Assessment of postoperative short-term and long-term mortality risk in Chinese geriatric patients for hip fracture using the Charlson comorbidity score

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ABSTRACT

Introduction: The clinical outcome of geriatric patients with hip fracture depends on surgical management as well as other medical factors. This study aimed to evaluate the relationship between Charlson comorbidity score and in-patient, 30-day, and 1-year mortality in Chinese geriatric patients who underwent surgery for hip fracture.

Methods: This was a historical cohort study conducted in a tertiary trauma referral centre in Hong Kong. From 1 January 2009 to 31 December 2010, 759 operated hip fracture patients who were over 65 years were recruited. The Charlson Comorbidity Index of each patient was retrieved from their medical records. The total Charlson comorbidity score, the highest Charlson comorbidity score, and the Charlson comorbidity score were calculated. The associations between these scores and in-patient, 30-day, and 1-year mortality were examined using Mann-Whitney *U* test and Cox regression model.

Results: The mean in-patient, 30-day, and 1-year mortality rate was 0.8%, 2.5%, and 16.3%, respectively. The total Charlson comorbidity score was significantly associated with in-patient mortality (P=0.031). The total Charlson comorbidity score (P<0.001) and Charlson comorbidity score (P=0.010) were significantly associated with 30-day mortality. All three scores were also significantly related to 1-year mortality (P<0.001). A Cox regression model demonstrated the relationship between total Charlson comorbidity score and 30-day and 1-year mortality. This can help predict 30-day and 1-year mortality risk in geriatric patients admitted for hip fracture surgery.

Conclusion: The Charlson comorbidity score provides a good preoperative indicator of 30-day and 1-year mortality in geriatric patients with hip fracture.

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New knowledge added by this study
- Charlson comorbidity score correlates well with the short-term and long-term mortality of Chinese geriatric patients with operated hip fracture.
- Hip fracture surgery is generally safe in terms of short-term mortality rate even in high-risk patients.

Implications for clinical practice or policy
- Preoperative assessment of geriatric patients admitted with hip fracture can provide a reasonably accurate indication of mortality risk. This helps improve patient and family rapport and subsequent satisfaction.

Introduction

The number of geriatric patients admitted to our hospital with hip fracture has been increasing steadily over the last decade. Such osteoporotic fractures are difficult to treat because of poor bone quality. The often extreme age of the patients and other comorbidities make the management of such patients even more challenging. The clinical outcome of geriatric patients with hip fracture depends on surgical management as well as many other medical factors.

Hip fracture is a significant cause of mortality.[1] Haentjens et al[2] reported a 5- to 8-fold increased risk for all-cause mortality in the first 3 months following hip fracture. Some clinical scores and assessments—for example, the American Society of Anesthesiologists (ASA) classification, the Barthel index, the Goldman index, the POSSUM (Physiological and Operative Severity Score for the enumeration of Mortality and Morbidity) scoring system, the Charlson index and the visual analogue scale for risk scale, or the cumulated ambulation score—are reported to correlate with postoperative complications and mortality of hip fracture.[3-5] Some of these scores can predict complication rates and others better predict short-term mortality.[4,6]

Individual clinical parameters also correlate with mortality rates.[6-11]

Among all these scores, the Nottingham Hip Fracture Score (NHFS) is one of the most well-known for the prediction of short- and long-term mortality in geriatric hip fracture patients, and has been validated in both western and Asian populations.[12-14] This excellent score includes patient age, sex, admission haemoglobin level, Mini-Mental State Examination (MMSE) score, previous institution, number of comorbidities, and also presence of malignancy.

In our hospital, a multidisciplinary hip fracture clinical pathway programme was started in 2007. The implementation of this pathway has not only shortened hospital stay, but also improved clinical outcomes, including pressure sore rate, infection rate, and mortality rate.[15] To enable early patient assessment and quantification of the risks of hip fracture surgery, a score that is easy to calculate and readily obtainable should be identified. This can greatly improve the rapport between the surgeon and patient, as well as their family, with regard to the operative risks and mortality risks. The NHFS is an excellent score that has been widely validated. Nonetheless it involves assessment of the MMSE score by a therapist and is not always possible before surgery. In this retrospective study, we used the Charlson Comorbidity Index (CCI) to evaluate patient comorbidities (Table 1).

The objective of this study was to determine the association of the CCI in operated hip fracture in patients older than 65 years with the in-patient, 30-day, and 1-year mortality.

Methods

Our hospital is a tertiary trauma referral centre in Hong Kong. When geriatric patients with hip fracture present to the accident and emergency department, they are transferred to the orthopaedic ward for preoperative workup and assessment once they are stabilised. Surgery is performed within 2 days. Postoperatively, they are observed in an acute ward for a mean of 5 days before being transferred to another convalescence hospital for rehabilitation. Patients are discharged after a mean of 3 weeks.

From 1 January 2009 to 31 December 2010, we recruited all patients aged over 65 years who underwent surgery for geriatric hip fracture. Patients with pathological fractures, multiple fractures, or old fractures were excluded from this study. Patient records were retrieved from the electronic medical record system. Since all these patients were managed according to our hip fracture clinical pathway protocol, all demographic data, pre-morbid walking status, comorbidities, past surgery, complications, and also length of stay in both acute and convalescence hospitals were available. Most

使用查爾森合併症評分評估華籍老年患者髖骨骨折的術後短期及長期死亡風險

劉德榮、方欣碩、梁加利

引言：老年髖部骨折患者的臨床結果取決於手術治療以及其他臨床因素。本研究評估接受髖骨骨折手術治療的華籍老年患者的查爾森合併症評分（CCS）與其住院、30天和1年死亡率之間的關係。

方法：我們於香港一所提供第三層創傷轉介服務的醫院進行一項歷史隊列研究。在2009年1月1日至2010年12月31日期間接受髖骨骨折手術治療的759名65歲以上的患者均被納入研究範圍。從醫療紀錄中找出他們的CCS指數，計算出每名病人的CCS總評分、CCS最高分數和CCS評分，並使用Mann-Whitney *U*檢驗和Cox迴歸模型分析這些評分與病人住院、30天和1年死亡率之間的關係。

結果：平均住院、30天和1年死亡率依次分別為0.8%、2.5%和16.3%。CCS總評分與住院死亡率相關（P=0.031）。CCS最高分數（P<0.001）和CCS評分（P=0.010）與30天死亡率顯著相關。三個分數亦與1年死亡率顯著相關（P<0.001）。Cox迴歸模型分析顯示CCS總評分與30天及1年死亡率相關。這些分析結果有助預測接受髖骨骨折手術治療的老年患者的30天及1年死亡風險。

結論：CCS評分為老年髖骨骨折的30天和1年死亡率提供良好的術前指標。

TABLE 1. Charlson Comorbidity Index*

Score	Condition
1	Myocardial infarction (history, not ECG changes only)
	Congestive heart failure
	Peripheral vascular disease (includes aortic aneurysm ≥6 cm)
	Cerebrovascular disease: CVA with mild or no residua or TIA
	Dementia
	Chronic pulmonary disease
	Connective tissue disease
	Peptic ulcer disease
	Mild liver disease (without portal hypertension, includes chronic hepatitis)
	Diabetes without end-organ damage (excludes diet-controlled alone)
2	Hemiplegia
	Moderate or several renal disease
	Diabetes with end-organ damage (retinopathy, neuropathy, nephropathy, or brittle diabetes)
	Tumour without metastases (exclude if >5 years from diagnosis)
	Leukaemia (acute or chronic)
	Lymphoma
3	Moderate or severe liver disease
6	Metastatic solid tumour
	AIDS (not just HIV-positive)

Abbreviations: AIDS = acquired immunodeficiency syndrome; CVA = cerebrovascular accident; ECG = electrocardiogram; HIV = human immunodeficiency virus; TIA = transient ischaemic attack

* For each decade >40 years of age, a score of 1 is added to the above score

importantly, the in-patient, 30-day, and 1-year mortality rates could be traced. In-patient mortality was defined as death that occurred in the acute or convalescence hospital, and the 30-day and 1-year mortality was defined as death occurring within 30 days and 1 year of admission, respectively. Mortality records are available when death occurs in any public hospital in Hong Kong with an electronic medical record system.

The CCI was calculated from the medical records of patients admitted with hip fracture obtained from the hospital electronic medical system. The clinical history of patients was reviewed by medical officers with comorbidities recorded. The final patient outcome was not known to the medical officers unless it was recorded in the same medical records. Using the CCI, three scores can be calculated—the total Charlson comorbidity score (TCCS) is the sum of all comorbidities combined with the score derived from the patient's age; the highest Charlson comorbidity score (HCCS) is the highest single comorbidity score of a patient; and the Charlson comorbidity score (CCS) is the sum of all comorbidity scores without consideration of age. All these scores were used to analyse and correlate with different mortality rates.

The independent sample Mann-Whitney *U* test was used to test the statistical association of different comorbidity scores and mortality rates. Receiver operating characteristic (ROC) curve was used to measure the best cut-off for the score with respect to different mortality rates. Multiple variant analysis using Cox regression model was employed to measure the survival rate of hip fracture patients with respect to the cut-off scores derived from the ROC curves. Age, sex, fracture sites, and the Charlson scores were the independent variables. This regression model can be used as a means to predict patient mortality rate before surgery is performed.

Results

During the 2-year period, we performed surgery on 759 geriatric patients with acute hip fracture. Among them, 28% were male and 72% were female. The mean age was 84 years: 25% aged from 70 to 79 years, 50% aged from 80 to 89 years, and 21% aged from 90 to 99 years. The oldest patient operated on was 102 years old. Overall, 72% of patients lived at home before the admission, and the remainder in a home for the elderly. With regard to premorbid mobility, 36% of them could walk unaided and 56% could walk with some form of aid such as a stick or walking frame.

With regard to the comorbidities, the three most common diseases were hypertension, diabetes mellitus, and dementia. Mini-Mental State Examination was used to evaluate the patients' mental function and revealed that 65% were considered severely or moderately demented. Premorbid functional status was assessed by the modified Barthel index: 40% of patients were independent, 42% were mildly and moderately dependent, and 18% were severely or totally dependent in their daily function. The ASA score was also documented: 2.5% were ASA 1 (with normal health), 38% were ASA 2 (with mild systemic disease), and 58% were ASA 3 (with severe systemic disease). When the type of fracture was analysed, 49% were at the femoral neck and 49% the trochanter. The remaining 2% were subtrochanteric fractures. Internal fixation was performed in 75%. Among this group of internally fixed hip fractures, 24% of them were impacted fractured neck of femur that was fixed by screws only. The remaining 76% were fixed by either an extramedullary or intramedullary device for the pertrochanteric fractures. The remaining 25% of fractures were displaced fractured neck of femur, managed by hemiarthroplasty. Postoperatively, 72% of patients did not require a blood transfusion. The mean preoperative waiting time was 1.44 days. The longest waiting time was 14 days due to unstable medical conditions. The mean total length of stay in both acute and convalescence hospitals was 26.6 days.

The statistical analysis of the difference in mortality rates compared with the difference scores is summarised in Table 2. Among these 759 operated patients, six died in the hospital. The in-patient mortality rate was 0.8%. Within 30 days of admission, 19 patients died. The 30-day mortality rate was 2.5%. In 1-year time, 124 patients died. The 1-year mortality rate was 16.3%. Mann-Whitney analysis showed that the in-patient mortality was significantly related to the TCCS ($P=0.031$). Regarding the 30-day mortality rate, statistical analysis showed that it was significantly related to TCCS ($P<0.001$) and CCS ($P=0.010$). Using Spearman's rank correlation coefficient, the TCCS was statistically correlated with HCCS and CCS. All three different scores derived from the CCI were significantly related to this 1-year mortality rate ($P<0.001$; Table 2).

An ROC curve analysis was used to identify the relationship between TCCS and mortality rates. Both 30-day mortality and 1-year mortality rates were analysed using MedCalc software (MedCalc Software, Ostend, Belgium). Both ROC findings were significant for 30-day and 1-year mortality (area under the curve=0.72 and 0.75 respectively, $P<0.001$). In both situations, the best cut-off value was a TCCS of ≥6 according to the Youden index method, with 30-day mortality (sensitivity 79%, specificity 59%, positive predictive value [PPV] 4.7%, and negative predictive value [NPV] 99%) and 1-year mortality (sensitivity 71%, specificity 64%, PPV 28%, and NPV 92%). Nonetheless when referring to the actual curve (Fig 1), this optimal cut-off point was

TABLE 2. Mann-Whitney *U* test for detecting statistical significance between mortality and difference scores

Mortality	Deceased vs survival: median (mean)					
	TCCS		HCCS		CCS	
In-patient	7.5 (6.8) vs 5.0 (5.4)	P=0.031	1.0 (1.0) vs 1.0 (1.0)	P=0.816	3.0 (2.2) vs 1.0 (1.5)	P=0.275
30-Day	7.0 (6.7) vs 5.0 (5.4)	P<0.001	1.0 (1.2) vs 1.0 (1.0)	P=0.158	3.0 (2.4) vs 1.0 (1.5)	P=0.010
1-Year	6.5 (6.6) vs 5.0 (5.2)	P<0.001	1.0 (1.4) vs 1.0 (0.9)	P<0.001	2.0 (2.5) vs 1.0 (1.4)	P<0.001

Abbreviations: CCS = Charlson comorbidity score (Charlson comorbidity index without age correction); HCCS = highest Charlson comorbidity score; TCCS = total Charlson comorbidity score (Charlson comorbidity index with age correction)

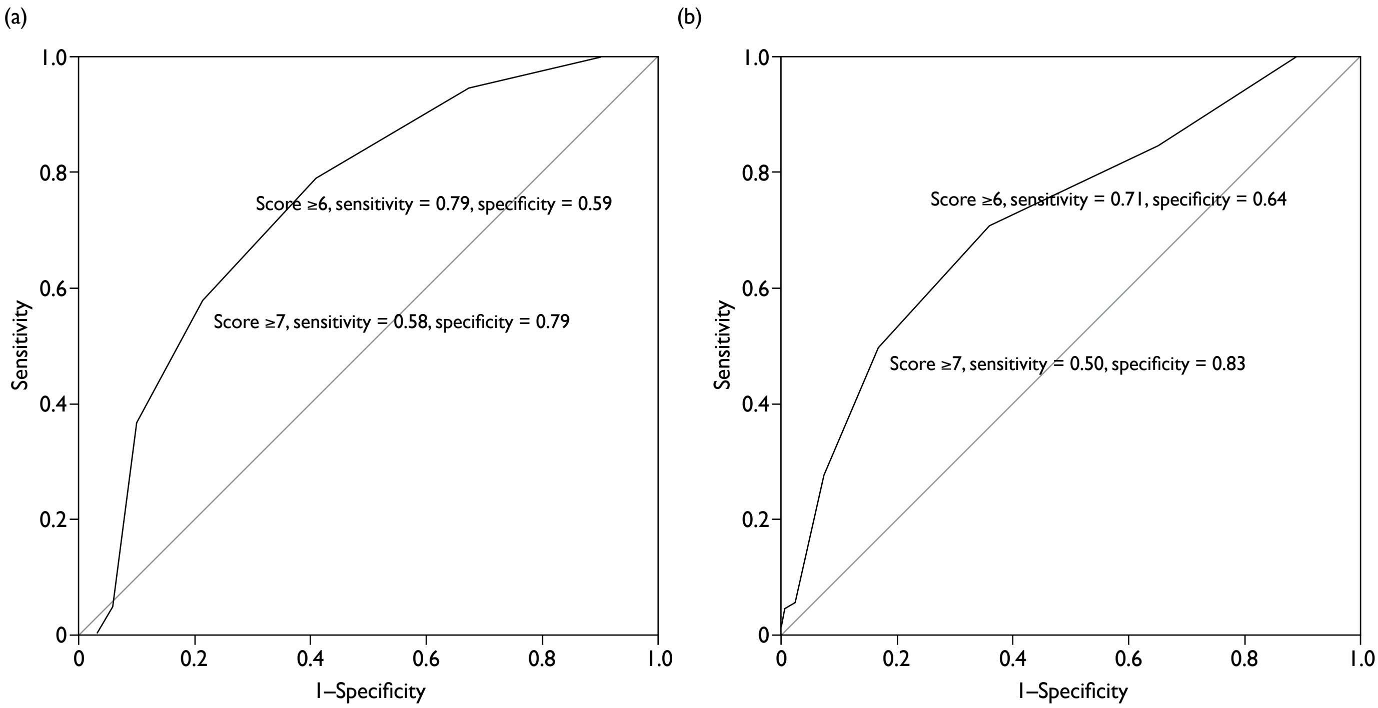

FIG 1. ROC curve for TCCS with respect to (a) 30-day and (b) 1-year mortality
Diagonal segments were produced by ties
Abbreviations: ROC = receiving operating characteristic; TCCS = total Charlson comorbidity score (Charlson Comorbidity Index with age correction)

not well-defined versus using the adjacent higher cut-off value of TCCS of ≥7.

If a TCCS cut-off value of ≥7 was used, the respective value of sensitivity, specificity, PPV, and NPV was 58%, 79%, 6.5%, and 99% for 30-day mortality, and 50%, 83%, 37%, and 90% for 1-year mortality. In a clinical situation, better specificity is preferred for predicting mortality. Thus we elected to use a 3-tier stratification of patients based on their TCCS in the regression analysis—low-risk group: TCCS 0-5, borderline group: TCCS 6-7, high-risk group: TCCS ≥8. These values are shown in Table 3.

Cox regression model was used to demonstrate the relationship between mortality rates by using the TCCS as the predictor (Fig 2). Using a score of ≤5 (low-risk group) as baseline, when score was equal to 6 or 7 (borderline group), the 30-day and 1-year mortality hazard ratio (HR) was 3.41 (95% confidence interval [CI], 0.88-13.19; P=0.075) and 2.66 (95% CI, 1.71-4.10; P<0.001), respectively. If the score was ≥8 (high-risk group), the 30-day mortality and 1-year mortality HR was 7.93 (95% CI, 1.93-32.54; P=0.004) and 5.08 (95% CI, 3.06-8.42; P<0.001), respectively.

The logistic regression model revealed that the 30-day mortality rate correlated with the TCCS in a good exponential relationship (Fig 3a). If the graph was analysed in more detail, it would show that operating on the hip fractures was generally safe. Even when the TCCS reached 9 points, the 30-day mortality rate remained <5%.

TABLE 3. TCCS correlation with 30-day and 1-year mortality

TCCS cut-off	Sensitivity (%)	Specificity (%)	Positive predictive value (%)	Negative predictive value (%)
30-Day mortality				
≥4	100.0	9.3	2.8	100.0
≥5	94.7	32.4	3.5	99.6
≥6	79.0	59.2	4.7	99.1
≥7	57.9	78.7	6.5	98.6
≥8	36.8	90.0	8.6	98.2
≥9	5.3	94.1	2.2	97.5
1-Year mortality				
≥4	100.0	10.9	18.0	100.0
≥5	84.7	35.0	20.3	92.1
≥6	71.0	63.9	27.8	91.9
≥7	50.0	83.2	36.7	89.5
≥8	27.4	92.6	42.0	86.7
≥9	13.7	95.6	37.8	85.0

Abbreviation: TCCS = total Charlson comorbidity score (Charlson Comorbidity Index with age correction)

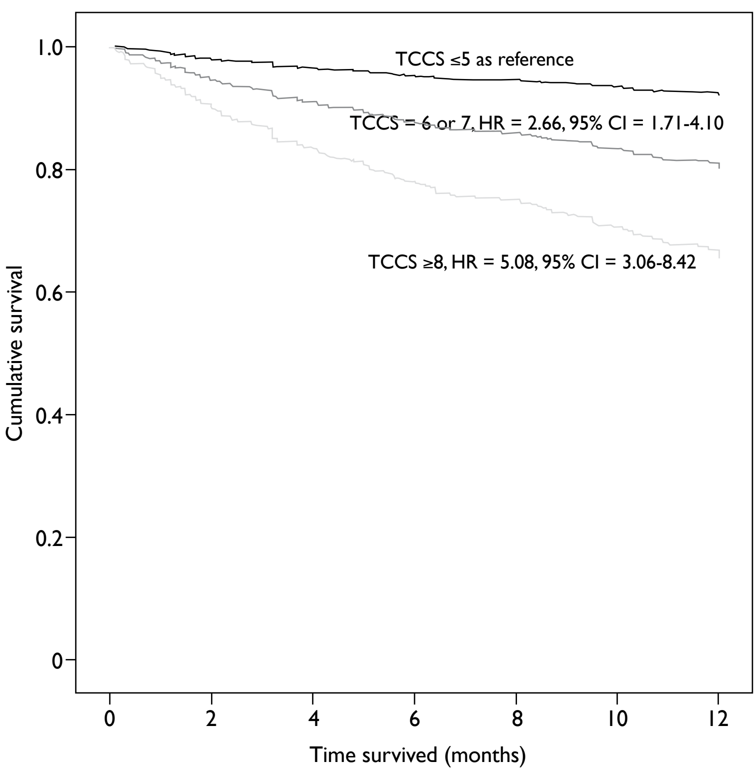

FIG 2. Cox regression model demonstrating the relationship between mortality rate and the total Charlson comorbidity score

Abbreviations: CI = confidence interval; HR = hazard ratio; TCCS = total Charlson comorbidity score

The 1-year mortality rate showed a different correlation with TCCS. The curve became more linear in shape (Fig 3b). When TCCS was <3, 1-year morality rate remained <5%. When the TCCS was >5, mortality rate rose almost linearly with the TCCS. When the TCCS was ≤10, 1-year mortality rate was approximately 50%. The increase in mortality rate appeared to plateau at TCCS of >15, where it reached 88%. An overview of our hip fracture patients reveals that there was a reasonable 1-year survival with only 10% 1-year mortality rate after hip fracture surgery if the TCCS was <5.

Discussion

In the last two decades, there has been an increasing attention on geriatric fragility fractures with a special focus on hip fractures.[6] Many parameters are significant predictors of associated clinical outcome and mortality. These include type of injury and surgery,[7] postoperative delirium,[8] timing of rehabilitation,[9] and surgical technique.[10,11] In addition, many other preoperative indicators have been found to affect postoperative mortality. The most commonly identified factors include advanced age,[16-18] male gender,[16,18,19] poor premorbid functional capability,[18,20] and presence of multiple comorbidities.[21,22]

The CCI is a system that allows classification of severity and uses recorded secondary diagnoses to assign a weight to morbidity, thereby generating the patient's risk of death.[23] This score can be combined with age to form a single index. This is particularly useful in our geriatric hip fracture patient group because our patients' age ranged from 65 to 102 years, which is a major factor in their mortality rates.

We have shown that the TCCS correlates well with both short-term and long-term mortality. The TCCS includes all the comorbidities and the age of the patient and reflects the general health of the patient on admission to hospital. Thus the poorer the general health is, the higher the short-term mortality rate will be. As most of these patients require surgery to either fix or replace the fractured hip, there is additional stress on their physiologically compromised body. Although many of the common comorbidities of geriatric hip fracture patients are minor problems, such as diabetes, hypertension, or previous cerebrovascular accident, these problems are nonetheless chronic diseases that lead to gradual multi-organ dysfunction and deterioration. The most commonly affected organs are the lungs, heart, general vascular system, kidneys, and brain. Surgery poses a major stress challenge to these diseased organs and can result in a rapid decline in general health. Therefore the severity of a patient's comorbidities has a significant prognostic implication for short-term mortality post-surgery. This explains why the TCCS correlates significantly

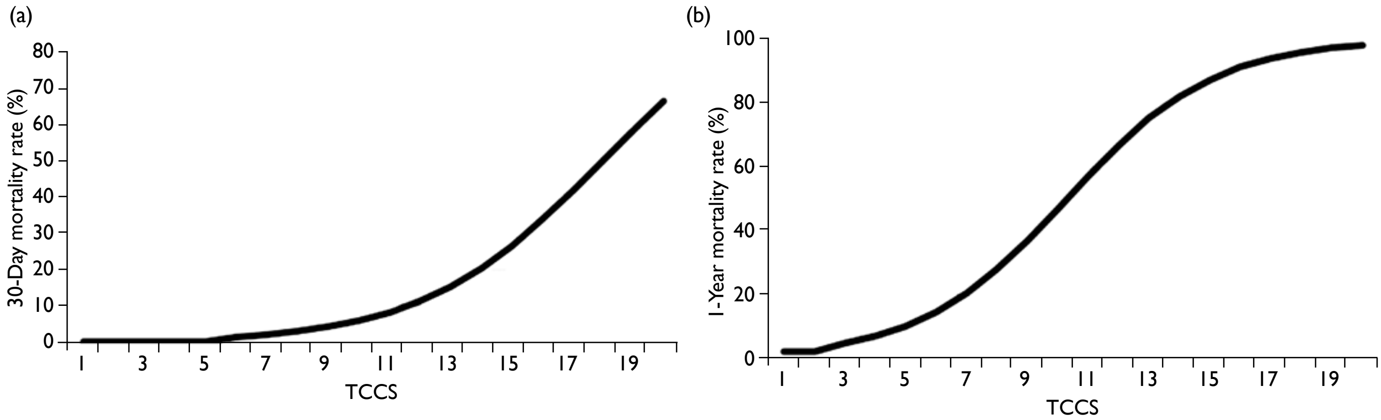

FIG 3. Logistic regression model demonstrating the relationship between (a) 30-day and (b) 1-year mortality rate and total Charlson comorbidity score (TCCS)

with the in-patient and 30-day mortality rates.

Using the logistic regression graph correlating the TCCS and 30-day mortality rate, different TCCSs correspond to an estimated 30-day mortality rate. This is valuable information when frontline staff are required to explain the risks to the newly admitted patient and their family. Many patients and their family are concerned about the impending need for surgery, believing that surgery will lead to death of their loved one who already has multiple existing comorbidities. With the information available, we can reassure the patient about their low mortality risk, despite these multiple comorbidities. Informed discussion between the patient, their family, and the surgeon can allay fears about surgery and allow extra effort and care during the postoperative period. A more experienced surgeon and staff should be involved in care to minimise surgical trauma and the possibility of surgical complications. Geriatricians and anaesthetists should be informed about the higher incidence of major life-threatening conditions during the pre-, peri-, and post-operative period. This allows better utilisation and coordination of limited medical and human resources such as intensive care unit beds, sophisticated preoperative and postoperative monitoring machines, and specialist nursing care.

Analysis of the 1-year mortality rate revealed a statistically significant correlation with all scores, similar to another study.[24] This is to be expected as the 1-year mortality relates more to general physical health and age, and not the hip fracture. The CCI independently predicts both short- and long-term mortality in acutely ill hospitalised elderly adults.[25] In our series, the 1-year mortality rate was 16.3%, slightly lower than some studies[17] but not uncommon.[24] This may be partly due to the general health status of our population and may be partly due to differences in the medical system.

Information about short- and long-term mortality can help reassure the patient and their family and allay their fears about surgery in the presence of other comorbidities. It can alleviate some of the stress associated with uncertainty.

This study is not without limitations. There is a possible discrepancy between the actual number of deaths because a small number may have occurred outside of the public hospital system. As a retrospective study, we were not able to control the confounding factors that could influence the results. Although age, sex, and fracture sites were accounted in the regression model, other factors such as smoking, medications, fracture sites, surgeon experience, and surgical procedure were not included in the analysis. Possible errors in coding and rating of CCI also exist. There might also have bias in data collection for the comorbidity index if patient mortality was known during the data collection process. Nonetheless based on our results in this retrospective cohort, a prospective study should be conducted to further analyse the relationship between comorbidity and mortality of the geriatric patients with hip fracture.

Furthermore, non-operated hip fracture patients were not included in this study. During the study period, 15 hip fracture patients were treated conservatively. The most common reasons for non-operative treatment were being unfit for surgery or refusal of surgery by family. The 30-day mortality rate was 13.3%. The 1-year mortality rate was 20%. Both the short-term and long-term mortality rates of these non-operated patients were generally higher than that of operated patients. However, since the number of deaths was small, a statistical comparison was not performed. Interpretation of the data should also be cautious because non-operated patients are usually very fragile with pre-existing life-threatening medical conditions. These patients may have had a very high short-term mortality rate if surgery were performed that would have influenced the final statistical analysis. Nevertheless the small proportion of non-operated hip fracture patients would not have been expected to have a large effect on overall results.

Conclusion

In this retrospective study of the short- and long-term mortality rates of geriatric patients undergoing surgery for hip fracture, scores derived from the CCI correlated well with mortality rates. Use of CCI before surgery to assess the patients' general health and operative risks can aid communication between the patient and doctors, and assist in deciding the best treatment option.

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