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ORIGINAL PAPER

Hip fracture time-to-surgery and mortality revisited: mitigating comorbidity confounding by effect of holidays on surgical timing

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Abstract

Purpose The association between delayed hip fracture surgery and mortality remains elusive because of strong confounding by comorbidity factors. We designed a study to investigate the effect of small delays in surgery due to holidays.

Methods Consecutive hip fractures operated in a high-income, publicly funded healthcare system between 2006 and 2013 were analysed. Age <65 years, pathological fractures, history of previous hip operation and time to surgery >seven days were excluded. Patients were grouped according to number of holidays following admission (HFA) as a surrogate for time to surgery, with difference in mean time to surgery tested for statistical significance and baseline characteristics including age, sex, Charlson comorbidity index (CCI) and fracture and operation types assessed. Survival up to two years was compared.

Results Thirty-one thousand five hundred and ninety-two patients were included. Patient groups with zero, one, two or three HFA had significantly different mean time to operation of 2.25, 2.47, 2.67 and 2.84 days, respectively (Kruskal–Wallis test $p < 0.0001$), but baseline characteristics were similar. There was no difference in mortality at six months ($p = 0.431$) and two years ($p = 0.785$). Cox's regression analysis identified age, gender and CCI as independent predictors of mortality but not HFA, and the adjusted hazards ratio for each HFA increment was 1.026 [95% confidence interval (CI) 0.999–1.025; $p = 0.056$] which was not statistically significant.

Conclusions We observed no increase in mortality rate in patients having small delays in surgery because of holidays.

Keywords Hip fracture · Mortality · Time to surgery · Surgical timing

Introduction

Hip fracture is a major cause of morbidity and mortality in the elderly. Despite a decreasing incidence in high-income countries [1], the economic burden of fragility fractures is expected to increase by 25% over the next 12 years [2]. In our region, one year mortality stands at 17% [3], with excess mortality persisting over time [4]. Advanced age, male gender, poor mental state, and high Charlson comorbidity index (CCI) [5] are established mortality risk factors [6, 7] to which multidisciplinary and orthogeriatric input have been advocated to improve outcomes [8, 9]. The association between surgery delay

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and mortality remains elusive because of strong confounding by comorbidity factors [10]. Rodriguez-Fernandez [11] reported no difference in mortality, but other studies have shown more favourable survival among patients operated within two days [12–14], <12 hours [15, 16], with a pilot trial underway [17] investigating whether aggressive surgery within six hours further improves survival. However, adjustment for comorbidity is either lacking or likely incomplete given the vast number of medical conditions at play at different levels of severity. This has practical implications because uncertainty over the surgical timing/mortality association leads to either unwarranted surgical prioritisation or the underuse of expedited surgery with survival benefit [18]. As it would be ethically insurmountable to conduct a randomised controlled trial intentionally postponing surgery for otherwise fit patients, we devised a way to study this association using different number of holidays following admission (HFA) as a surrogate for time to surgery. Instead of directly comparing patient groups with different pre-operative length of stay, our study design has the advantage of evaluating patient groups with similar comorbidities—an assumption that we subject to statistical significance testing.

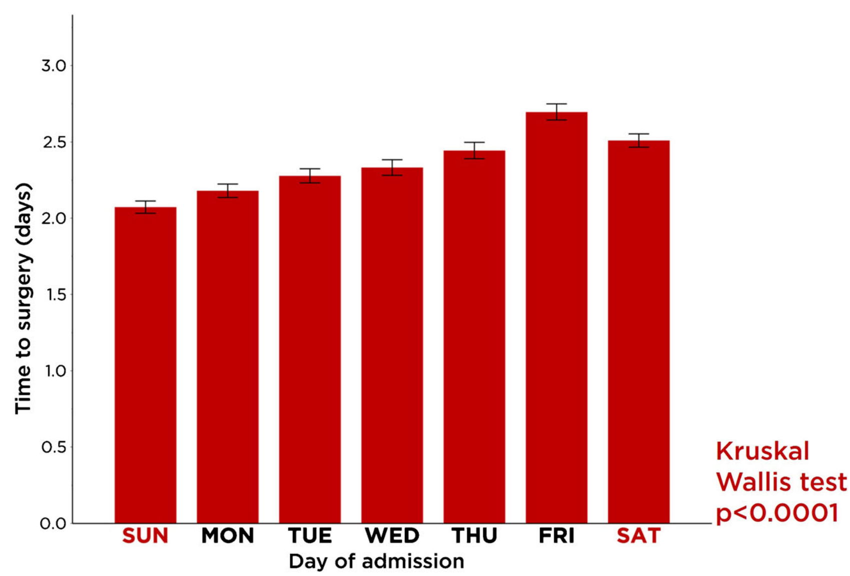
Materials and methods

All consecutive hip fractures coded under International Classification of Diseases 9th revision (ICD-9) 820 operated in publicly funded hospitals in a high-income territory (GDP per capita US$32,860 [19]) between 2006 and 2013 were retrospectively identified through a centralised, territory wide, public hospital Clinical Data Analysis and Reporting System [20]. Holiday is defined as Saturday, Sunday or statutory holidays. Exclusion criteria involves age <65 at the time of fracture, pathological or stress fractures as coded in ICD, prior hip operations on the ipsilateral femur and outliers defined as patients receiving operation >seven days after admission. Mortality data was compiled from the death registry and most recent clinical attendance to document survival status. Comorbidities were recoded into the CCI from ICD codes via a validated method [21]. Data analysis was performed by IBM SPSS Statistics Version 23. Baseline characteristics of age, CCI, gender, fracture type and operation performed were compared using analysis of variance (ANOVA) (for the first two parameters) and chi-squared test (for the remainder). Kruskal–Wallis test was used to detect difference in time to surgery among patients with different number of HFA. Chi-square test was used to identify difference in mortality at one, three, six, 12 and 24 months. Stepwise Cox regression hazard model was used to estimate the incremental effect of every HFA on mortality with age, gender and CCI together as independent covariates. Hazard ratios (HR) with the corresponding 95% confidence intervals (CI) are reported. Statistical significance was set as $p < 0.05$.

Results

Of 41,295 patients identified with the ICD-9 code 820, 31,592 fulfilled our inclusion criteria and were included in analysis. Hip fracture admissions were spread evenly across different days of the week (chi-square test $p = 0.227$). Mean time to surgery increased as the week progresses (Kruskal–Wallis test $p < 0.0001$), peaking on Friday at 2.70 days (Fig. 1). Patients with zero, one, two or three HFA had significantly different time to operation, with means of 2.25, 2.47, 2.67 and 2.84 days, respectively (Kruskal–Wallis test $p < 0.0001$) (Fig. 2). Baseline

Fig. 1 Time to surgery on different days of the week



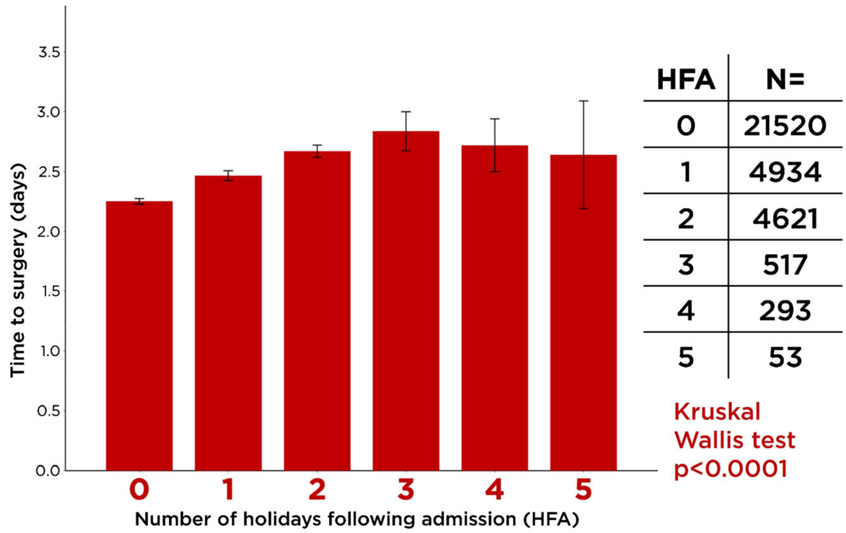


Fig. 2 Time to surgery for different holidays following admission (HFA) groups

characteristics and comorbidities were similar (Table 1). Survival analysis revealed no significant mortality difference at 180 days and two years (Pooled: $p = 0.785$ and $p = 0.431$, respectively) (Fig. 3) and with pairwise comparison of each HFA group (Table 2). Chi-square test showed no difference in mortality rate at one ($p = 0.776$), three ($p = 0.730$), and six months ($p = 0.765$), and one ($p = 0.327$), and two ($p = 0.407$) years. Cox proportional hazards model using age, gender and CCI as independent baseline covariates revealed an adjusted HR of 1.027 (95% CI 0.999–1.055) $p = 0.056$ for each increment in HFA (Table 3), which was not statistically significant.

Discussion

The association between time to surgery and mortality has been extensively studied, but direct comparison among patient groups with different times to surgery is marred by strong confounding due to comorbidities amounting to a longer pre-operative workup. To our knowledge, this is the first study in the literature to report the association between time to surgery and mortality using holidays to mitigate confounding. Large case numbers enabled sufficient powering to detect small differences in survival. Ethical implications limit studies such as this to being nonrandomised and observational in nature. Our data

Table 1 Baseline characteristics among holidays following admission (HFA) groups

Patient characteristics	0 HFA	1 HFA	2 HFA	3 HFA	*P* value	Test
No.	21,520	4934	4621	517		
Age mean (SD) in years	83.19 (7.35)	83.16 (7.36)	83.36 (7.33)	83.40 (7.32)	0.394	ANOVA
Sex (F:M)	2.31: 1	2.27: 1	2.38: 1	2.31: 1	0.644	Chi-square test
Comorbidities (CCI)					0.172	ANOVA
None (0)	5504 (25.6%)	1352 (27.4%)	1234 (26.7%)	138 (26.7%)		
Mild (1–2)	7383 (34.3%)	1700 (34.5%)	1631 (35.3%)	168 (32.5%)		
Moderate (3–4)	4570 (21.2%)	1006 (20.4%)	915 (19.8%)	112 (21.7%)		
Severe (≥5)	4063 (18.9%)	876 (17.8%)	841 (18.2%)	99 (19.2%)		
Fracture type					0.509	Chi-square test
Intracapsular	9161	2183	1952	204		
Extracapsular	12,330	2745	2665	312		
Unspecified	29	6	4	1		
Operation type					0.994	Chi-square test
Ostectomy	59	14	13	1		
Internal fixation	14,153	3222	3029	349		
Arthroplasty	7308	1698	1579	167		
Mean time to surgery	2.25	2.47	2.67	2.84	0.0001	Kruskal–Wallis

SD standard deciation,*CCI* Charlson comorbidity index, *ANOVA* analysis of variance

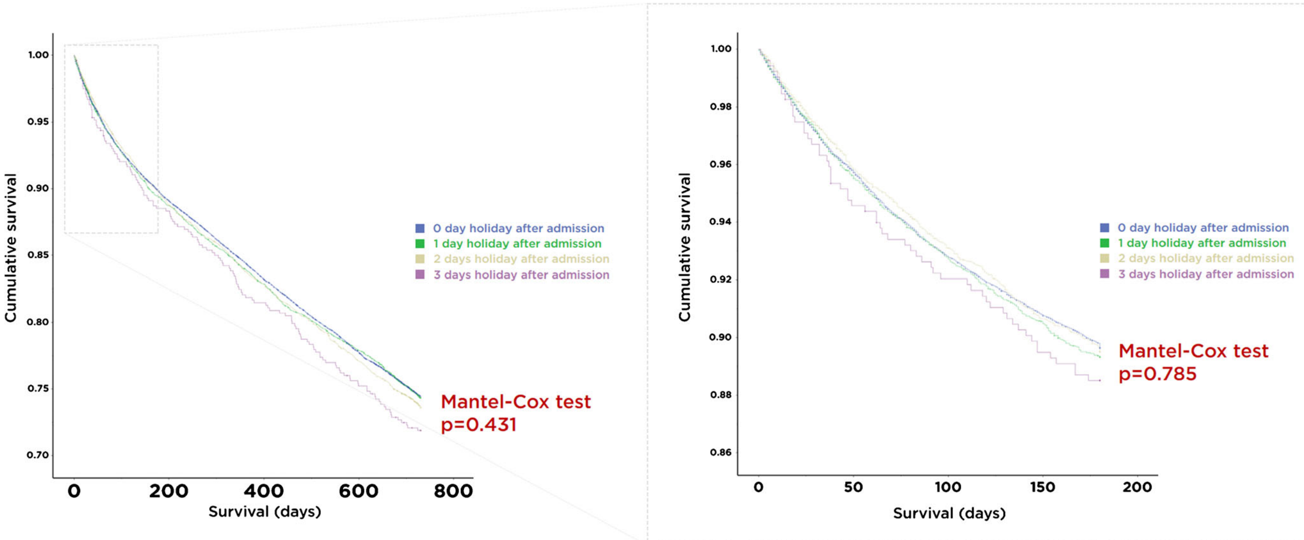


Fig. 3 Kaplan–Meier survival for different holidays following admission (HFA) groups

source (clinical data analysis and reporting system) is a validated database with a reported positive predictive value of 100% for hip fracture diagnostic code relative to radiography imaging and clinical notes [20].

The prevailing school of thought mandates that hip fracture surgery not be delayed by extensive pre-operative medical workup, with immobilisation and longer pre-operative inflammatory state among postulated causes for an apparent higher mortality rate [22]. Best-practice tariff, key performance indicators and guidelines have accordingly been established to incentivise orthopaedic units to expedite hip fracture surgery within 36-48 hours of admission. However, the exact duration of delay translating to clinical hazard is still a matter for debate. Maheshwari [16] reported an odds ratio (OR) of 1.05 for every ten hour delay on one year mortality; Neufeld [23] observed that surgery within 48 hours (compared with 36 h) did not significantly alter the likelihood of 30-day mortality, while Lizaur-Utrilla [24] reported that difference in mortality only exists when surgery was delayed for >four days. Furthermore, not all hip fracture patients may benefit from prompt surgery: De Palma [25] demonstrated that among patients with comorbidities requiring stabilisation, delayed surgery was not associated with inferior survival.

Such conflicting evidence could be explained in part by comorbidity confounding. Upon mitigation of such factors, this study detected no association between surgical timing and mortality. In light of our findings, caution must be exercised before racing patients to operating theatres under the belief that earlier surgery in itself confers survival benefit. Nevertheless, we believe that surgery should not be delayed in fit patients where resources and expertise are available for pain relief and for reducing post-operative complications, length of hospital stay and healthcare costs [11]. Implications on cost effectiveness and resource prioritisation would probably benefit from further "big data" synthesis across multiple national hip fracture registries, where association and causality could be more finely delineated and whether expedited surgery benefits certain subgroups of patients can be further studied.

Our study is limited by small difference in mean time to surgery among comparison HFA groups. This may be a result of two days being already set as one of the key performance indicators for hip fracture surgery in the region. As this is a territory-wide study, variations exist at the hospital level as to the presence of a dedicated trauma list, holiday work pattern, experience of operating surgeon, level of orthogeriatric care, staffing and specialist intensities.

Table 2 Pairwise comparison of 2-year mortality amongst holidays following admission (HFA) groups

	0 HFA	1 HFA	2 HFA	3 HFA
0 HFA	–	$p = 0.839$	$p = 0.281$	$p = 0.183$
1 HFA	$p = 0.839$	–	$p = 0.487$	$p = 0.229$
2 HFA	$p = 0.281$	$p = 0.487$	–	$p = 0.378$
3 HFA	$p = 0.183$	$p = 0.229$	$p = 0.378$	–
Pooled		$p = 0.431$		

Table 3 Multivariable analysis of 2-year mortality

	Adjusted hazard ratio (95% CI)	*P* value
Age	1.061 (1.056–1.064)	<0.0005
CCI grade	1.551 (1.518–1.585)	<0.0005
Gender	2.092 (1.999–2.188)	<0.0005
Holidays following admission	1.027 (0.999–1.055)	0.056

CCI Charlson comorbidity index

In conclusion, our study of a large population failed to detect a significant increase in mortality among hip fracture patients who had to endure small delays to surgery before long holidays. Having said that, we advocate surgery be performed at the earliest possible setting, not because it equates better survival, which was not observed in this study, but for the patient's humanitarian relief and as their clinical champion.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This article does not contain any studies with human participants or animals performed by any of the authors.

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