**Frailty: an independent predictor of burns mortality following in-patient admission**

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**Abstract**

Introduction

Burn injury in the elderly is associated with increased morbidity and mortality. It is not uncommon for biological age, or frailty, to differ from chronological age in this patient group and thus predicting individual clinical outcomes remains challenging. It has been previously shown that Rockwood’s Clinical Frailty Score, a global clinical measure of fitness and frailty in older people, can be a useful adjunct for predicting outcomes for elderly patients with burns>10%TBSA. We refine our previous work to investigate the impact of frailty on mortality of elderly patients with thermal burns of any size admitted to a burns unit and explore its role as a meaningful adjunct to the modified Baux score.

Methods

A retrospective analysis of case notes for all patients ≥65 years admitted to our burns centre as an in-patient during an 8-year period was performed with standard demographics, burn injury parameters, length of stay and mortality outcomes collected. Measures of frailty were reviewed and statistically analysed to assess the impact of biological aging on clinical outcome in order to assess how the modified Baux score may be developed for the elderly using Rockwood’s Clinical Frailty Score.

Results

239 patients met the inclusion criteria. Mean age was 77 years (range: 65-99 years) and mean burn size was 14.46% TBSA (Range: 0.1-98% TBSA). The modified Baux and Frailty Score were both independent predictors of mortality (p<0.0001). Increased premorbid Frailty Score was associated with increased in-hospital (OR: 2.33, 95% CI: 1.63-3.34) and one-year mortality (OR: 3.13, 95% CI: 2.22-4.41) independent of burn size compared to the modified Baux Score (IHM OR: 1.09; 95% CI: 1.07-1.13, 1yr M: OR 1.08; 95% CI: 1.05-1.11). The

Frailty Score (>3) was a much more sensitive predictor of one-year mortality (Sensitivity: 83.9%; Specificity: 66.4%) than the modified Baux (>97) (Sensitivity: 59.8%; Specificity: 82.9%). A Frailty Score >3 when combined with the modified Baux score demonstrated increased area under ROC curve for both in-hospital (0.89 (95% CI: 0.85-0.94); p=0.02) and one-year (0.88 (95% CI: 0.84-0.92); p=0.02) mortality when compared to the modified Baux alone.

Conclusion

We demonstrate that Rockwood’s Clinical Frailty Score can be used to independently predict in-hospital and one-year mortality for thermal burns of any size in the elderly admitted as an in-patient to a burns unit. We also find that the Frailty Score can be employed in combination with the modified Baux score to improve mortality prediction. We recommend that Frailty Score is integrated into the modified Baux score and used to focus burn care resources appropriately.

**Introduction**

In the context of an aging developed world population 1, burn care teams can expect to manage increasing numbers of frail elderly patients with complex medical and social needs 2 3. It is widely accepted that elderly patients tend to have a higher mortality risk and poorer outcome than younger patients with similar burn injuries, particularly as burn size and depth

increases 4-11. When caring for elderly patients, medical teams are not only faced with the clinical challenge of providing the highest standards of burn care in the context of multiple medical comorbidities but also face the ethical challenge of separating patients that are likely to benefit from aggressive surgical management and intensive care from those where such treatment is likely to be futile and best supportive care is most appropriate 9 12.

When making decisions on the utility and futility of treatment, a number of validated outcome measures such as the modified Baux can be used to predict survival 8 10 13-17. These measures employ chronological rather than biological age and, as a result, are limited by the fact that they fail to incorporate the subtle complexity of clinical judgement in their predictions. In particular, they cannot discriminate between two patients of similar chronological age with marked differences in their premorbid biological state when comorbidities, physiological reserve and societal factors are considered 10 18-20.

One way to incorporate biological rather than chronological age into the prediction of survival is to consider the presence of frailty as a proxy for physiological age 21. Frailty represents a loss of resilience for an individual and is characterised by generalised loss of reserves across multiple organ systems that increases vulnerability to physiological decompensation following stressors. It can be defined as a clinical syndrome in older adults that carries increased risk for poorer health outcomes, in particular falls, incident disability, hospitalization and mortality 22. The Canadian Study for Health and Aging derived a scale, the Clinical Frailty Scale (herein “Frailty Score”), for quantifying frailty (see Figure 1). The measure ranges from one (“very fit”) to seven (“severely frail”) and judges the fitness, dependency and symptom control 23 of an older individual.

The effects of frailty have previously been considered in burns, including previous published work from our institution showing that the Frailty Score can accurately predict survival in the elderly for burns >10% TBSA requiring admission to a Burns Intensive Care Unit 18. In this latest study, we set out to improve our understanding of how the Frailty Score could be used in our institution to predict mortality for elderly patients with a burn of any size that necessitated admission for further management and compared its predictive efficacy to established tools for predicting burn mortality.

**Methodology**

A retrospective analysis of prospectively collected data was performed for all patients aged 65 years (current UK pensionable age) or older who had sustained thermal burns of any size that were admitted to our burns centre for more than 24 hours between 1 January 2008 and 31 December 2015. For each patient, the following variables were collected: burn type, percentage total body surface area, sites involved, presence of inhalation injury, medical history, presence of polypharmacy (>4 medications), surgical management, length of stay on burns intensive care, total inpatient stay and mortality (both in-hospital and one-year).

Inhalational injury was identified on the basis of the reported mechanism of injury and bronchoscopic findings of mucosal damage during the initial clinical assessment.

The premorbid independence and social care needs of every patient are recorded as standard in our institution but a specific Frailty Score has only been assigned since 2012. The medical records of every patient were reviewed and a Frailty Score (1-7) was retrospectively allocated in accordance with the Canadian Study of Health and Aging Clinical Frailty Scale (Figure 1) by two independent burn specialists. Where disagreement occurred, either between the original or the retrospectively assigned Frailty Score, the opinion of a third deciding burn specialist was sought and accepted. No other data was available to them apart from the detailed descriptions of the clinical comorbidities and premorbid needs of each patient. The modified Baux score and Abbreviated Burn Severity Index were calculated for each patient. Univariate statistical analysis was performed using the Mann-Whitney U and Chi square tests. Multivariate statistical analysis was performed using multiple logistic regression analysis. ROC curve analysis was performed for the modified Baux score alone and combined with the Frailty Score as predictors of mortality. The Frailty Score was analysed as a continuous and categorical variable (cut-offs at >3 and >4).

**Results**

**Sample**

During the study period, 372 patients ≥65 years of age were admitted to the burns service with 239 patients meeting the study inclusion criteria. Patients admitted for less than 24 hours were excluded because they were considered to require outpatient level care only. Most of these patients presented late in the evening and were admitted overnight for practical non-medical considerations, such as transport home or supervised care on discharge, to be addressed. Patients with medical causes of skin loss (.e.g. SJS-TENs), undergoing secondary elective burns reconstructive procedures or the small number of patients (n=14) with non-thermal burns (friction, chemical or radiation burns) were excluded. All admitted patients with flame, scald, contact and electrical burns were included. The study sample comprised 135 males (56.5%) and 104 (43.5%) females. The median age was 76 years (Range: 65-99 years). The median Frailty Score was 5 (range: 1-7). The distribution of the frailty score within the cohort is demonstrated in Figure 1. Concordance between frailty scorers was >90%. There was no association between age and Frailty Score. The median burn size was 7% TBSA (Range: 0.1-98% TBSA) and the median length of stay was 15 days (Range: 1-308 days). 124 patients (51.9%) underwent surgical debridement this included 109/190 survivors (57.3%) and 15/49 non-survivors (30.6%).

**In-hospital & One-year Mortality**

49 patients (21%) died during their in-patient stay with 190 patients (79%) surviving to discharge. 87 patients died (36.4%) within one-year of hospital admission with 152 patients (63.6%) surviving to one-year post-discharge. For in-hospital and one-year mortality univariate analysis demonstrated that there were statistically significant differences between survivors and non-survivors for TBSA, presence of inhalational injury, modified Baux and Frailty Score – all factors that were all associated with mortality (see Figure 2).

**Mortality Association**

The degree of statistical correlation between the modified Baux and Frailty scores towards in-hospital and one-year mortality was further examined using the Spearman’s Rank Correlation Co-efficient (Rho) – (see Figure 3). Both variables had a moderate statistical correlation with in-hospital mortality with the modified Baux score demonstrating the strongest association. The Frailty Score demonstrated the strongest association with one-year mortality.

**Regression Analysis**

To more fully analyse and compare the individual predictive effects of the modified Baux and Frailty Scores on mortality, multiple logistic regression analysis was performed (adjusted for confounders). Odds of mortality for every single-point score increase in the modified Baux and Frailty Score were calculated (see Figure 4). Odds of mortality for every single point increase were greatest for the Frailty Score and equivalent for the modified Baux when one-year and in-hospital mortality were considered.

**ROC Curve Analysis**

To identify whether the modified Baux and Frailty Score may improve the accuracy of mortality prediction when combined, ROC curve analysis was performed (see Figure 5). For in-hospital and one-year mortality, the modified Baux and Frailty Scores in combination (as a continuous and categorical variable with a cut-off at both 3 and 4) demonstrated statistically significant improved mortality prediction compared to the modified Baux score alone.

**Discussion**

Frailty can be considered as two concepts: either as a phenotype, or conversely as a

Frailty Score we have considered frailty in accordance with the frailty phenotype model. The concept of frailty is difficult to define and has been debated in the literature for over 25 years. 24 26. It remains controversial particularly regarding its definition, position on the spectrum

between normal ageing and pathological physiology as well as whether it is a syndrome or series of age-related adversity risk factors. The contribution of cognitive impairment, affective disorders and socio-demographic factors also add to the debate. 24

In the UK, the role of frailty as a risk factor for morbidity, mortality and prolonged hospital admission has been recognised by the influential National Confidential Inquiry into Patient Outcome and Death (NCEPOD). Its report “an age old problem” recommends the presence of frailty is specifically sought as a marker of adverse outcome and met with tailored specialist care (NCEPOD, 2010). Its conclusion that frailty is a marker of adverse surgical outcome for elective surgery is well evidenced in the literature. In particular a well-designed prospective study of 594 patients demonstrated frailty to be associated with post-operative complication (OR: 2.54; 95% CI: 1.12–5.77), prolonged admission (OR: 1.69; 95% CI: 1.28–2.23) and dependency on discharge (OR: 20.48; 95% CI 5.54–75.68)27. These findings are echoed by other authors showing frailty to be a marker or adverse outcome in every surgical outcome for elective surgery is well evidenced in the literature.

 A number of instruments are available to screen for and measure frailty. The most evidenced based and reliably predict adverse outcomes or treatment responders. Instruments

vary with some validated as population-based screening rather than diagnostic tools40. In our study, we chose to use Rockwood’s Clinical Frailty Scale (“Frailty Score”) because its simplicity, previous wide-use, validation (compared to the other models) and clear criterion made it the most suitable instrument for our burns practice.

 To determine the impact of frailty on burns survival in the elderly, we report mortality for all patients greater than 65 years of age managed within our regional burns service during an 8-year period. We observed in-hospital and one-year mortality for our cohort of 21% and 36.4% respectively.

In our study, we found a statistically significant association with both in-hospital and one-year mortality for the Frailty Score but no association between the dual mortalities and age >65 years. The stronger association between Frailty Score and mortality in comparison to age alone reflects that frailty score provides a global appreciation of a patient’s health and functioning and encompasses how variation in co-morbidity impacts upon functioning more pragmatically than age. The utility of the Frailty Score for predicting outcomes post-burn has been examined by Romanski et al. in a 2 year retrospective review of 89 patients >65 years. The study found age and discharge to a skilled nursing facility were both associated with increased Frailty Score, whilst a lower Frailty Score was associated with survival. Excluding Masud’s previous work from our centre, Romanski et al. is the only directly comparable

research to our work but unfortunately did not consider longer-term mortality although by examining the proxy measure of discharge dependency highlights how assessing the frailty score on admission can provide an insight into longer-term outcomes 56.

The simplicity and pragmatic ease of applying the Frailty Score when burns physicians are judging the likely utility vs. futility of acute burn treatment is important. During the initial period following any burn, information regarding the circumstances of injury, as well as personal and medical background of a patient, are frequently unavailable. This means that clinicians can be called upon to make treatment decisions based on limited information - a situation that the Frailty Score lends itself towards by requiring only very basic lay information about a patient’s health and dependency with little prior history. In the complex and busy period of an initial burn care, the Frailty Score is simple to calculate with clear criterions based on defined levels of patient functioning, whilst being easy to understand and communicate.

The association between Frailty Score and mortality was stronger and more discriminative for one-year mortality than in-hospital mortality. This is an important finding demonstrating the utility of the Frailty Score for predicting outcomes from any elderly burns in the longer-term. By reflecting on one-year mortality, clinicians can discuss realistic outcomes with patients and their relatives, especially those who do not return to their premorbid level of health and succumb to their comorbidities on discharge (whether this is dependent or independent of the burn injury). More holistically, measuring one-year mortality allows burn care teams to look beyond the effect of the acute hospital care and measure the impact of social care, primary care and post-burn follow-up on burn outcomes.

In our study we directly compared the Frailty Score against the modified Baux score. We found that both scores independently predicted in-hospital and one-year mortality. The multiple logistical regression analysis demonstrated that for both in-hospital and one-year mortality the Frailty Score for every single-point increase was more discriminative with odds ratios of 2.33 and 3.13 for in-hospital and one-year mortality compared with 1.09 and 1.08 for the modified Baux score. The higher odds ratios for each single-point increase in Frailty Score is useful because it reduces the utility of a futility cut-off that is commonly employed and frequently criticised when interpreting the modified Baux score. It also emphasises the point that no matter the size of burn, increased frailty is a predictor of post-burn mortality and therefore any burn in the elderly, regardless of size, should be managed judiciously. Finally, our work demonstrates that when combined the Frailty Score and modified Baux score predict both one-year and in-hospital mortality with greater sensitivity and specificity than the modified Baux score alone. This finding held true for both mortalities when frailty was employed as a continuous and categorical variable >3 and demonstrates that incorporating the Frailty Score into the modified Baux will improve the accuracy of mortality predictions for elderly patients.

With the association between frailty score on admission and mortality clear, the ethical and moral perspective for offering aggressive burn care to the frail patient should be reflected upon as society places increasing imperative on a “good” and “dignified” death.

When it is clear a moderately or severely frail patient (with or without apparent co-morbidity) is at risk of probable mortality following burn excision, clinicians should broach the appropriateness of best supportive care alone 57 clearly discussing care goals58. The scenario of burn excision complicated by graft loss, non-healing wounds, prolonged admission, gradual decline and mortality in a frail patient with multiple comorbidities should be avoided whenever there is predictive certainty on admission. We would encourage burn care teams to use the Frailty Score as a tool to offer evidence-based ethical burn care and, where possible, guide properly informed consent for aggressive burn care in the lucid but frail patient admitted to a burns service 59.

Our study has two major limitations. Firstly, it is an analysis of the impact of frailty from a single-centre and therefore represents outcomes based on our local practice of burn care. Variation in the specific delivery of care between burn services, whether nationally or internationally, may be subtle but can influence outcomes significantly and, as a result, this study reflects our standards of burn care and may not be directly transferrable to others.

Nevertheless, we believe that this study highlights the importance of frailty in burn care and would encourage other burn services to consider adopting its routine use as part of their standard practice. Secondly, the Frailty Score was attributed to some patients retrospectively through case-note review rather than prospectively collected on admission. This may be a source of observer error although the use of two independent burns specialists to review

 medical records and allocate the score was an attempt to minimise such error. To overcome these limitations, we reiterate the recommendation that a prospectively conducted multi- centre review of the impact of the Frailty Score on burns would be worthwhile18. A minor limitation was the exclusion of non-thermal burns, including chemical burns, from the study although the intention had been to reduce variability in the patient study population. This will be considered by the authors in future work. A final minor limitation of our study is that we did not consider impact of frailty in patients less than 65 years of age. As health inequalities increase discordance between physiological and chronological age, it is likely that the young elderly (60-65 years)60 or patients at risk of early senescence (e.g. Down's Syndrome) could potentially be considered as distinctive cohorts whose association between frailty and outcome warrant further investigation.

In summary, it is clear that increased frailty is a valid marker of poorer burn outcome in patients > 65 years than is currently appreciated and that chronological age alone does not predict survivorship. It is also clear that association with frailty applies regardless of the size of the burn. We recommend that burn services assess the frailty of all patients > 65 years on admission and target burn care appropriately. We recommend further statistical work integrating the Frailty Score into the modified Baux score for patients greater than 65 years of age to more robustly predict the mortality risk in elderly burn victims.

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 **Figure 1. “Frailty Score” distribution within sample & CSHA23 criterion for each score**

|  |  |  |
| --- | --- | --- |
| Frailty Score | n= | Description |
| 1 - *Very fit* | 7 | Robust, active, energetic, well-motivated and fit; thesepeople commonly exercise regularly and are in the most fit group for their age |
| 2 - *Well* | 22 | Without active disease, but less fit than people in category 1 |
| 3 - *Well, with controlled co-**morbidities* | 87 | Disease symptoms are well-controlled compared to those in category 4 |
| 4 - *Apparently vulnerable* | 60 | Although not frankly dependent, these people commonly complain of being “slowed up” or have disease symptoms |
| 5 - *Mildly frail* | 38 | With limited dependence on others for instrumental activities of daily living |
| 6 - *Moderately frail* | 33 | Help is needed with both instrumental and non- instrumental activities of daily living |
| 7 - *Severely frail* | 2 | Completely dependent on others for the activities ofdaily living, or terminally ill. |

**Figure 2. Univariate analysis for in-hospital and one-year mortality**

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| --- |
| **In-Hospital Mortality** |
|  | **Survived n= 190** | **Died n= 49** | ***P=*** |
| **TBSA (%)\*** | 6 (5 – 7) | 28 (20 – 44) | <0.0001 |
| **Patient age (years)\*** | 76 (74 – 78) | 76 (73 – 79) | 0.48 |
| **Inhalation injury** | 12 | 20 | < 0.0001 |
| **Modified Baux\*** | 86 (83 – 89) | 108 (101 – 126) | < 0.0001 |
| **Frailty score\*** | 3 (3 – 4) | 4 (4 – 5) | < 0.0001 |
| **>= 4 Meds** | 100 | 26 | 0.85 |
| **Gender (males)** | 106 | 31 | 0.34 |
| **One-Year Mortality** |
|  | **Survived n= 152** | **Died n= 87** | ***P=*** |
| **TBSA (%)** | 6 (5 – 6.5) | 15 (8.9 – 20) | <0.0001 |
| **Age (years)** | 75 (73 – 78) | 78 (75 – 80) | 0.15 |
| **Inhalation injury** | 7 | 25 | < 0.0001 |
| **Modified Baux** | 85 (81 – 87.6) | 101 (96.9 – 105.1) | < 0.0001 |
| **Frailty Score** | 3 (3 – 3) | 5 (4 – 5) | < 0.0001 |
| **>= 4 Meds** | 74 | 52 | 0.08 |
| **Gender (males)** | 92 | 45 | 0.18 |

 **Figure 3. Mortality Associations**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Rho (IH Mortality)** | ***P-value*** | **Rho (1-year M)** | ***P-value*** |
| **Modified Baux Score** | 0.50 (0.4 – 0.59) | < 0.0001 | 0.47 (0.37 – 0.56) | < 0.0001 |
| **Frailty Score** | 0.31 (0.19 – 0.42) | < 0.0001 | 0.50 (0.40 – 0.60) | < 0.0001 |

Rho 0.1-0.29: small association Rho 0.3-0.49: moderate association Rho >0.5 large association

**Figure 4. Odds of Mortality (in-hospital and one-year) for the modified Baux and Frailty Score**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **IH Mortality OR (95% CI)** | ***P* value** | **1-year Mortality OR (95% CI)** | ***P* value** |
| **Modified Baux Score** | 1.09 (1.07 – 1.13) | < 0.0001 | 1.08 (1.05 – 1.11) | < 0.0001 |
| **Frailty score** | 2.33 (1.63 – 3.34) | < 0.0001 | 3.13 (2.22 – 4.41) | < 0.0001 |

**Figure 5. ROC scores for in-hospital & one-year mortality: Frailty Score & modified Baux**

|  |  |  |
| --- | --- | --- |
|  | **In-Hospital Mortality** | **One-Year Mortality** |
| **ROC Area (95% CI); SE** |
| Mod Baux Score& Frailty Score (continuous) | 0.90 (0.85-0.95); 0.02 | 0.88 (0.84-0.93); 0.02 |
| Mod Baux Score & Frailty Score >3 | 0.89 (0.85-0.94); 0.02 | 0.88 (0.84-0.92); 0.02 |
| Mod Baux Score & Frailty Score >4 | 0.88 (0.82-0.93); 0.03 | 0.84 (0.78-0.89); 0.03 |
| Mod Baux Score alone | 0.85 (0.79-0.91); 0.03 | 0.78 (0.71-0.84); 0.03 |



Figure 6. ROC curvel panel. a). In-hospital mortality



Figure 6. b). One-year mortality