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# Threshold age and burn size associated with poor outcomes in the elderly after burn injury

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ABSTRACT

Elderly burn care represents a vast challenge. The elderly are one of the most susceptible populations to burn injuries, but also one of the fastest growing demographics, indicating a substantial increase in patient numbers in the near future. Despite the need and importance of elderly burn care, survival of elderly burn patients is poor. Additionally, little is known about the responses of elderly patients after burn. One central question that has not been answered is what age defines an elderly patient. The current study was conducted to determine whether there is a cut-off age for elderly burn patients that is correlated with an increased risk for mortality and to determine the burn size in modern burn care that is associated with increased mortality. To answer these questions, we applied appropriate statistical analyses to the Ross Tilley Burn Centre and the Inflammatory and Host Response to Injury databases. We could not find a clear cut-off age that differentiates or predicts between survival and death. Risk of death increased linearly with increasing age. Additionally, we found that the LD50 decreases from 45% total body surface area (TBSA) to 25% TBSA from the age of 55 years to the age of 70 years, indicating that even small burns lead to poor outcome in the elderly. We therefore concluded that age is not an ideal to predictor of burn outcome, but we strongly suggest that burn care providers be aware that if an elderly patient sustains even a 25% TBSA burn, the risk of mortality is 50% despite the implementation of modern protocolized burn care.



## 1. Introduction

A severe burn is an injury that affects every organ system, leading to significant morbidity and mortality [1,2]. It has been shown that outcomes after burn are linked to age [3]. The best outcomes can be found in children, followed by adults and lastly, the elderly [3,4]. While significant advances in outcomes have been made in children and adults [5], there have been minimal improvements in the outcomes for elderly burn patients with small burn which is recently reported in a

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historical cohort study [3]. The LD50 burn size in elderly has remained almost the same, at around 35% TBSA burn, over the last few decades. In general, the elderly have a thinning of the skin [6], decreased sensation, decreased metabolic resources and capacity [7], mental alterations, pre-existing medical conditions and other contributing factors [8–10]. The failure of their immune system to fight off burn infections along with altered inflammatory and immune responses [11] contribute to worsened outcomes after burn.

There is an ongoing effort to determine why the elderly have such poor outcomes on a cellular and mechanistic level; however, there are several essential questions that have not been addressed or well-defined. First, when is an elderly patient considered elderly? The definition of when a human becomes an elderly is not entirely clear. The World Health Organization (WHO) and the National Institutes of Health (NIH) have defined 'elderly' as 65 years or older (www.who.int/healthinfo/survey/ageingdefnolder/en/), but there is ongoing discussion about the age that defines an individual as elderly, varying from 55 to 75 years [12]. It is currently not clear what age can be defined as elderly in burn patients; therefore, the first aim of this study was to determine whether there is a cut off age for elderly burn patients. Second, we aimed to determine the minimum burn size that is associated with increased mortality. We tried to define elderly cut-off age by using the increase in mortality as an indicator for it. To do this, we looked at two databases: the Ross Tilley Burn Centre database and the Inflammation and Host Response to Injury (Glue Grant; https://www.gluegrant.org) database and compared their cut-off age and cut-off burn size. We hypothesized that elderly burn patients would have a cut-off age that is clearly associated with burn size and mortality. We further hypothesized that a particular burn size would be associated with increased morbidity and mortality after burn.

## 2. Methods

### 2.1. Patients

In this study, two existing databases were used to examine the cut-off age for elderly after burn and the cut-off burn size associated with increased morbidity and mortality. The first database was that of a single ABA-verified burn center, Ross Tilley Burn Centre (RTBC) at Sunnybrook Health Sciences Centre (SHSC). Research Ethics Board (REB) at Sunnybrook approved this study (# 003-2011). Patients from January 2006 to October 2014 with TBSA ≥20 and removing those cases that were futile (died within 2 days of admission).

The second database was that of the Inflammation and the Host Response to Injury Glue Grant (https://www.gluegrant.org). The study was approved by Institutional Review Boards (IRB) of the participating institutions (University of Texas Medical Branch, Galveston, TX; Loyola University Medical College, Chicago, IL; University of Texas Southwestern, Dallas, TX; University of Washington Seattle, Seattle, WA; Massachusetts General Hospital, Boston, MA). Over an 8-year period, 573 patients meeting all inclusion criteria were prospectively enrolled. Inclusion criteria were as follows: age of 0–99 years, admission to a participating hospital no later than 96 h after burn and ≥20% TBSA burns with the need for at least one surgical intervention. All hospitals followed standard operating procedures set forth by the burn patient-oriented research core [13,14]. Each subject or a family member provided written informed consent before study participation. One of the main inclusion criteria was patient survival, but there were 5 patients that died within 3 days out of total of 86 cases that we did not remove.

Patients were treated according to treatment protocols specific to each study. Treatment protocols for both the RTBC and the Glue grant have been published previously [15–17].

### 2.2. Outcomes

The primary objectives of the study were (1) to determine the age that best defines elderly in burns; (2) to identify the LD50 burn size associated with increased mortality in the elderly after burn.

### 2.3. Statistics

Continuous variables were summarized using means and standard deviations or medians and interquartile ranges and compared using either a Student's *t* test or Wilcoxon rank-sum test, as appropriate. Discrete variables were presented using frequencies and percentages and tested using $\chi^2$ or Fisher's exact test. As the cohorts were different with respect to age and % TBSA, we determined an age cut-off point separately for

**Table 1 – Patient characteristics and outcomes.**

| Variable | Sunnybrook (N = 235) | Glue grant (N = 347) | p-value |
|---|---|---|---|
| Age | 48 (17) | 40 (17) | <0.0001 |
| Male | 181 (77.0%) | 262 (75.5%) | 0.6737 |
| TBSA (%) | 34.4 (13.4) | 42.1 (19.1) | <0.0001 |
| Inhalation Injury (*n*, %) | 94 (40.0%) | 140 (40.5%) | 0.9112 |
| Outcomes | | | |
| LOS (days) | 29 (19-59) | 33 (20.5–61) | 0.3043 |
| LOS/TBSA (days/%) | 1.03 (0.68–1.57) | 0.96 (0.60–1.55) | 0.1186 |
| Pneumonia (*n*, %) | 119 (50.6%) | 160 (46.1%) | 0.2833 |
| Burn Wound Infection (*n*, %) | 111 (47.2%) | 188 (54.2%) | 0.100 |
| Sepsis (*n*, %) | 82 (34.9%) | 37 (10.7%) | <0.0001 |
| Death (*n*, %) | 34 (14.5%) | 48 (19.6%) | 0.1154 |