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Predicting outcome after hip fracture: using a frailty index to integrate comprehensive geriatric assessment results

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Abstract

Introduction: hip fracture is expensive in terms of mortality, hospital length of stay (LOS) and consequences for independence. Poor outcome reflects the vulnerability of patients who typically sustain this injury, but the impact of different comorbidities and impairments is complex to understand. We consider this in a prospective cohort study designed to examine how a patients' frailty index (FI) predicts outcome.
Methodology: consecutive patients with low trauma hip fracture were assessed, excluding only those unfit for surgery. Comprehensive Geriatric Assessment (CGA) findings were used to derive a FI for each patient, which was examined alongside other assessment and outcome data from our National Hip Fracture Database (NHFD) submission for these individuals.
Results: we describe 178 patients; mean age 81 years, 73.5% female. The mean FI was 0.34 (SD = 0.16), and logistic regression identified abbreviated mental test score and FI as the strongest predictors of poor outcome. When patients were stratified by FI, 56 (31.5%) were in the low-frailty group (FI ≤0.25), 58 (32.5%) in intermediate (FI >0.25–0.4), and 64 (36%) in the high-FI group (FI >0.4). All the patients in the low-FI group returned to their original residence within a mean of 21.6 days. The mean LOS for the intermediate group was 36.3 days compared with 67.8 days in the high-FI group ($P < 0.01$) while 30-day mortality was 3.4% for the intermediate group compared with 17.2% for the high-FI group ($P < 0.001$).
Conclusions: individual CGA findings proved disappointing as outcome predictors, while FI turned out to be a better predictor of mortality, 30-day residence and length of inpatient stay.

Keywords: *frailty index, outcome, hip fracture, length of stay, frailty, mortality, older people*

Introduction

Frailty is a concept that represents a state of increased vulnerability to adverse outcomes [1, 2]. Every individual accumulates physical and psychological deficits during their life, and the greater the number of deficits, the frailer the individual is [3].

The frailty index (FI) expresses the number of deficits identified in an individual as a proportion of the total number of deficits considered. For example, if 40 potential deficits were considered, and 10 were present in a given person, their FI would be 10/40 = 0.25 [4]. In large, community-dwelling samples, FI is a more accurate predictor of adverse outcomes than chronological age [5]. A valid FI can be derived from the information collected as part of a Comprehensive Geriatric Assessment [6–8].

People who suffer hip fracture are frailer than their age-matched peer and hip fractures are strongly linked with causes and consequences of frailty such as osteoporosis [9], falls [10], low body mass index [11], polypharmacy [12] and cognitive impairment [13]. Yet, to our knowledge, no studies have formally examined the nature and extent of frailty in hip fracture, nor its implications on prognosis or outcome.

We set out to define the FI of sequential patients admitted with hip fractures, and to determine whether FI can predict outcome following this injury.

Methodology

We prospectively studied a cohort of patients, consecutively admitted to a teaching hospital with fragility hip fracture over

a 4-month period (August to December 2011). We excluded only those who were moribund or unfit for surgery.

Each patient had a FI documented on Day 3–5 post-operatively. This was based on deficits identified at that time point, rather than on pre-fracture frailty. Some deficits, such as ability to manage finances, were rated on perceived ability, rather than performance. Fifty-one deficits across different aspects of health were scored, and FI calculated by dividing the deficits accumulated by the total number for which data were available. Deficits included motivation, self-rated health, cognitive assessments, clock face drawing, co-morbidities, continence, mobility and functional independence (Supplementary data are available in *Age and Ageing* online, Appendix 1).

This work was designed as an extension of admission patient assessment. The FI and the Nottingham Hip Fracture Score (NHFS) [14] were simply added to the existing data set for the National Hip Fracture Database (NHFD) that is routine in our unit and every other UK trauma unit. Local ethics approval was not necessary since all information was collected as part of routine care and NHFD has approval from National Information Governance Board Ethics and Confidentiality Committee.

FI of 0.25 has been proposed as the demarcation between 'fitness' and 'frailty' in community-dwelling older people [15]. An FI of 0.4 and above describes older people who are completely dependent for activities of daily living and have a higher risk of death and institutionalisation [16]. Our group has previously shown these categories to predict the rehabilitation potential of older medical inpatients [8].

We categorised patients into 'low', 'intermediate' and 'high' frailty groups with a cut-off of 0.25 between low and intermediate, and 0.4 between intermediate and high-frailty groups.

Patient follow-up was based on the routine performance monitoring of the NHFD, and in this study we therefore focused on the length and outcome of hospital stay, and on outcome at 30 days after admission.

Results

One hundred and eighty consecutive admissions with fragility hip fracture were assessed, either by senior geriatricians or by general practitioner trainees. Two patients were lost to follow-up and excluded from this analysis. Outcome data at 30 days were incomplete in 4 (2.2%) of the remaining 178 cases. Acute trauma length of stay (LOS) figures were collected for all the patients, but overall LOS data were missing for 11 patients (6.2%) who were transferred out of area for post-acute rehabilitation.

The mean age of the 178 patients included was 81 years (range 47 to 101) of which, 131 (73.5%) were female. The mean FI was 0.34 (range 0.06 to 0.70; standard deviation 0.16). One hundred and thirty eight (77.5%) were admitted from their own homes. The FI cut-offs at 0.25 and 0.4 conveniently divided this cohort of patient into thirds with 56 (31%) of patients having low, 58 (33%) intermediate and 64 (36%) high FI (Table 1).

Low-FI group: FI ≤0.25

The outcome for the 'fittest' group was good, with 100% achieving discharge to their own home and 45 (80%) returning to independent living within 30 days. Overall LOS in acute and rehabilitation wards or 'super-spell' averaged 21 (SD: 16.5, 95% CI: 17.3–25.9) days (see Figure 1). There were no inpatient deaths in this group.

Intermediate FI group: FI 0.25–0.4

Outcome was significantly poorer among the 58 (33%) patients with intermediate FI. Two patients (3.4%) died within 30 days, and 3 (5.2%) as inpatients ($P < 0.001$). The mean length of hospital stay for this group was 36.3 (SD: 23.4, 95% CI: 29.7–41.7) days.

Table 1. Descriptive statistics

FI group	Low	Intermediate	High	*P*-value
n	56	58	64	
Age (SD)	73.98 (12)	82.12 (9.5)	86.05 (8.6)	**
Female (%)	33 (58.9)	45 (77.6)	53 (82.8)	*
AMT <7 (%)	1 (1.8)	19 (33.9)	52 (82.5)	**
Abnormal CFD (%)	7 (12.5)	33 (58.9)	58 (92.1)	**
Admitted from home (%)	55 (98.2)	50 (86.2)	33 (51.6)	**
Walked indoors without aids	43 (78.2)	25 (43.9%)	14 (22.2%)	**
From care home/house-bound	0	1 (1.75%)	21 (33.3%)	**
Outdoor mobility	25 (61%)	21 (45.7%)	21 (43.8%)	NS
Mean ASA grade (SD)	2.83 (0.73)	2.89 (0.7)	2.83 (0.66)	NS
Nottingham Score (SD)	3.64 (1.68)	4.97 (1.64)	6.09 (1.25)	**
Return home by 30-days	45 (80%)	24 (41.37%)	4 (6.25%)	**
30-Day mortality (%)	0	2 (3.4%)	11 (17.2%)	**
Inpatient mortality (%)	0	3 (5.2%)	18 (28.1%)	**

AMT: abbreviated mental test score; CFD: clock face drawing; ASA: American Society of Anaesthesiologists' grade, SD: standard deviation
Outdoor mobility—able to walk outdoors with no more than the use of a stick.
*$P < 0.01$.
**$P < 0.001$. NS, not significant

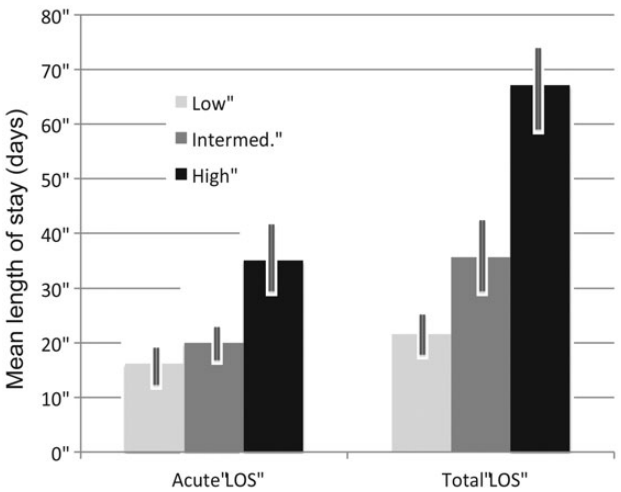

Figure 1. Length of stay in orthopaedic unit, and overall hospital 'super-spell' for different frailty index groups—means and 95% confidence intervals.

High-frailty group: FI >0.4

The average age of the 64 (35.7%) very frail patients was 86.1 years. Majority were cognitively impaired; 82.5% having an abbreviated mental test score <7, and 92.1% with an abnormal clock face drawing test. The mean length of hospital stay was 67.8 (SD: 39.3, 95% CI: 57.5–76.7) days, with a 30-day mortality of 17.2% and an overall inpatient mortality of 28.1% ($P < 0.001$). Thirty-three (52%) were admitted from their own home, but only 4 (6.3%) successfully returned there.

Within the high-frailty group were 13 'extremely frail' people with a FI score of >0.6. 2 were transferred to hospitals in other areas with limited outcome data. Thirty-day outcome in the remainder of this group was very poor with 6 (54.5%) dying, three needing new nursing home placements, one in a residential home and only one (9%) returning to their own home.

The overall super-spell was 21.6 days in the low-FI group compared with 36.3 and 67.8 days in the intermediate and high-FI groups, respectively. Both acute and overall hospital LOS figures showed significant correlation with FI on a scatter plot (Figure 2) with an *R*-value of 0.59 ($P < 0.0001$).

A number of individual admission assessment findings, including age, gender, American Society of Anaesthesiologists (ASA) grade and mental test assessments showed association with outcome. These were not surprising, and have been extensively reported in previous work [17, 18]. FI showed strong correlation with the LOS ($r = 0.44$, $P < 0.001$), but in this small study, age failed to achieve significance ($r = 0.15$, $P = 0.63$).

The best available clinical outcome prediction score—the NHFS [14]—also showed an association with LOS and outcome at 30 days. Our numbers were small compared with the very large studies upon which the NHFS is based, but we still found a statistically significant difference (χ^2 test) with a 30-day mortality of 1.6% in those with a lower score (NHFS <5), compared with 10.4% in those with NHFS of 5 or more. These figures can be compared with the range between the tertiles of patients in our low-, intermediate- and high-FI groups—who at 30 days suffered no mortality, 3.4% mortality and 17.2% mortality, respectively.

We compared how effectively different individual assessment findings might compare with the results of predictions made by FI. Age, sex, ASA Grade, AMTS, Clock Face Drawing, Nottingham Score and FI were analysed with logistic regression. Only AMT ($P < 0.005$) and FI ($P = 0.012$) proved predictive of outcome; both remaining in the logistic regression models to predict return home by 30 days, and mortality at 30 days after hip fracture. The Nottingham score was not independently predictive in the logistic regression model, perhaps reflecting importance of AMT in calculating this simple score, compared with FI where it is only one of 51 potential deficits.

Among the 138 patients who were admitted from home (average FI of 0.30), 72 (52%) were successfully returned home by 30 days after admission. Ten had died, one been placed in nursing care, 20 (14.5%) were still in the acute ward, and 33 (24%) in rehabilitation ward at this time-point. Their average total LOS was 34 days; 30-day mortality was 7.3%.

The receiver operator characteristic was used to examine whether FI could identify patients who would have a good outcome (Figure 3). The more comprehensive nature of FI meant that it out-performed other scores in this analysis (Figure 3), though the area under the curve (AUC) differed relatively little between FI (AUC = 0.82; 95% CI = 0.75–0.89), the much simpler NHFS (AUC = 0.73; CI 0.64–0.82) and AMT scores (AUC = 0.78; 95% CI: 0.70–0.86).

Discussion

FI is significantly associated with adverse outcome after hip fracture including mortality and length of hospital stay. In this cohort study, we have shown that previously described categories of FI can provide powerful predictions of outcome following hip fracture. The one-third of patients in the high-frailty group

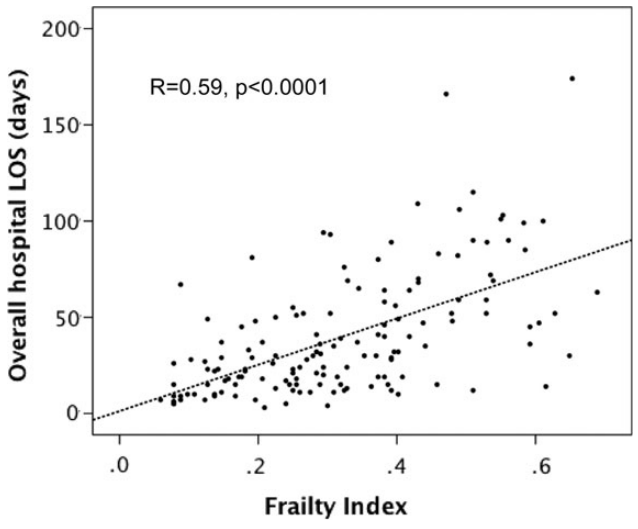

Figure 2. Frailty index and length of overall inpatient stay (super-spell).

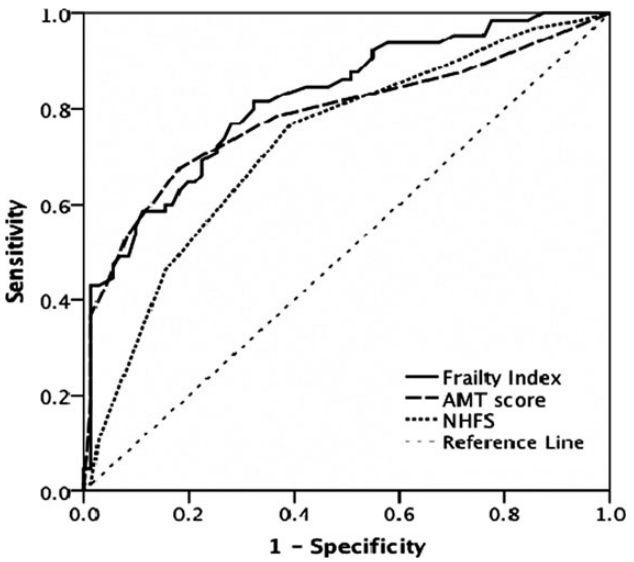

Figure 3. Prediction of failure to return home by 30 days, among those patients admitted from home. Area under curve (AUC) for frailty index: 0.82; 95% CI = 0.75–0.89.

had a mean LOS nearly twice that of the intermediate and over three times that of the low-frailty group. Their 30-day mortality was 17.2% compared with 3.4% in the intermediate group, while all low-frailty patients returned to their original residence.

We acknowledge the study's weaknesses. The sample size was small, with all patients recruited from a single hospital site. The study also has certain strengths. Although this work relied on our contributions to the NHFD for outcome data, the routines underlying this hip fracture follow-up are very rigorous, having been in place for over 15 years. As a result we achieved a very complete, robust outcome data set.

The mean FI of 0.34 observed in this hip fracture cohort was identical with that (0.34, SD: 0.09) observed in our previous study of medical inpatients [8]. This work confirmed previous observations [8, 16, 19] of the positive implications of outcome for an FI of <0.25; a figure that accounted for one-third of our subjects—all of them successfully returned home.

Calculating a FI based on 51 potential deficits initially appeared daunting, but a clinician performing Comprehensive Geriatric Assessment will have automatically noted many of the potential deficits (e.g. those relating to past medical history, current medication or hearing impairment) when taking a basic history. As a result, we found that on average it took <10 min to complete the assessment—using a tablet-based spread sheet which included prompts for specific deficits, and which automatically calculated the final FI.

While frail older patients are at greater risk of poor outcome, frailty status should not be used as justification for therapeutic nihilism. Interventions, such as nutritional support are known to have the potential to delay the onset of frailty [15, 20], and to improve mortality in people recovering from hip fracture [21]. FI is not intended to replace clinical judgment, and lacks the practical appeal of the NHFS. However, geriatricians facing the heterogeneity and complexity of patients who typically suffer hip fracture may find it helpful to understand the component deficits that make up their frailty. In particular, FI may prove useful as a risk stratification tool around which to design trials that explore the relationships between patient frailty and their potential to respond to more intensive or prolonged rehabilitation.

Key points

- FI can easily be calculated during routine Comprehensive Geriatric Assessment of post-operative hip fracture patients.
- FI is significantly associated with adverse outcome after hip fracture including mortality and length of hospital stay.
- Previously defined FI categories divide this population into thirds that are powerful indicators of outcome.
- Thirty-day mortality was 17.2% for patients of 'high frailty' (FI >0.4), compared with 3.4% in 'intermediate frailty' patients (FI: 0.25–0.4), while all 'low-frailty' patients (FI ≤0.25) successfully returned to their original residence.
- Patients in the 'high frailty' group stayed in hospital three times as long as those in the 'low-frailty' group.

Conflicts of interest

None declared.

Supplementary data

Supplementary data mentioned in the text is available to subscribers in *Age and Ageing* online.

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