or discharge disposition. We have long utilized multidisciplinary teams in burn care; however, we need to consider the addition of additional team members in the care of elderly burn patients. Additionally, it seems imperative that long-term follow-up should be conducted by a team that specializes in elderly burn care. It is hypothesized that a strong multidisciplinary team engaged in long-term follow-up will improve acute and long-term outcomes for elderly patients.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

We would like to leverage the power of the Burn Model System and the LIBRE project that have already established research protocols to further look at long-term physical and emotional outcomes to examine the outcomes of elderly burn patients. The Burn Model System has started this work and we would suggest that they continue to collect this data and subset analyze based on age their studies that do not particularly target the elderly but include elderly patients. Furthermore, investigation should focus toward development of an outpatient burn clinic multidisciplinary team model for the follow-up of elderly burn patients. This team should focus on pain management, psychological treatment, peer support, nutrition supplementation, and, if needed palliative care, rehabilitation and physical or occupational therapy.

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Posttraumatic Stress Disorder and the Elderly Burn Patient

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The incidence of posttraumatic stress disorder (PTSD) in the burn population is reported to be between 31 and 45.2%.[1] Initially, after sustaining a burn injury, patients may experience acute stress disorder (ASD), which occurs when nine (or more) symptoms from any of the five categories of intrusion, negative mood, dissociation, avoidance, and arousal are present. These symptoms begin or worsen after the traumatic event and last >3 days but less than 1 month after trauma exposure. Following this, PTSD is characterized when these symptoms continue past the first month after trauma exposure and result in difficulty functioning in social, occupational, and other areas of life. ASD has been shown as a risk factor for development of PTSD in the burn population,[2] and both ASD and PTSD are associated with decreased physical and social function. Although older age has been associated with higher levels of psychological distress after traumatic injury,[3] the incidence of PTSD in the elderly burn population is not known.

CURRENT KNOWLEDGE

Van Loey et al[4] studied survivors of two fire disasters and found no clear relationship between PTSD and age in patients who sustained burns but noted possible sex vulnerability in older females, with the oldest patient in the group being 52 years old. El Hamaoui[5] showed a possible link between age and PTSD; however, the oldest patient in the review was only 40 years old. Adding to this evidence, other studies have shown that the elderly may have diminished psychosocial support networks and may be more susceptible to psychological stress. Like pain, elderly patients may not express thoughts of depression or stress to others, leading to under diagnosis of psychological issues.[6] PTSD may also be associated with development of dementia and decreased cognition in the elderly.[7] Despite these initial findings, specific

screening protocols and treatment regimens targeting the elderly burn patient have not been developed or adequately researched.

Several scoring systems have been developed to identify the presence and severity of ASD and PTSD symptoms in nonburn-specific patients. These include the Acute Stress Disorder Scale (ASDS)[8] for ASD, the Davidson Trauma Scale (DTS),[2] the Impact of Event Scale-Revised (IES-R),[9] and the PCL-5 (an updated version of the PCL-C)[10] for PTSD. The PCL-C has been studied in the outpatient burn population,[11] but none of these scoring systems have been specifically studied or validated in the elderly burn population. The clinician-administered PTSD scale for Diagnostic and Statistical Manual of Mental Health-5 (CAPS-5) is the gold standard for PTSD diagnosis,[10] which consists of a 30-item interview that takes 45–60 minutes to administer and appears suitable for burn patients. However, this level of mental health resources may not be readily available to all burn units and their patients.

In general, treatment of patients with ASD consists of psychotherapy and/or symptom management with pharmacology (ie, prazosin for nightmares). However, for elderly patients with ASD, additional factors should be considered as prazosin may also cause bradycardia. In comparison, PTSD therapies consist of psychotherapy and pharmacologic therapy, including selective serotonin reuptake inhibitors, such as sertraline, paroxetine, and fluoxetine as first-line agents.[2] For elderly patients with PTSD, medications should be administered in lower doses and with slower titration.[12] Tricyclic antidepressants and benzodiazepines should also be avoided in the elderly patient population, along with medications that have strong anticholinergic properties. These medications can increase the risk for falls, confusion, delirium, depression, and possible prolongation of PTSD symptoms.[12] Some promising therapies include third-generation non-Selective Serotonin Reuptake Inhibitor antidepressants and adjunctive treatments with mood stabilizers, alpha adrenergic agents, atypical antipsychotics, and anticonvulsants.[2]

Additionally, the elderly may also have baseline dementia and cognitive disorders in addition to their ASD/PTSD, which complicates implementation of psychotherapy. More confounding is the presence of delirium in the injured elderly population. The use of first-generation (ie, haloperidol) and second-generation (olanzapine, quetiapine, and risperidone) antipsychotics contain a black box warning for all-cause mortality in the elderly patient with dementia.[12,13] There are no studies to guide therapy in an elderly burn patient with dementia who tests positive for PTSD and then develops symptoms of delirium.

Due to these issues, implementation of these therapies should be initiated with the coordination of a psychiatrist or psychologist in order to optimize PTSD treatment, continuity of care, and balancing of medication needs. Treatment of the elderly patient with PTSD will require outpatient follow-up and support, while questions remain about the adequacy of mental health resources available for these patients. A multimodal approach must also be considered by treating anxiety, PTSD, sleep disturbance, and depression, with a community integration focus. Cukor et al[14] described a robust pilot showing positive results in the treatment of burn patients with PTSD using 14 weekly sessions of cognitive-behavioral techniques provided by psychologists but, again, the oldest patient was only 61 years old. It is unknown if these strategies are efficacious in an elderly population that are prone to psychological disturbances, delirium, and other complicating factors.

AREAS FOR IMPROVEMENT AND OPPORTUNITIES FOR RESEARCH

No studies exist in the diagnosis, treatment, and follow-up of elderly burn patients with ASD and/or PTSD, a gap in knowledge that desperately must be filled given our aging population and their future imminent medical needs. The effects of burn trauma may persist for decades beyond the initial insult as evidenced by elderly veterans who still experience PTSD symptoms from World War II.[15] As such, there may be differences between elderly patients that recently experienced trauma versus those who continue to cope with trauma from years past. Further research and efforts must be implemented in order to optimize the psychological care for our aging population. The incidence of ASD/PTSD in the elderly burn population must first be established in conjunction with research on specific screening protocols and treatment regimens. Investigation regarding the impact of dementia and delirium on ASD/PTSD in the elderly burn population will be vital to understanding this complex problem further. Finally, identification of the scope of inpatient and outpatient resources needed to provide optimal mental health care to the elderly burn population will be required.

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SUMMARY

There are many important tasks and questions in order to improve outcomes of elderly burn patients. Due to the complexity of these tasks we the Board of Trustees agreed to form a permanent committee on elderly burn care. This committee has an interest in the care of elderly that within the committee will assign tasks as well as coordinate efforts of investigators with the goal to improve outcomes and quality of life in elderly burn patients. The committee will review the progress and will request to collect more data by accessing the National Burn Registry, in conjunction with creating novel and elderly specific databases and registries. The committee also reaches out to create strong collaborations, for example, ISBI and other stakeholders. The committee feels there is a lot of work that needs to be done as the information on elderly burn care is vague and lacking good substantial data.

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