Original Article

Can Preoperative Scoring Systems be Applied to Asian Hip Fracture Populations? Validation of the Nottingham Hip Fracture Score (NHFS) and Identification of Preoperative Risk Factors in Hip Fractures

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Abstract

Introduction: Hip fractures in the elderly are a major cause of morbidity and mortality. Determining which patients will benefit from hip fracture surgery is crucial to reducing mortality and morbidity. Our objectives are: 1) to define the rate of index admission, 1-month and 1-year mortality in all hip fracture patients, and 2) to apply the Nottingham Hip Fracture Score (NHFS) to determine validity in an Asian population. Materials and Methods: This is a prospective cohort study of 212 patients with hip fractures above 60 years from September 2009 to April 2010 for 1-year. Sociodemographic, prefracture comorbidity and data on functional status was collected on admission, and at intervals after discharge. The main outcome measures were mortality on index admission, 1 month and 12 months after treatment. Results: In our study, the overall mortality at 1-month and 1-year after surgery was 7.3% and 14.6% respectively. Surgically treated hip fracture patients had lower odds ratio (OR) for mortality as compared to conservatively treated ones. The OR was 0.17 during index admission, 0.17 at 1-month, and 0.18 at 12-months after discharge. These were statistically significant. Adjustments for age, gender, and duration to surgery were taken into account. The NHFS was found to be a good predictor of 1-month mortality after surgery. Conclusion: Surgically treated hip fracture patients have a lower OR for mortality than conservatively managed ones even up to 1-year. The NHFS has shown to predict 1-month mortality accurately for surgically treated hip fracture patients, even for our Asian population. It can be used as a tool for clinicians at the individual patient level to communicate risk with patients and help plan care for fracture patients.

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Introduction

Osteoporotic hip fractures are common and have significant consequences on mortality and functional capability which indirectly has familial, social and economic repercussions.[1] The inpatient mortality rates approach 4% to 12%,[2-8] while 1-year mortality is between 12% to 37%.2,[4-14] Studies from Denmark,[15,16] Italy,[17] the United Kingdom (UK),[18] and the United States (US)[19] showed that the 1-year survival rate might be as low as 64% to 75%. Those from Sweden,[20] Greece,[21] and Japan[22] however revealed that the survival rate is around 80% to 90%. In Singapore, the mortality rates have been shown to be around 5.7% at index admission and between 15% and 26% at 1-year.[23-26]

The aims of hip fracture surgery are to prevent progression to disability and restore pre-existing functionality.[27] Singapore has an ageing population with 9% above the age of 65 years in 2010 and this is projected to increase yearly.[28] This places an increasing burden on healthcare resources as postfracture recovery and rehabilitation is often protracted, requiring tertiary healthcare and step-down facilities to handle the increase in patient demand. Wong et al[23] in 2002 estimated that each hip patient required S$7367 to manage surgically. The costs have inflated over time, and hence government subsidies will become increasingly stretched.

Quickly identifying suitable patients for hip fracture surgery becomes important. It is better to identify patients

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who will do well in the long-term, as this may possibly reduce time to surgery and hence the duration of hospital stays. We know that earlier surgery has been associated with better functional outcome, shorter hospital stay, shorter duration of pain, and lower rates of nonunion, postoperative complications and mortality.[29-35] Chronological age, gender, residence, cognitive function, pre-existing comorbidities all play a role in postoperative mortality and functional outcome.[17,19,36-42] There are pre-existing scoring systems designed to risk stratify hip fracture patients, one of which is the Nottingham Hip Fracture Score (NHFS), which has been validated in the UK.[43,44] To our knowledge, this score has not been validated in an Asian population.

Our hospital-based analysis looked at: 1) rates of mortality at index admission, 1-month and 1-year in hip fracture patients, 2) application of the NHFS to an Asian population to determine validity, and 3) identification of preoperative risk factors for mortality.

Materials and Methods

This was a prospective cohort study at a large public tertiary hospital in Singapore. A hip fracture database was set up from September 2009 which includes sociodemographic, prefracture comorbidity and data on functional status. Inpatient and outpatient data regarding treatment and complications was collected. Data collection after discharge was done via outpatient clinical notes and phone calls at 1-month, 3-month, 6-months and 1-year. Mortality was established by contacting the patient's family and hospital electronic records. We identified a consecutive series of all hip fracture patients above 60 years of age, identified from September 2009 to April 2010. Hip fractures sustained as a result of malignant pathological fractures were excluded.

Univariate analysis was performed to establish relationship between mortality and covariates. Where necessary, multivariate logistic regression was used to adjust for the necessary covariates. A P value <0.05 was considered significant. Data was analysed using STATA version 10 (Statacorp, College Station, Texas) and Microsoft Excel spreadsheets.

The NHFS was first developed and validated in the UK as published by Maxwell et al.[43] It is a weighted score with 7 independent admission variables which reliably predicts 30-day mortality (Table 1). The variables included age, gender, admission haemoglobin levels, admission mini-mental test scores, number of comorbidities, presence of malignancy, and premorbid place of residence. Each patient can have their predicted 30-day mortality calculated on admission. In this study, the risk score for each patient was calculated, then logistic regression was used to derive receiver operating characteristic (ROC) curves.

Table 1. Nottingham Hip Fracture Scores (NHFS)

Variable	Value	Score
Age (year)	<66	0
	66 – 85	3
	≥86	4
Sex	Male	1
Admission haemoglobin	≤10 g/dL	1
Admission MMTS	≤6 out of 10	1
Living in institution	Yes	1
Number of comorbidities	≥2	1
Malignancy	Yes	1

MMTS: Mini-mental test score

Note: Predicted 30-day mortality is calculated by substituting the total NHFS into the equation: 30-day mortality (%)1⁄4100/1+$e^{[4.71822(NHFS/2)]}$

Results

Over a 7-month period from September 2009 to April 2010, 212 hip fracture patients were recruited into the study, with 15 patients lost to follow-up. A total of 138 patients were treated surgically. Characteristics of the patients are shown in Table 2. A total of 70% of patients were treated surgically. The overall mortality rate was 7.3% at 1-month and 14.6% at 12-months after discharge.

The difference in mortality between the genders was not statistically significant. The average duration of index admission was 12 days and of note, 68.9% of our hip fracture patients were discharged to inpatient rehabilitation facilities (community hospitals). Of the 59 patients treated conservatively, 20 of them had declined surgery, while 29 were deemed medically unfit due to acute illness or pre-existing comorbidities. A total of 8 were premorbidly bed or wheelchair ridden, and would not benefit from surgery, while 2 did not have surgery for unknown reasons. The mortality rate for conservatively managed patients was 18.6% at 1-month and 32.2% at 1-year. We conducted a univariate analysis looking at individual preoperative factors. Results when analysing 1-month mortality are shown in Table 3.

In our study, surgically treated hip fracture patients had lower odds ratio (OR) for mortality as compared to conservatively treated ones. The OR was 0.17 during index admission, 0.17 at 1-month, and 0.18 at 12-months after discharge. These were statistically significant. Adjustments for age, gender, and duration to surgery were taken into account.

To validate the NHFS in our population, the score was only applied to surgically treated patients, as described by Maxwell in his original paper. This included all surgically treated hip fractures, as well as individual subgroups of neck of femur, and intertrochanteric fractures. ROC curves were

Table 2. Characteristics of Study Population (Standard Deviation)

Demographics	Surgical	Conservative
Age	78.78 (8.97)	82.95 (9.58)
Race (%)		
Chinese	87	89
Others	13	11
Gender (%)		
Male	48	41
Female	52	59
Fracture type (%)		
Neck of femur	52	69
Intertrochanteric	42	28
Subtrochanteric	6	3
Admission haemoglobin (g/dL)	11.64 (1.74)	10.92 (1.79)
Abbreviated mental test (AMT)	6.79 (3.31)	5.02 (2.38)
Charlson comorbidity index score (CCIS)	4.59 (1.88)	5.92 (1.99)
Days to surgery (median, range)	4.55 (3.56)	-
Number of falls last 12 months (median, range)	1.72 (1.63)	1.61 (1.46)
Community ambulant prior to fracture (%)	69	36
Walking aid not required (%)	59	30
Discharge destination (%)		
Community hospital	77	37
Own home	14	29
Nursing home	9	34

generated. An example for 1-month mortality is illustrated in Figure 1. Area under the curve (AUC) values from these curves are presented in Table 4. NHFS can be seen as a good predictor for mortality at 1-month.

Discussion

In our centre, hip fracture patients above 60 years of age are co-managed by a specialised multidisciplinary team of orthopaedic surgeons, orthogeriatricians, nurse managers, physiotherapists, occupational therapists, medical social workers and pharmacists. These patients are put on a hip fracture clinical pathway, which streamlines care, and allows each discipline to better understand and manage each patient.

This study boasts a relatively low mortality rate for both 1-month and 1-year follow-up, given that international hip fracture mortality rates published can range from 4% to 12% for the index admission and from 12% to 37% at 1-year. In our local setting, the resources such as community hospitals are available across the island; 68.9% of our study population was discharged to community hospitals for further rehabilitation. These centres have multidisciplinary management, led by rehab physicians. Each admission to a community hospital usually lasts 2 to 3 weeks. Upon discharge from a community hospital, patients will be better conditioned and confident of returning to their homes. Perioperative morbidity can also be identified early and referred back to the tertiary centre for specialist care. Our city state also allows for early referral to a tertiary centre, even if the patient rehabilitates at home. Continuity of care and easy access to medical facilities allows complications to be arrested and corrected early on. In the UK, only 26.5% of hip fracture patients are discharged to intermediate care, as compared with 86.6% in US hospitals.[45] Japan, interestingly,

Table 3. Odds Ratios for Various Preoperative Risk Factors; Mortality at 1-month

Factor	Value	Odds Ratio	*P* Value	95% Confidence Interval
Age	>66 – 85	0.35	0.23	0.06 – 1.96
	>85	1.21	0.81	0.22 – 6.47
Sex	Female	0.73	0.59	0.23 – 2.29
AMT	>5	2.58	0.17	0.66 – 10.0
Residence	Institution	1.24	0.84	0.14 – 10.5
Premorbid mobility	Homebound	1.01	0.98	0.33 – 3.03
Haemoglobin	>10	0.54	0.44	0.11 – 2.55
Site of fracture	Extracapsular hip fractures	0.59	0.40	0.17 – 2.0
Fracture management	Surgical	0.17	0.005	0.51 – 0.59
CCIS	>5	1.94	0.31	0.53 – 7.01
Comorbidities	≥2	0.79	0.68	0.25 – 2.45

AMT: Abbreviated mental test; CCIS: Charlson comorbidity index score

Table 4. All Hip Fractures Surgically Treated

Mortality (Month)	All Hip Fractures (AUC,* 95% CI)
1	0.800, 0.65 – 0.94
3	0.600, 0.40 – 0.79
12	0.607, 0.41 – 0.80

AUC: Area under the curve; CI: Confidence interval
*AUC values using the Nottingham Hip Fracture Score (NHFS) for 1-month, 3-month and 12-month mortality

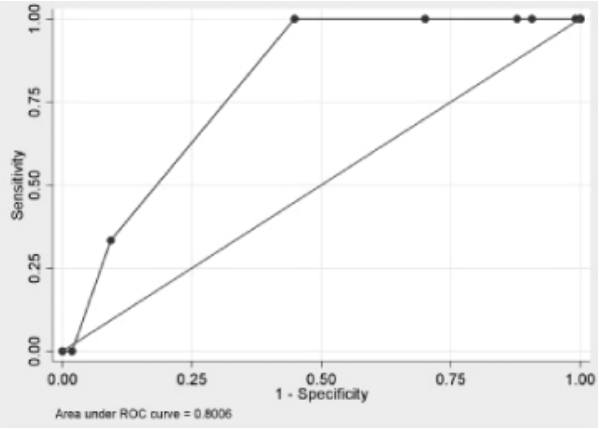

Fig. 1. Graph showing 1-month mortality ROC curves for surgically treated hip fractures.

has a longer average duration of stay than most European countries or the US (average of 48 days in 2001), and one of the lowest mortality rates of 10% at 1-year.[46] Most hospitals in Japan have both acute care and rehabilitation facilities combined; hence there is little need for further step-down community facilities. Differences in mortality between genders were analysed, but were not significant for age, treatment type or comorbidities.

Having studied various preoperative factors which might influence mortality, we can conclude that surgical treatment has a lower risk of mortality up to 1-year. We understand that there may be a bias due to possible selection of healthier patients for surgery. For example, patients of younger age, fewer comorbidities, faster time to surgery etc. may have benefited from surgery. We have observed that our conservatively managed patients tended to be older, have poorer premorbid function, lower abbreviated mental test (AMT) scores, lower haemoglobin levels, and higher Charlson comorbidity index score (CCIS) scores. Although we attempted to study these possible reasons through a multivariate model, the results were inconclusive. We postulate that surgical treatment allows early mobility, resulting in decreased morbidity from immobility. Neck of femur fractures treated with hemiarthroplasty can start weightbearing a few days after surgery. Intertrochanteric and subtrochanteric fractures when surgically fixed, likewise allow early weightbearing or at least wheelchair mobility. Conversely, non-operated patients can have adverse outcomes from immobility, with poorer return to function and weightbearing as a result of prolonged bedrest, reduced muscle strength, limb length discrepancy and mal-alignment.

Factors which showed the highest OR for 1-month mortality included age >85, CCIS, and place of residence before admission. Although these scores were not significant, their OR trended towards higher risk for surgical treatment. This is reflected as well when computing NHFS scores, which includes these risk factors in the computation. Surprisingly, AMT scores >5 had a higher OR for 1-month mortality. This result unfortunately could not be explained.

International Scoring Systems for Hip Fracture Patients

Given that elderly patients with osteoporotic hip fractures can have significant comorbidities, it is important to stratify their risk of surgery. This helps to identify patients which would most likely benefit from surgical intervention. It is also necessary to provide quick and accurate risk counselling to the patient and their concerned families on admission.

Different scoring systems have been developed to attempt to predict mortality. Burgos et al[47] compared 6 different scoring systems: the American Society of Anesthesiologists (ASA) classification,[48] the Barthel index,[49] the Goldman index,[50] the Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity (POSSUM) scoring system,[51] the Charlson index[52] and the Visual Analogue Scale for Risk (RISK-VAS) scale.[53] Each system was unable to predict hip fracture mortality at 90 days. O-POSSUM scoring has been shown to over predict mortality in hip fractures,[54] while the Donati score shows a poor concordance when a range of risks is considered.[55] The Estimation of Physiologic Ability and Surgical Stress (E-PASS) score[56] was recently developed by a Japanese group to predict morbidity and mortality after hip fracture surgery. It has been shown to better predict morbidity and mortality than the O-POSSUM, however the scoring system requires intraoperative details such as the amount of blood loss, operating time, and the extent of skin incision to calculate the final risk score for the patient.

Maxwell et al's[43] original paper showed that the NHFS achieved an AUC of 0.719. This demonstrates a reasonable predictive value for the score. In comparison, ASA and Donati scores each show scores of 0.718 and 0.717 respectively.[48,51] In a recent study published by Wiles et al[44] in January 2011, the NHFS was retrospectively calculated for 6202 patients who had undergone hip fracture surgery

in the UK. They found that survival was greater in the low-risk group (NHFS score ≤4 at 30 days) [96.5% vs. 86.3% (*P*, 0.001)] and at 1-year [84.1% vs. 54.5% (*P*, 0.001)]. In 2012, Moppett et al[57] further established the NHFS as a robust predictor of 30-day mortality in geographically distinct UK centres.

The NHFS is simple to use, and data required from each patient is available on admission. Based on our literature review, we are the first centre in Asia to attempt to validate this scoring system in our local population.

In our centre, hip fracture patients are encouraged to undergo surgery when possible, and this is reflected in our population where 70% of cases are managed surgically. Patients are managed conservatively if they will clearly not benefit from surgery (e.g. bedbound premorbidly), patients and family decline surgical intervention, or they have overwhelming medical conditions that do not allow surgical intervention. As such, only surgically treated hip fractures are included in the application and analysis of the NHFS.

Our results show that the NHFS with an AUC value of 0.800 suggests good accuracy for predicting 1-month mortality when applied to all operated hip fractures. Unfortunately, the AUC values for 3-month and 12-month mortality are poor. These values indicate that there are other confounders possibly pre and postoperative, which are yet unknown.

Factors that predict 12-month mortality may very well differ from factors predicting 1-month mortality in our population. There could be subtle differences in the preoperative characteristics between populations. In his original paper to develop and validate the NHFS, Maxwell et al[43] shows that for surgically operated patients, the average admission haemoglobin level was 12.3 g/dL while 23% of patients were previously living in an institution. For conservatively managed patients, they had an average haemoglobin level of 11.7 g/dL, while 40% were living in an institution. Both Maxwell and Wiles conducted studies for patients treated at Queen's Medical Center, Nottingham, which they believe is representative of the general population in the UK. In comparison with our study group, only 7.7% of patients were living in an institution and had a haemoglobin of 11.4 g/dL. Both haemoglobin levels and prefracture residence have been shown in earlier research to be positively associated with mortality in hip fractures. Our mortality rates for surgically treated patients also differ: 3.6% at 1-month and 7.5% at 1-year while Wiles et al quotes mortality at 8.3% for 1-month and 29.3% at 1-year.

Given the lower mortality rates in our study, we feel that we should increase our study cohort to better validate the NHFS. We were also unable to calculate the AMT scores for a small percentage of patients, as they were unable to communicate effectively to give an accurate score. Hence their NHFS scores cannot be determined and these patients were excluded from the scoring. Future research should attempt to apply the NHFS in a prospective study to assess its validity.

Conclusion

In this study, surgically treated hip fracture patients have a lower OR for mortality than conservatively managed ones even up to 1-year. The NHFS has shown to predict 1-month mortality accurately for surgically treated hip fracture patients, even for our Asian population. It can be used as a tool for clinicians at the individual patient level to communicate risk with patients and help plan care for fracture patients.

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