Geriatric Orthopaedic Surgery & Rehabilitation
2017, Vol. 8(1) 49-53

DOI: 10.1177/2151458516687810
journals.sagepub.com/home/gos
SAGE

Seasonal Variation in Hip Fracture Mortality

Dennis K. H. Yee, MBBS, FRCS, FHKAM[1], Christian Fang, MBBS, FRCS, FHKAM[2], T. W. Lau, MBBS, FRCS, FHKAM[1], Terence Pun, MBBS, FRCS, FHKAM[1], T. M. Wong, MBBS, FRCS, FHKAM[2], and Frankie Leung, MBBS, FRCS, FHKAM[2]

Abstract

Objectives: This study aims to identify if wintertime surgery increases the mortality of the patients after hip fracture operations. **Design:** Retrospective observational cohort study. **Setting:** The data for this citywide retrospective observational cohort study came from Clinical Data Analysis Reporting System. **Patient:** This study included 35 409 patients with hip fracture operations from July 2005 to December 2013. **Main Outcome Measures:** Cox regression hazard model was used to estimate the independent effect of operation being performed in winter on the hazard of mortality. The hazard model included covariates found to be independent predictors of mortality: age, sex, surgical delay, and Charlson Comorbidity Index (CCI). **Results:** There was a seasonal variation with more hip fracture operations happening in the winter months. The 1-month, 6-month, 1-year, and 5-year mortality were 3%, 11%, 17%, and 47%, respectively. Operation performed in winter was associated with a higher hazard of mortality (hazard ratio [HR] 1.040; 95% confidence interval: 1.010-1.072; $P = .009$). The HR was greater with male sex (HR 1.786; $P = .000$), advanced age ($\geq$85 years old: HR 2.819; $P = .000$), the longer surgical delay (HR 1.018; $P = .000$), and higher CCI (severe CCI group: HR 2.963; $P = .000$). **Conclusion:** Wintertime hip fracture surgery was associated with an increased hazard of mortality after adjusting for other known risk factors affecting mortality post hip fracture operations.

Keywords

trauma surgery, geriatric trauma, fragility fractures, osteoporosis, anesthesia

Introduction

Hip fracture posed a major challenge to the health-care system, with the 1-year mortality of hip fracture reported as being approximately 20%.[1] The incidence of hip fracture has increased throughout the world over the last 40 years.[2] Multiple studies demonstrated a seasonal variation with an increased incidence of hip fracture in winter.[2,3] A study performed in the authors' own institution in 1996 showed there were 36% more fractures in the 6 colder months from November to April than the rest of the year.[3]

Hip fractures, most of which are related to osteoporosis, are associated with significant morbidity and mortality.[4,5] Risk factors for mortality after hip fracture surgery had been linked to multiple factors, including the presence of comorbidity, age, and gender.[5,6] It is known that many cardiopulmonary diseases also demonstrate seasonal variation in mortality. Boulay et al showed that chronic heart failure deaths peaked in winter (December-January), and the distribution of monthly deaths differed by nearly 35%.[7] Sheth's study showed acute myocardial infarction deaths were highest in January and lowest in September. The seasonal mortality variation of stroke increased with age, from 11.6% for 65 to 74 years to 19.3% for >85 years.[8] As a result, we hypothesize that the mortality of hip fracture has seasonal variability.

The purpose of this study was to determine if wintertime surgery was an independent risk factor for a higher mortality among patients after hip fracture operations.

Method

The data for this citywide retrospective observational cohort study came from Clinical Data Analysis Reporting System (CDARS), which is the database from The Hong Kong Hospital

[1] Queen Mary Hospital, Pok Fu Lam, Hong Kong
[2] The University of Hong Kong, Pok Fu Lam, Hong Kong

Received August 31, 2016. Revised October 17, 2016. Accepted November 6, 2016.

Corresponding Author:
Dennis K. H. Yee, Queen Mary Hospital, 5/F, Professorial Block, 102 Pokfulam Road, High West, Hong Kong.
Email: yeedns@ortho.hku.hk

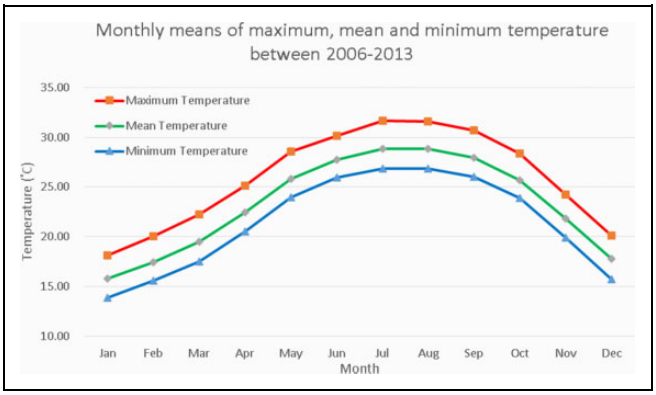

Figure 1. Monthly means of maximum, mean, and minimum temperature between 2006 and 2013.

Authority. The Hong Kong Hospital Authority is a public health-care institution that provides medical service to the majority of patient loads in Hong Kong. According to government data, it accounts for 95.6% of bed-day utilization in the territory for patients aged older than 65 years.[9] Since 1999, data on hospitalization, demographics, diagnosis, surgical procedures, and outcomes were all computerized according to the *International Classification of Disease, Ninth Revision, Clinical Modification* (*ICD-9-CM*) and recorded on CDARS.[10]

Patients undergoing surgical treatment for hip fractures from July 2005 to December 2013 were searched using *ICD* code 820 using CDARS. The CDARS reported on patient characteristics including demographics, preoperative comorbidities, surgical delay, and survival status. The demographic data included age and sex. Comorbidities were grouped and presented as Charlson Comorbidity Index (CCI).[11] Patients were divided into 4 groups: none, with CCI = 0; mild, with CCI scores of 1 to 2; moderate, with CCI scores of 3 to 4; and severe, with CCI scores ≥5.

Regarding the effect of season, Hong Kong has a subtropical climate tending toward temperate for nearly half of the year, with 4 different seasons present (spring: March-April; summer: May-August; autumn: September-November; winter: December-February). The monthly means of maximum, mean, and minimum temperature between 2006 and 2013 are depicted in Figure 1. The number of hip fracture admissions per month was calculated for winter months and nonwinter months.

Cox regression hazard model was used to estimate the independent effect of operation being performed in winter on the hazard of mortality. Hazard ratios (HRs) with the corresponding 95% confidence interval were reported. The hazard model included covariate found to be independent predictors of mortality: age, sex, surgical delay, and CCI. For CCI, we used the lower comorbidity (none) as the reference group. Based on age, the patients were divided into 3 groups: 65 to 74 years old, 75 to 84 years old, and ≥85 years old, with the first group used as the reference group. Surgical delay was defined as the difference in days between the admission date and the operation date. The level of significance was set at $P < .05$. Statistical analysis and data storage were performed using SPSS statistical program software (version 22; SPSS, Chicago, Illinois) and Microsoft Excel 2013 (Redmond, Washington).

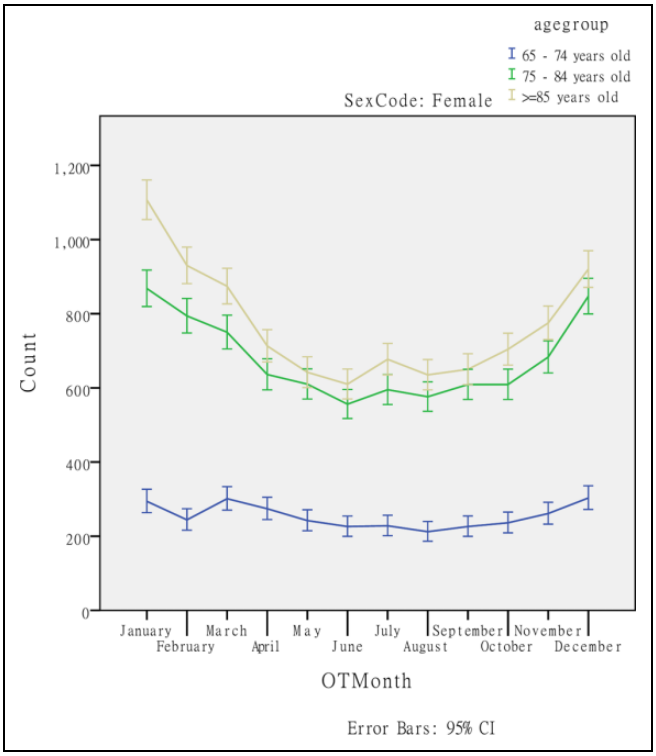

Figure 2. Average hip fracture admission number per month (female).

Result

Over the period from July 2005 to December 2013, we identified 41 667 hip fracture operations using *ICD* code 820 with CDARS. In all, 6258 hip fractures were excluded from the study: 1878 hip fractures were not put as the principle diagnosis for the admission and were excluded; 204 hip fractures were excluded because they were not acute hip fractures; 216 patients were pathological fractures, and they were excluded; 29 patients had bilateral simultaneous hip fractures and were excluded; 1555 patients who had sequential hip fractures within the study period had the first hip excluded; 247 hip fractures required revision operations and were excluded; 2129 hip fractures were younger than 65 years and were excluded. This left a cohort of 35 409 patients with hip fracture operation performed and they were the participants of this study.

The mean age was 82.7 (range 65-112). Study participants included 24 596 (69.5%) females and 10 813 (30.5%) males. The mean surgical delay was 3.11 days (range 0-153).

Figures 2 and 3 show the average hip fracture admission number per month for male and female patients. There was a seasonal variation with more hip fractures operations in the winter months for both genders. The seasonal variation was more markedly seen in the patients aged ≥75 years.

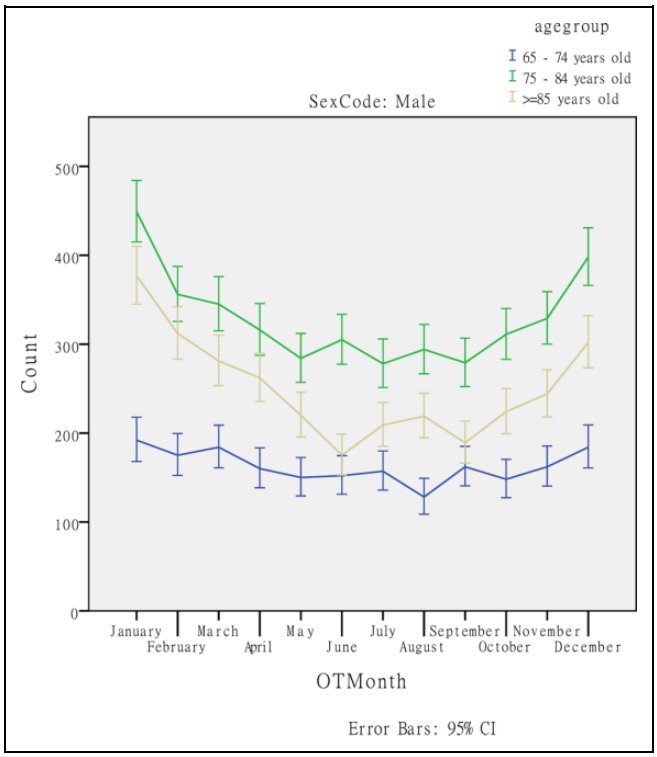

Figure 3. Average hip fracture admission number per month (male).

The patient characteristics for winter and nonwinter seasons were compared and reported in Table 1. The patients operated in winter months were slightly older and had a longer surgical delay.

The 1-month, 6-month, 1-year, 2-year, and 5-year mortality were 2.9%, 11.1%, 16.8%, 26.8%, and 47.4%, respectively. The median survival for patients operated in winter and nonwinter months were 51.4 months (95% confidence interval: 50.0-52.7) and 54.6 months (95% confidence interval: 53.5-55.7), respectively ($P = .001$). Cox proportional hazard model was used to estimate the hazard of mortality for the patients operated in winter months compared with nonwinter months. Table 2 listed the HR with 95% confidence interval of age, sex, surgical delay, the season of operation, and CCI groups. Operation performed in winter was associated with an increased risk of mortality (HR 1.040; 95% confidence interval: 1.010-1.072; $P = .009$). Male sex was associated with an almost 2-fold increased risk of mortality (HR 1.786; $P = .000$). The HR was greater with advanced age (≥85 years: HR 2.819; $P = .000$), the longer surgical delay (HR 1.018; $P = .000$), and higher CCI (HR corresponding to severe CCI group: 2.963; $P = .000$).

The HR for wintertime surgery was calculated with respect to 1-month, 6-month, 1-year, 2-year, and 5-year mortality (Table 3). It was highest at 1 month (HR 1.182; 95% confidence interval: 1.039-1.345) with a trough at 1 year (HR 1.003; 95% confidence interval: 0.949-1.060). There was a trend for an increase in HR after 1 year with the HR of 5-year mortality reaching 1.040 ($P = .018$).

Subgroup analysis was performed with reference to gender. The HR for wintertime surgery was higher for female (HR 1.057; 95% confidence interval: 1.019-1.098; $P = .003$) than male (HR 1.008; 95% confidence interval: 0.959-1.060; $P = .744$).

Table 1. Patient Characteristics for Winter and Nonwinter Seasons.

Characteristic	Winter (n = 10 883)	Nonwinter (n = 24 526)	*P* Value
Age[a] (years)	83.1 ± 7.204	82.6 ± 7.346	.000
Surgical delay[a] (days)	3.17 ± 3.569	3.08 ± 3.455	.027
Male	7508 (30.4%)	3305 (30.6%)	.646
Charlson Comorbidity Index			.080
None	2670 (24.5%)	5909 (24.1%)	
Mild	4115 (37.8%)	9027 (36.8%)	
Moderate	2240 (20.6%)	5218 (21.3%)	
Severe	1858 (17.1%)	4370 (17.8%)	
Fracture subtype			.072
Pertrochanteric	5107 (46.9%)	11 830 (48.2%)	
Transcervical	5424 (49.8%)	11 937 (48.7%)	
Unspecified site	352 (3.2%)	759 (3.1%)	

[a]The values are given as the mean and the standard deviation.

Discussion

The seasonal variation in the incidence of hip fractures with a higher incidence in winter is supported by multiple studies.[2,3] In this study, we demonstrated similar findings showing a higher incidence of hip fractures in winter especially for the older age-group. The association between wintertime surgery with mortality, however, has been controversial.

Chiu et al have shown that there was a trend of a higher mortality rate for patients admitted for hip fractures in the colder 6 months compared to the hotter 6 months.[3] However, they also showed that patients admitted during the colder 6 months were older and had a longer surgical delay, which could be the confounders for the apparently higher mortality. Crawford and Parker have investigated the seasonal variation in proximal femoral fractures and showed that the 30, 120, and 365 days mortality were higher for patients admitted in winter compared with those admitted in summer.[2] This was not adjusted for possible confounders and thus could not prove that season itself was an independent risk factor for mortality. Risk calculators had been developed to predict mortality for hip fractures and were based on age, sex, long-term care residence, and comorbidities,[5] without consideration of the season of the operation.

In this study with 36 751 patients with hip fractures, we found an association between mortality and season of the operation after adjusting for other known risk factors affecting mortality post hip fracture operations. The findings of this study are important because it is the first to show an association between wintertime hip fracture surgery and mortality.

Multiple studies conducted in different continents had demonstrated an excess of winter mortality in the general population.[12-14] In a study utilizing the New Zealand national mortality data from 1980 to 2000, the author noted the winter

Table 2. Hazard Ratio With 95% Confidence Interval of Season of the Operation, Sex, Age-Group, Charlson Comorbidity Index (CCI) Group, and Surgical Delay.

	Hazard Ratio (95% Confidence Interval)	*P* Value
Season		
Nonwinter	1	
Winter	1.040 (1.010-1.072)	.009
Sex		
Female	1	
Male	1.786 (1.734-1.839)	.000
Age-group		
65-74	1	
75-85	1.575 (1.503-1.649)	.000
≥85	2.819 (2.693-2.951)	.000
Charlson Comorbidity Index group		
None	1	
Mild	1.413 (1.357-1.472)	.000
Moderate	1.952 (1.867-2.040)	.000
Severe	2.963 (2.834-3.098)	.000
Surgical delay	1.018 (1.015-1.020)	.000

Table 3. Hazard Ratio for Wintertime Surgery Calculated With Respect to 1-Month, 6-Month, 1-Year, 2-Year, and 5-Year Mortality.

	Hazard Ratio (95% Confidence Interval)	*P* Value
1-month mortality	1.182 (1.039-1.345)	.011
6-month mortality	1.074 (1.004-1.148)	.037
1-year mortality	1.003 (0.949-1.060)	.907
2-year mortality	1.023 (0.979-1.068)	.311
5-year mortality	1.040 (1.007-1.075)	.018

mortality rate was 18% higher than that expected from the nonwinter rates.[14] After adjusting for the major covariates, the winter to nonwinter mortality rate ratio was 9% higher in females than in males. A population-based study in Britain showed a month-to-month variation in mortality, with most of the seasonal fluctuation being attributed to cold weather.[13] Female sex and a self-reported history of respiratory illness increased the vulnerability to winter deaths.

One may speculate that the excess mortality for wintertime surgery demonstrated in the current study came from the early postoperative period as a result of an overall increased mortality in winter. This may be partially true as the HR for wintertime surgery was highest for the 1-month mortality. The trough for the HR noted at the 1-year mortality may reflect that all patients were equally exposed to the excess mortality risk from winter. But we also observed a trend for an increase in the HR for wintertime surgery after 1 year, with the HR of 5-year mortality being 1.040 (95% confidence interval: 1.007-1.075). This suggests a component of excess mortality in patients undergoing wintertime hip fracture operation.

Among patients with hip fracture, the most common cause of death was circulatory diseases.[15] Many investigators had documented a seasonal variation in morbidity and mortality of respiratory and cardiovascular diseases with a peak in winter months[7]. Many postulations had been proposed. It was suggested that sympathetic nervous system plays an important role in the physiological responses to cold weather. The sympathetically mediated vasoconstriction caused an elevation of afterload. This may result in acute pulmonary edema by overloading the left ventricle.[16] Another proposed mechanism is the change in extracellular volume hemostasis with fluid retention caused by a decrease in insensitive water loss.[17]

Impaired fracture healing in winter with an increased risk of conversion to hip arthroplasty after osteosynthesis of femoral neck fracture had been demonstrated in a study by Sebestyen et al.[18] This raised the possibility of an association between seasonal changes in vitamin D levels with impaired fracture healing. Although our study was not intended to investigate revision hip operations, this increase in revision surgery may also contribute to an increase in mortality.

In the subgroup analysis, we noted the HR for wintertime surgery was higher for female compared with male patients. This was consistent with the reports from Britain, New Zealand, and China noting females were more susceptible to the wintertime excess mortality.[13,14,19] Although male sex was associated with an increased mortality, they showed less seasonal variation than females did. The present study showed that wintertime hip fracture surgery was associated with an increased hazard of mortality; in other words, these group of patients were more susceptible to the effect of winter excess mortality. However, we cannot conclude from this study whether it is the injury causing the fracture itself, the effect of the operation or the resultant disability from the injury that cause the increased susceptibility. It may be due to a decreased physiological adaptation to changes in temperature. Literature had shown that advanced age, low education level, and blue-collar occupation class suffered more from decreased temperature-related mortality risk.[20]

This large retrospective cohort study has several limitations. First, we did not include some of the factors that may affect the mortality such as long-term care residents at the time of fracture, cognitive status,[21] and prefracture functional status.[6] Second, this is a retrospective study. The clinical information was obtained from the electronic database instead of a predefined form designed for the study. We are unable to analyze if the cause of death for those who died in winter compared to the nonwinter season was different.

In conclusion, the present study confirmed an increased hazard of mortality for wintertime hip fracture surgery. Increased resources and awareness of the treating physician should be made available to care for the patients with hip fracture.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Dr Fang, Dr Lau, Dr Wong, and Dr Leung have previously received research and conference support from the AO Foundation. Dr Leung has previously been the Speaker for DePuy Synthes on matters unrelated to this study.

References

1. Schneider EL, Guralnik JM. The aging of America. Impact on health care costs. *JAMA*. 1990;263(17):2335-2340.
2. Crawford JR, Parker MJ. Seasonal variation of proximal femoral fractures in the United Kingdom. *Injury*. 2003;34(3):223-225.
3. Chiu KY, Ng TP, Chow SP. Seasonal variation of fractures of the hip in elderly persons. *Injury*. 1996;27(5):333-336.
4. Zuckerman JD. Hip fracture. *N Engl J Med*. 1996;334(23): 1519-1525.
5. Jiang HX, Majumdar SR, Dick DA, et al. Development and initial validation of a risk score for predicting in-hospital and 1-year mortality in patients with hip fractures. *J Bone Miner Res*. 2005;20(3):494-500.
6. Pugely AJ, Martin CT, Gao Y, Klocke NF, Callaghan JJ, Marsh JL. A risk calculator for short-term morbidity and mortality after hip fracture surgery. *J Orthop Trauma*. 2014;28(2):63-69.
7. Boulay F, Berthier F, Sisteron O, Gendreike Y, Gibelin P. Seasonal variation in chronic heart failure hospitalizations and mortality in France. *Circulation*. 1999;100(3):280-286.
8. Sheth T, Nair C, Muller J, Yusuf S. Increased winter mortality from acute myocardial infarction and stroke: the effect of age. *J Am Coll Cardiol*. 1999;33(7):1916-1919.
9. Food and Health Bureau HKSARG. *Your Health Your Life. Healthcare Reform Consultation Document*. Food and Health Bureau; 2008. Web site. http://www.fhb.gov.hk/beStrong/files/consultation/exsummary_eng.pdf
10. Cheuk BL, Cheung GC, Cheng SW. Epidemiology of venous thromboembolism in a Chinese population. *Br J Surg*. 2004; 91(4):424-428.
11. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987; 40(5):373-383.
12. Healy JD. Excess winter mortality in Europe: a cross country analysis identifying key risk factors. *J Epidemiol Community Health*. 2003;57(10):784-789.
13. Wilkinson P, Pattenden S, Armstrong B, et al. Vulnerability to winter mortality in elderly people in Britain: population based study. *BMJ*. 2004;329(7467):647.
14. Davie GS, Baker MG, Hales S, Carlin JB. Trends and determinants of excess winter mortality in New Zealand: 1980 to 2000. *BMC Public Health*. 2007;7:263.
15. Panula J, Pihlajamaki H, Mattila VM, et al. Mortality and cause of death in hip fracture patients aged 65 or older: a population-based study. *BMC Musculoskelet Disord*. 2011;12:105.
16. Izzo JL Jr, Larrabee PS, Sander E, Lillis LM. Hemodynamics of seasonal adaptation. *Am J Hypertens*. 1990;3(5 Pt 1): 405-407.
17. Argiles A, Mourad G, Mion C. Seasonal changes in blood pressure in patients with end-stage renal disease treated with hemodialysis. *N Engl J Med*. 1998;339(19):1364-1370.
18. Sebestyen A, Mester S, Voko Z, et al. Wintertime surgery increases the risk of conversion to hip arthroplasty after internal fixation of femoral neck fracture. *Osteoporos Int*. 2015;26(3): 1109-1117.
19. Ou CQ, Song YF, Yang J, et al. Excess winter mortality and cold temperatures in a subtropical city, Guangzhou, China. *PLoS One*. 2013;8(10):e77150.
20. Yang J, Ou CQ, Ding Y, Zhou YX, Chen PY. Daily temperature and mortality: a study of distributed lag non-linear effect and effect modification in Guangzhou. *Environ Health*. 2012; 11:63.
21. Radcliff TA, Henderson WG, Stoner TJ, Khuri SF, Dohm M, Hutt E. Patient risk factors, operative care, and outcomes among older community-dwelling male veterans with hip fracture. *J Bone Joint Surg Am*. 2008;90(1):34-42.