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Original Article

Assessing the Relationship Between Cognition, Premorbid Function and Functional Outcomes After Hip Fracture Surgery

*Zhi Yang Loy[1], Chin Yee Ng, Seng Kwing Cheong[1], Ying Tze Lim Julia, Kiat Sern Goh[2], Kiat Mun Serena Low[3], Hong Weng Tan[1], Liang Tee Lee

[1]Ren Ci Hospital, Singapore
[2]Department of Geriatrics, Changi General Hospital, Singapore
[3]Clinical Research Unit, Khoo Teck Puat Hospital, Yishun, Singapore

***Correspondence**
Dr. Zhi Yang Loy
Ren Ci Hospital, Singapore
E-mail:
loyzhiyang@gmail.com

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ABSTRACT

Background/Purpose: Elderly who sustain hip fractures exhibit significant morbidity and mortality. Due to the aging population, the healthcare burden from hip fractures in Singapore is expected to increase significantly. Rehabilitation after hip fracture surgery is an integral component of hip fracture management with a multitude of factors influencing outcomes.

Methods: A retrospective cohort study of all elderly patients above 60 admitted for rehabilitation to a local Community Hospital after hip fracture surgery over 1 year. Variables including demographics, premorbid function, post-operative weight bearing status, complications, comorbidities, admission cognitive status (Abbreviated Mental Test) were collected. Functional outcomes measured include Modified Barthel Index (MBI) gain and MBI efficiency. Scores for MBI were measured at admission and before discharge.

Results: Patients with better cognitive status (AMT score ≥7) had better rehabilitation outcomes as measured by both MBI gain as well as MBI efficiency p <0.001). Patients that had a better premorbid functional status also had a better rehabilitation outcomes (p <0.001).

Conclusion: Cognitive level and premorbid function were both closely associated with functional recovery after surgical repair of hip fracture.

1. INTRODUCTION

Fractures of the hip remain one of the most common and potentially devastating injuries in the geriatric population.[1] It is a significant healthcare concern, with mortality rates within the first year after hip fracture ranging from 14–36%.[2] Furthermore, hip fractures are the commonest cause of acute orthopaedic admissions amongst the elderly.[3]

According to a systemic review of 18 studies, the probability of falling at least once in any given year for individuals 65 years and older is approximately 27 percent.[4] Old persons are susceptible to falls for many reasons, such as poor balance, neuromuscular disease, polypharmacy, visual impairment and cognitive impairment. Hip fractures can also be very debilitating for geriatric patients, especially because they differ significantly from their younger counterparts in their

greater number of comorbidities,[5] frailty and higher risk of severe disability.

In Singapore, hip fractures in persons aged 50 years and above, has increased fivefold in women and 1.5 fold in men, over the past 30 years. The age-adjusted hip fracture rate among Singaporean women over the age of 50 years is about 450/100 000 females.[6] The majority of local hip fracture patients undergo a period of rehabilitation at a community hospital following surgical repair in the acute orthopaedic unit.

A plethora of factors may influence the functional outcomes of these patients with hip fracture. Such variables include socio-demographic factors such as age, gender, ethnicity, pre-fracture mobility status underlying comorbidities and cognition; surgical factors such as type of fracture, postoperative weight bearing status; and post-operative complications amongst others.[7-9] Stephanie Low et al found that premorbid frailty, dementia, delirium and advance age of >90 years were independently predictive of poor outcomes.[10]

Knowledge of major factors influencing postoperative functional outcomes will facilitate the inter-disciplinary team in planning interventions for modifiable risk factors and in engaging patients and families for development of individualized rehabilitation programs, as well as aid estimation of resource utilisation.

There have been varying opinions on whether cognitive status affects the recovery of patients. Previous studies have suggested that cognitive impairment, was a predictor of poor functional recovery after hip fracture surgery.[11-13]

Other studies demonstrate that although cognitively impaired patients may not be able to achieve the same level of functional recovery as their cognitively intact counterparts do, they may still achieve positive outcomes.[14,15] Other investigators specializing in geriatric rehabilitation have reported that the cognitively impaired patients could actually achieve functional gains similar to that achieved by the cognitively intact patients.[16]

With regards to studies performed locally, a retrospective study done in a community hospital setting in 2014, Tan AHK et al.[17] showed that older age, Malay ethnicity and fewer number of rehabilitative sessions were significant predictors for poor outcomes. In another hip fracture rehabilitation cohort, depression and cognitive impairment were significant predictors of poor outcomes at one year follow-up.[18]

In this study, we examine how various factors affect post-surgical recovery of hip fracture patients in Singapore, with particular focus on cognition and premorbid function using Modified Barthel Index[19] (MBI) Gain and Modified Barthel Index Efficiency as functional outcome measures.

2. METHODS

2.1. Participants

All patients aged 60 and above with hip fractures who underwent surgical fixation, transitioning from acute hospital orthopaedic units to Ren Ci Community Hospital from November 2016 to October 2017 were included. Ren Ci Community Hospital is a 121 bedded Community Hospital in central Singapore which is situated next to Tan Tock Seng Hospital, a tertiary hospital.

Patients who were managed conservatively or diagnosed to have pathologic fractures secondary to bone metastases were excluded. Patients with bilateral hip fractures were excluded as well.

Patient characteristics are presented in the Table 1 below.

Other patient personal data including length of community hospital stay and comorbidities were evaluated. The comorbidities captured included hypertension, diabetes mellitus, ischemic heart disease, cardiovascular accidents, chronic kidney disease, chronic obstructive pulmonary disease and cancer. Post operation complications were recorded comprising urinary tract infection, delirium, pneumonia, pressure sores, and sepsis.

Abbreviated Mental Test (AMT)[20] was performed upon admission, and Modified Barthel Index (MBI) was evaluated on admission and discharge. An interdisciplinary team including nurses, occupational therapists and physiotherapists performed the assessments.

2.2. Assessment of the Functional Outcome

Modified Barthel Index was done on admission to Ren Ci Community Hospital, throughout the length of stay and on discharge. MBI Gain was calculated as follows:

MBI Gain=MBI On Discharge–MBI On Admission.
Knowing the final outcome of rehabilitation like discharge MBI, or absolute function gain (AFG) is inadequate, as this does not take into consideration the length of stay and the trajectory of recovery. It is important for rehabilitative services to be more efficient in terms of achieving maximum gain to the patient as well as reducing the length of stay. Reducing the length of stay is the aim of many healthcare systems and is thought to indicate the efficiency of the system.[21-23]

Table 1. Baseline patient characteristics

Characteristics	Study cohort (N=211)
Age, mean±*SD*	79.86±8.37
Age group (%)	
<65 years	10 (4.7)
65-75 years	43 (20.4)
76-85 years	101 (47.9)
>85 years	57 (27.0)
Female, n (%)	142 (67.30)
Chinese ethnicity, n (%)	193 (91.47)
Malay ethnicity, n (%)	11 (5.21)
Indian and others, n (%)	7 (3.32)
Intertrochanteric fracture, n (%)	97 (46.19)
Neck of femur fracture, n (%)	104 (49.52)
Subtrochanteric fracture, n (%)	9 (4.29)
Length of stay (days)	31.7±16.6
Number of complications, n (%)	
0	116 (54.981)
1	69 (32.70)
2	23 (10.90)
3	3 (1.42)
Mean±*SD*	0.58±0.74
Number of comorbidities, n (%)	
0	31 (14.62)
1	76 (35.85)
2	67 (31.60)
3	30 (14.15)
4	6 (2.83)
5	1 (0.47)
Mean±*SD*	1.56 (1.03)
Premorbid Fully Independent, n (%)	175 (82.94)
Premorbid Non-fully Independent, n (%)	36 (17.06)
Weight Bearing as Tolerated, n (%)	201 (95.26)
Non Weight Bearing, n (%)	10 (4.74)
Admission AMT, mean±*SD*	7.30±3.11
Admission AMT, n (%)	
0-6	62 (29.38)
7-10	149 (70.62)
Admission MBI, mean±*SD*	53.8±15.4
Discharge MBI, mean±*SD*	70.1±18.5
MBI Gain, mean±*SD*	16.3±11.53
MBI Efficiency, mean±*SD*	0.6±0.56

Hence there is a need for more effective measures that show how efficient the rehabilitative method is, taking into account the length of stay or number of rehabilitative sessions in the rehabilitation centre.

In our study, MBI efficiency (MBI-E) was derived as follows:

MBI Efficiency=[(MBI on Discharge–MBI on Admission)/Days Admitted in Community Hospital]

2.3. Evaluation of Premorbid Function

Premorbid function of the patients were obtained by extracting information from the clinical notes. We divided the patients into two groups. The first group consisted of patients who were independent in all basic Activities of Daily Living (ADLs) before the fracture. The second group consisted of patients who were not fully independent in their basic ADLs before suffering the fracture.

2.4. Evaluation of Cognitive Function

The patient's cognitive function was assessed by Abbreviated Mental Test (AMT) by a trained doctor, upon admission. We analysed the AMT scores as categorical data which we divided the patients into two groups, using the cut-off score of 7("0-6", "7-10").[24]

2.5. Statistical Analysis

Continuous data was presented as means (standard deviation) for variables with normal distribution and median (interquartile range) for variables for skewed distribution. Categorical data was presented as number (percentages). Linear regression was used to examine the association between patient characteristics and change in MBI and MBI Efficiency which were log transformed. Variables were included in the multiple linear regression model if biologically relevant or statistically significant in the univariable linear regression. Analyses were performed with stratification by age groups and weight bearing status. The models were adjusted for age, gender and ethnicity. Statistical significance was taken at P <0.05. Statistical analysis was performed using STATA version 14 (STATA Corporation, College Station, Texas).

3. RESULTS

Data from 211 patients were analyzed, and presented in Table 1. Of these, 142 (67.3%) were females and 193 (91.47%) were of Chinese ethnicity. They had a mean age of 79.86 years (*SD*=8.37). Most of the patients were between 76 and 85 years old (47.9%). The mean initial MBI and discharge MBI were 53.8 (*SD*=15.4) and 70.1 (*SD*=18.5) respectively. The mean length of stay was 31.7days (*SD*=16.6).

Neck of femur (n=104, 49.52%) and intertrochanteric (n=97, 46.19%) fractures were the predominant fracture types. 201(95.26%) were allowed weight bearing as tolerated during rehabilitation and 62 (29.38%) had an AMT score of 0-6. 175 (82.94%) were premorbidly fully independent before the fracture.

The mean MBI gain was 16.3 (*SD*=11.53) and the mean MBI efficiency was 0.6 (*SD*=0.56).

The univariate analysis of the individual variables against MBI gain and MBI efficiency are summarized in Table 2. Admission AMT (MBI gain, Coef:-0.411, p=0.001; MBI efficiency, Coef: -0.594, p <0.001) was a significant predictor for poorer outcomes for both MBI gain and MBI efficiency. Premorbid function was also associated with poorer outcomes which was statistically significant (MBI gain, Coef:-0.572, p <0.001; MBI efficiency, Coef: -0.69, p <0.001).

Of note, the number of complications was a significant predictor of poorer outcome for MBI efficiency (Coef: -0.161, p=0.049) but not MBI gain.

The individual variables were further analysed using multiple linear regression model. The results of MBI gain and MBI efficiency are summarized in Table 3.

Admission AMT and premorbid function remained significant predictors of poorer outcome for both MBI gain and MBI efficiency.

When stratified by age groups, AMT remained significantly associated with poorer outcome for MBI gain and efficiency in those aged 76-85 years old. However, the association lost statistical significance in those aged <75 years and >85 years (Table 4). Also, for those aged 76-85 years old, premorbid function was significantly associated with poorer MBI efficiency but not a poorer MBI gain.

The association of premorbid function and cognition with MBI

Table 2. Association of characteristics with mbi gain/efficiency in univariate analysis

Univariate Analysis						
	Predictor (MBI Gain)			Predictor (MBI Efficiency)		
	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	-0.411	0.125	0.001	-0.594	0.130	<0.001
Age						
<65 years	1	-	-	1	-	-
65-75 years	-0.037	3.592	0.992	-0.063	0.250	0.800
76-85 years	0.878	3.318	0.791	-0.023	0.231	0.920
>85 years	-5.795	3.459	0.095	-0.468	0.242	0.055
Gender						
Female	1	-	-	1	-	-
Male	0.221	0.122	0.073	0.152	0.131	0.249
Ethnicity						
Chinese	1	-	-	1	-	-
Malay	-0.143	0.260	0.581	-0.249	0.277	0.370
Indian and Others	-0.293	0.362	0.420	-0.129	0.386	0.739
Type of Fracture						
Subtrochanteric fracture	1	-	-	1	-	-
Intertrochanteric fracture	0.131	0.293	0.655	0.157	0.313	0.617
Neck of femur fracture	-0.084	0.292	0.775	-0.056	0.312	0.858
Number of Complications	-0.029	0.077	0.705	-0.161	0.081	0.049
Number of Comorbidities	0.025	0.055	0.646	-0.041	0.059	0.481
Premorbid Function						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	-0.572	0.147	<0.001	-0.690	0.155	<0.001
Weight Bearing Status						
Weight Bearing as Tolerated	1	-	-	1	-	-
Non Weight Bearing	0.151	0.259	0.560	0.114	0.276	0.681

Table 3. Association of characteristics with mbi gain/ efficiency in multivariate analysis

Multi-variate Analysis						
	Predictor (MBI Gain)			Predictor (MBI Efficiency)		
	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	-0.284	0.141	0.046	-0.309	0.145	0.034
Age						
<65 years	1	-	-	1	-	-
65-75 years	0.000	0.266	1.000	-0.105	0.273	0.700
76-85 years	0.067	0.256	0.794	-0.046	0.263	0.862
>85 years	-0.212	0.275	0.443	-0.257	0.283	0.365
Gender						
Female	1	-	-	1	-	-
Male	0.106	0.120	0.377	0.104	0.123	0.399
Ethnicity						
Chinese	1	-	-	1	-	-
Malay	-0.238	0.247	0.337	-0.303	0.254	0.234
Indian and Others	-0.062	0.349	0.860	-0.032	0.358	0.929
Type of Fracture						
Subtrochanteric fracture	1	-	-	1	-	-
Intertrochanteric fracture	0.170	0.279	0.018	0.061	0.286	0.832
Neck of femur fracture	0.011	0.003	0.002	-0.206	0.286	0.472
Number of Complications	-0.010	0.078	0.901	-0.023	0.080	0.778
Number of Comorbidities	0.038	0.054	0.485	0.025	0.055	0.653
Premorbid Function						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	-0.413	0.173	0.018	-0.386	0.179	0.031
Weight Bearing Status						
Weight Bearing as Tolerated	1	-	-	1	-	-
Non Weight Bearing	-0.130	0.251	0.60	-0.057	0.258	0.825

gain and MBI efficiency was not consistent in all stratifications of age, this may be because the stratified analysis may have been under-powered.

When stratified by weight bearing status, premorbid function, but not AMT, was significantly associated with poorer outcome in terms of MBI gain and MBI efficiency among those that are weight bearing as tolerated (Table 5).

Similar to the association with stratifications of age, the association of premorbid function with MBI gain and MBI efficiency was not consistent in all stratifications of weight bearing status, which may be because the stratified analysis may have been under-powered.

4. DISCUSSION

Patients with hip fracture require intensive rehabilitation in order to optimise their potential of returning to a quality of life that they experienced before the fracture. However, this is a clinically heterogenous group, for which rehabilitation interventions and prognostication should ideally be stratified according to the characteristics of individual patients. The significant predictors of functional outcome after hip surgery detected in this study will be useful as a guide for the interdisciplinary team in planning and prescribing therapy interventions, goal setting as well as post-discharge care planning. The results will also help to prognosticate the functional outcomes of hip fracture patients after surgery and hence enhance the communication of extent of recovery with patients and family.

Table 4. Association between AMT and pre-morbid function with log-ransformed MBI stratified by age groups

	Multi-variate Analysis					
	Predictor (MBI Gain)			Predictor (MBI Efficiency)		
	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
Age <65 years						
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	0.390	0.685	0.627	0.403	0.917	0.703
Premorbid Function[1]						
Premorbid Fully Independent	-	-	-	-	-	-
Premorbid Non-fully Independent	-	-	-	-	-	-
Age 65-75 years						
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	-0.106	0.465	0.821	-0.128	0.436	0.771
Premorbid Function[1]						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	-1.369	0.969	0.169	-0.814	0.909	0.378
Age 76-85 years						
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	-0.588	0.201	0.004	-0.606	0.202	0.004
Premorbid Function[1]						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	-0.815	0.337	0.663	-0.821	0.306	0.009
Age >85 years						
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	-0.017	0.258	0.949	-0.091	0.286	0.753
Premorbid Function[1]						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	-0.379	0.278	0.181	-0.323	0.308	0.301

Note 1. There is no patient in the non-fully independent group aged <65 years.

Table 5. Association between AMT and pre-morbid function with log-transformed MBI stratified by weight bearing status

	Multi-variate Analysis					
	Predictor (MBI Gain)			Predictor (MBI Efficiency)		
	Coefficient	Standard Error	*p*-value	Coefficient	Standard Error	*p*-value
Weight Bearing as Tolerated						
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-6	-0.272	0.147	0.066	-0.283	0.151	0.063
Premorbid Function[1]						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	-0.417	0.178	0.021	-0.387	0.183	0.036
Non-weight Bearing						
AMT on Admission						
AMT 7-10	1	-	-	1	-	-
AMT 0-61	1.007	-	-	1.098	-	-
Premorbid Function[1]						
Premorbid Fully Independent	1	-	-	1	-	-
Premorbid Non-fully Independent	0	-	-	0	-	-

Note 1. There are only 10 patients (4.7%) in the NBW/TWB group.

In our study, pre-fracture function was found to significantly affect MBI gain and MBI efficiency. This is consistent with findings in other studies.[12,13] It would be more realistic to set higher goals for patients with

better prefracture function, commiserating with higher frequency and intensity of rehabilitation. We also found that poorer cognitive status was associated with lower MBI gains and efficiency. This finding is consistent with other studies.[12,13] A study by Bellelli and colleagues showed that among patients with hip fracture admitted to a rehabilitation unit, those who were older and had a higher level of cognitive impairment received fewer rehabilitation interventions.[25]

However, in the clinical setting, it may not be appropriate to write off patients who have poorer premorbid function or cognitive status. Rather, it would serve as a good guide for discussion with patients and their families regarding realistic rehabilitation goals as well as discharge planning.

Rehabilitating cognitive impaired patients poses unique challenges. It may require the co-implementation of strategies to manage cognitive and behavioural issues, whilst tailoring rehabilitation interventions and goals in accordance to the severity of cognitive impairment. Despite poorer outcomes, cognitive impairment should not be viewed as an impediment to rehabilitation following hip fracture.

Demographic factors such as age, gender and ethnicity did not have a significant impact on the functional outcome in this study. Hence advanced age should not be the sole factor in prognosticating rehabilitative outcomes, nor influence decisions for surgery. Likewise, the cumulative burden of pre-existing medical conditions also had little effect on functional outcome, we postulate that other unexplored factors such as frailty and fear of falling may have a greater impact on rehabilitation outcomes.

There are limited local studies examining the factors influencing functional recovery after hip fracture surgery, hence the results of this study give impetus to further development and refinement of rehabilitation protocols, whilst providing impetus for future research. This study also has few exclusion criteria, reflecting a typical hip fracture rehabilitation population in a local community hospital.

4.1. Limitations

Being a retrospective study, we were not able to collect information on significant factors which may influence rehabilitation outcomes, including the presence of depression,[18] pain, sarcopenia, frailty[10] and fear of falling.

Prefracture mobility and function could have been better defined with New Mobility Score[26] and MBI respectively. The retrospective nature of the study posed challenges to have an objective premorbid functional score. Stratification into 2 categories of being premorbid fully independent and premorbid not fully independent may see a ceiling effect for the former and a floor effect for the latter.

In the Singapore setting, hip fracture patients may undergo inpatient rehabilitation in the acute hospital or at a community hospital after surgery. As our study only includes the group of patients referred to our community hospital, this may lead to a certain degree of selection bias. Also length of stay (LOS) in the acute hospital before transfer to community hospital is not factored into the MBI efficiency.

We were also not able to factor in other potential confounders during the community hospital stay such as rehabilitation frequency and rehabilitation intensity even though session durations are uniform for each patient. These factors are often patient and therapist dependent. Patients who are medically ill may be given lower intensity therapy, whilst strongly motivated patients and caregivers would usually receive additional sessions.

Admission AMT was used as a surrogate for cognitive status which may not be a true indication of pre-fracture cognition. AMT scoring can be affected by delirium, mood, hearing impairment, educational level and language barriers. Mini mental state examination and Montreal cognitive assessment would have been superior indicators of cognitive status.

5. CONCLUSION

Premorbid mobility and cognition are factors that impact rehabilitative outcomes for hip fracture patients after surgery. These findings can be used to prognosticate recovery, as well as develop and implement individualized rehabilitation programs.

Further prospective studies that take into consideration more potential variables are required to help the interdisciplinary team more accurately prognosticate the functional outcomes in this vulnerable hip fracture population. Developing specific therapy protocols and defining meaningful goals for the subgroup of cognitively impaired and premorbidly non-independent patients are promising domains for future research.

CONFLICTS OF INTEREST

No conflicts of interest to declare.

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