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ORIGINAL PAPER

Predictors of early mortality after hip fracture surgery

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Abstract
Purpose The aim of this study was to examine causes and potential risk factors for 30-day mortality after hip fracture surgery (HFS) at a high-volume tertiary-care hospital.
Methods We retrospectively reviewed 467 patients who underwent HFS at our institution. Multivariate analysis was undertaken to identify potential predictors of early mortality.
Results The 30-day mortality rate was 7.5 % (35/467). The most common causes of death were pneumonia (37.1 %, 13/35), acute coronary syndrome (31.4 %, 11/35) and sepsis (14.3 %, 5/35). Surgery after 48 hours of admission had a significantly higher 30-day mortality rate (11 % versus 4 %, $p=0.006$). There was a significant difference in age ($p=0.034$), admission source ($p<0.001$), preoperative haemoglobin ($p<0.001$), walking ability ($p=0.004$), number of comorbidities ($p=0.004$) and pre-existing dementia ($p=0.01$), cardiac disease ($p<0.001$), chronic obstructive pulmonary disorder (COPD) ($p=0.036$) and renal failure ($p=0.007$) between the 30-day mortality group and the rest of the cohort. Surgical delay greater than 48 hours, admission source and pre-existing cardiac disease were identified as the strongest predictors of 30-day mortality.
Conclusion Surgical delay is an important but avoidable determinant of early mortality after HFS. Respiratory and cardiac function needs to be optimised postoperatively with early intervention in patients with signs of cardiovascular compromise or infection.

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Keywords Trauma · Hip fracture · Neck of femur · Co-morbidities · 30-day mortality · Risk factors

Introduction

Despite improvements in perioperative care, the mortality rate after hip fracture surgery (HFS) remains high, with 30-day mortality reported to be over 13 % [1]. This excess mortality rate is highest in the immediate period following the hip-fracture event and appears to decrease with time thereafter [2–4]. One-year mortality is estimated to be between 22 % and 33 % [5, 6]. Researchers aimed to predict the risk of death in HFS patients and suggest that the excess mortality is due to a combination of direct consequences of the hip fracture and the effect of pre-existing medical conditions [1, 7–9].

The 30-day mortality rate is considered to be a quality indicator for hospital care of HFS patients [10]. It is generally agreed that age, gender and pre-existing comorbidities are non-modifiable factors contributing to early death of such patients. However, there is a paucity of information on modifiable risk factors Identifying these factors will allow stratification of high-risk patients with a view to developing focused strategies aimed at reducing risk and improving outcomes. Furthermore, decision makers could then justify the allocation of medical resources to those with the greatest medical need.

We have previously shown that readmission after HFS is associated with a higher one-year mortality rate [11]. Patients who die soon after surgery are unlikely to affect early readmission rates, and it could therefore be argued that institutions with high early mortality rates could potentially pass quality standards designed to look at readmission rate alone. This study was therefore undertaken to assess the 30-day mortality rate after HFS at our institution. We also aimed to assess the causes and risk factors of early mortality and

determine whether delay in surgery was associated with higher mortality after HFS.

Methods

Data on all patients admitted or transferred to our institution with a primary diagnosis of hip fracture is prospectively entered into a National Hip Fracture Database (NHFD) by trained orthopaedic coordinators. We used this database to identify consecutive, unselected patients admitted with a hip fracture between 1 April 2009 and 31 March 2010. All entries were cross referenced with patient records, which were reviewed for an additional 30 days following surgery to account for any deaths within this period. Primary and secondary causes of death were noted directly from death certificates and coroners' records. We identified 498 consecutive patients diagnosed with a hip fracture during the study period. We excluded two incorrect entries, six duplicate entries, six patients who died preoperatively and 17 patients who had incomplete data. A total of 467 patients were therefore included in the study for further analysis. All patients were treated according to standards defined in a locally developed hip-fracture pathway. We retrospectively reviewed all of their records to collect data on age, gender, American Society of Anaesthesiologists (ASA) grading, source of admission and pre-injury walking ability. We grouped the source of admission into five categories: patients living independently in their own homes or sheltered accommodation; those who were care dependant in nursing or residential homes; those who had an injury resulting in hip fracture while inpatients in hospital; those transferred from another tertiary care facility; those with admission source unknown. The total number of comorbidities in each patient, prevalence of individual comorbidities at admission, mechanism of injury, any concomitant injuries and the admitting specialty was noted for all patients. Patient comorbidity data was identified using the *International Classification of Diseases*, 10th revision (ICD-10) codes [12]. Mechanisms of injury were categorised into a mechanical fall (resulting from tripping due to an environmental hazard); a fall due to nonmechanical reasons, such as seizures or arrhythmias; mechanical causes other than falls, including pathological fractures; road traffic accidents and high-energy trauma; mechanism of injury unknown. Concomitant injuries at the time of fracture were divided into associated lower-limb, upper-limb and head injuries.

Surgery-related data collected included the type of implant used, preoperative haemoglobin levels (measured at time of admission), postoperative haemoglobin levels (measured 24 hours after surgery) and time from admission to surgery. We dichotomised time from admission to surgery and chose the cut-off value of 48 hours based on recommendations made by the British Orthopaedic Association on the optimal timing of surgery in HFS patients [13]. Records of patients who died within 30 days of surgery were reviewed to determine the primary cause of death and time from surgery to death. Patients who died within 30 days of surgery (group 1) were compared with those who survived beyond 30 days (group 2).

Statistical analysis

We undertook univariate and multivariate analysis to ascertain independent risk factors for 30-day mortality. Descriptive statistics of mean and standard deviation (SD) were calculated, and the Mann–Whitney test was used to compare continuous variables. Proportions as percentages were calculated, and the chi-square test was used to compare categorical variables. All variables that demonstrated a significant relationship on univariate analysis ($p < 0.05$) were then included in a logistic regression analysis using backward selection to identify the significant independent predictors of 30-day mortality. Correlation analysis was undertaken using Spearman's correlation coefficient between the most common causes of 30-day mortality and associated pre-existing comorbidities of interest. All statistical analyses were performed using XLSTAT version 7.0 software (Addinsoft, New York, NY, USA).

Results

The 30-day mortality rate was 7.5 % (35/467). Demographic and clinical data of patients in both groups are summarised in Table 1. The most common causes of death within 30 days of surgery are shown in Fig. 1. Mean time to death was 11.3 (SD 8.1) days. All deaths within 48 hours of surgery ($n = 6$) representing 17.1 % of the total 30-day mortality were due to acute myocardial injury (MI).

Patients in group 1 were significantly older than those in group 2 ($p = 0.034$, Mann–Whitney). There was no difference in the distribution by gender ($p = 0.307$), ASA grade ($p = 0.145$), fracture type ($p = 0.884$), mechanism of injury ($p = 0.703$), presence of concomitant injuries ($p = 0.715$) or admitting specialty ($p = 0.918$,; all chi-square test) between groups. Intracapsular fractures accounted for the majority of cases in both groups. A higher proportion of patients in group 2 was admitted from residential or nursing homes. In contrast, most patients in group 1 were functionally independent in their own home or sheltered accommodation prior to admission ($p < 0.001$; chi-square test). The majority of patients in group 1 were wheelchair bound prior to their hip fracture, whereas most patients in group 2 were independent walkers ($p = 0.004$; chi-square test). The majority (94 %) of patients in both groups was admitted under the orthopaedics team at presentation. A higher prevalence of the comorbidities dementia ($p = 0.017$), cardiac disease ($p = <0.001$), chronic obstructive pulmonary disorder (COPD) ($p = 0.036$) and renal dysfunction (p

Table 1 Comparison of demographic and clinical data between the 30-day mortality cohort (group 1) and survivors (group 2)

Variable	Group 1 (n=35)	Group 2 (n=432)	P value
Mean age ± SD	83.9±8.3	79.3±12	0.034*
Gender, n (%)			
Male	7 (20 %)	121 (28 %)	0.307
Female	28 (80 %)	311 (72 %)	
ASA Grade			
I	1 (3 %)	25 (6 %)	0.145
II	9 (24 %)	177 (41 %)	
III	17 (48 %)	181 (42 %)	
IV	8 (24 %)	47 (11 %)	
V	0 (0 %)	2 (0.5 %)	
Fracture type, n (%)			
Intracapsular	19 (54 %)	240 (56 %)	0.884
Extracapsular	16 (46 %)	192 (44 %)	
Admission source, n (%)			
Own home or sheltered housing	13 (37 %)	307 (71 %)	<0.001*
Residential or nursing home	16 (46 %)	89 (21 %)	
Inpatient	6 (17 %)	32 (7 %)	
Tertiary referral	0 (0 %)	2 (0.5 %)	
Unknown	1 (3 %)	1 (0.3 %)	
Preinjury walking ability, n (%)			
Independent	7 (20 %)	178 (41 %)	0.004*
1 stick	2 (6 %)	42 (10 %)	
2 sticks or frame	2 (6 %)	53 (12 %)	
Wheelchair or buggy	24 (69 %)	153 (35 %)	
Unknown	0 (0 %)	6 (1 %)	
Mechanism of Injury, n %			
Mechanical fall	15 (43 %)	195 (45 %)	0.703
Nonmechanical fall	16 (46 %)	151 (35 %)	
No history of fall	0 (0 %)	1 (0.3 %)	
Pathological fracture	0 (0 %)	3 (0.7 %)	
Road traffic accidents	0 (0 %)	15 (3 %)	
Mechanism unknown	4 (11 %)	67 (16 %)	
Concomitant injuries, n (%)			
None	32 (91 %)	401 (93 %)	0.715
Upper limb	2 (6 %)	12 (3 %)	
Lower limb	0 (0 %)	5 (1 %)	
Head	1 (3 %)	14 (3 %)	
Admission specialty[a], n (%)			
T&O	33 (94 %)	401 (94 %)	0.918
Medical specialty	2 (6 %)	23 (5.5 %)	
Other surgical specialty	0 (0 %)	2 (0.5 %)	
Number of comorbidities, n (%)			
0–1	8 (23 %)	207 (48 %)	0.004*
≥ 2	27 (77 %)	225 (52 %)	

SD standard deviation, *T&O* trauma and orthopaedics

* Significant,

[a] Admission specialty data missing in six patients in group 2

=0.007; all chi-square test) was seen in group 1 (Table 2). A significantly higher proportion of patients in group 1 had more than two comorbidities (77 % in group 1 versus 52 % in group 2; p=0.004, chi-square test).

Surgery-related features of patients in both groups are summarised in Table 3. There was a statistically significant difference in time to surgery from admission between groups (p=0.006; chi-square test), with the majority of patients in group 1 having a surgical delay of 48 hours or more. Patients in group 1 had a significantly lower preoperative haemoglobin level than those in group 2 (11.2 g/dl versus 12.1 g/dl, respectively, p <0.001; Mann–Whitney test); however, postoperative haemoglobin levels were no different (p=0.07, Mann–Whitney test). There was no significant difference between groups with respect to type of implant used (p=0.423, chi-square test). The dynamic hip screw (DHS) was the most common implant utilised in both groups.

Ten parameters were significant on univariate analysis and were considered to be potential risk factors for 30-day mortality. These were subsequently included in a multivariate analysis, which showed three parameters to have a significant bearing on early mortality (Table 4). Thirty-day mortality was 28 % (10/36) in patients who had all three significant risk factors, compared with 0.7 % (1/139) in those who had none of these risks (p <0.001; chi-square test). Correlation analysis showed a moderate but significant correlation between the presence of cardiovascular disease (CVD) as a comorbidity at presentation and acute MI as a cause of death within 30 days (r=0.427, p=0.01). No such correlation was found between pre-existing COPD and death due to pneumonia (r=−0.046, p=0.791).

Discussion

In our study cohort of 467 consecutive HFS patients treated at our institution over a one-year period, 35 (7.5 %) died within 30 days of surgery. Pneumonia and acute MI were the most common causes of early death, followed by sepsis of unknown origin. Patients who died within 30 days were older, socially dependent prior to admission, unable to walk independently and had a lower preoperative haemoglobin. They had a higher prevalence of pre-existing dementia, cardiac disease, COPD and renal dysfunction during their pre-injury state. A surgical delay over 48 hours was also associated with higher 30-day mortality.

The 30-day mortality rate is considered a care-quality indicator following HFS [10]. Its incorporation into the latest NHFD report allows interhospital comparison of management for HFS patients [10]. Although there has been a steady downward trend in the rate over the past three years, from 9.4 % to 8 %, our cohort compares favourably, with an incidence of 7.5 %. Previous epidemiological studies reporting mortality

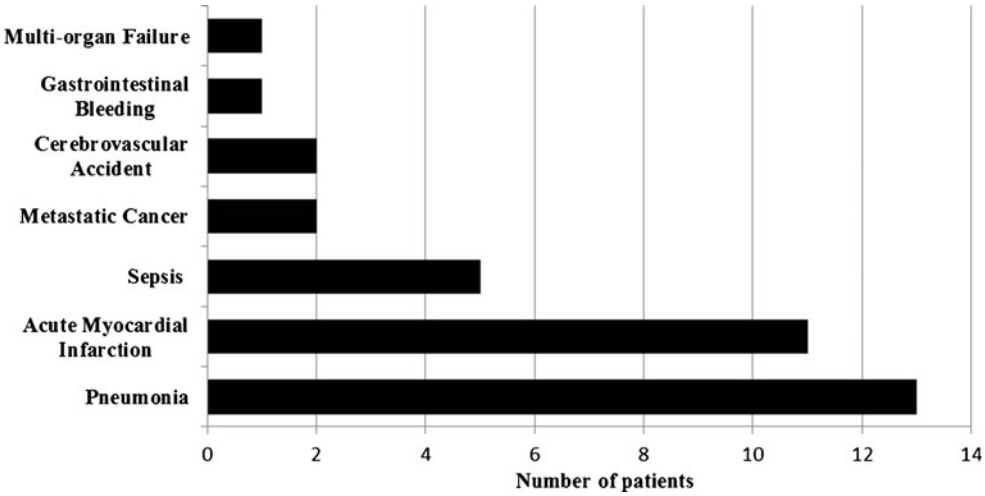

Fig. 1 Frequency of causes of death within 30 days of hip-fracture surgery

from national databases, such as the Danish National Indicator Project and the US Medicare population, report 30-day mortality rates of 10.3 % and 11 %, respectively [14, 15]. The mortality rate in our cohort is lower in comparison; however, it should be noted that previous studies included a nationwide cohort of patients with a varied case mix, whereas our cohort represents a smaller geographic population.

More than two thirds of 30-day mortality occurrences in our cohort were due to pneumonia and acute MI. These findings are in agreement with an autopsy-based study of more than 500 deaths after HFS showing bronchopneumonia and MI as the principal causes of death [16]. Pneumonia is common in the postoperative course of HFS patients [17] and has been associated with early readmission [11, 18]. Our findings concur with previous studies that demonstrate the development of postoperative pneumonia is associated with up to a fivefold increase in mortality following HFS [19]. Interestingly, however, postoperative pneumonia did not correlate with the presence of COPD as a pre-existing comorbidity in our cohort.

The medical profile of hip-fracture patients is such that there is a high prevalence of CVD [20]. Previous work has shown a genetic link between the presence of CVD and the development of subsequent hip fractures [21]. MI and cardiac

Table 2 Comparison of pre-existing comorbidities between the 30-day mortality cohort (group 1) and survivors (group 2)

Co-morbidities	Group 1 (n=35)	Group 2 (n=432)	P value
Dementia	14 (40 %)	96 (22 %)	0.017*
Cardiac disease, including AF[a]	21 (60 %)	117 (27 %)	<0.001*
COPD	9 (26 %)	56 (13 %)	0.036*
Renal dysfunction	8 (23 %)	38 (9 %)	0.007*
Diabetes	1 (3 %)	53 (12 %)	0.094
Hypertension	12 (34 %)	156 (36 %)	0.829
Neurological disorders[b]	4 (11 %)	54 (13 %)	0.853
Thyroid dysfunction	2 (6 %)	20 (5 %)	0.771
Malignancy	3(9 %)	38 (9 %)	0.964
Anaemia	4 (11 %)	59 (14 %)	0.710
Autoimmune/inflammatory disorders	2 (6 %)	14 (3 %)	0.439
Alcohol dependence	0 (0 %)	13 (3 %)	0.298

AF atrial fibrillation, *COPD* chronic obstructive pulmonary disease

*Significant

[a] Cardiac disease included a previous history of ischaemic heart disease, myocardial injury, congestive heart failure and atrial fibrillation

[b] Neurological disorders included a previous history of stroke, transient ischaemic attacks, Parkinson's disease or neuromuscular disease

Table 3 Comparison of surgical features between the 30-day mortality cohort (group 1) and survivors (group 2)

Variable	Group 1 (n=35)	Group 2 (n=432)	P value
Time to surgery[a]			
< 48 h	10 (29 %)	226 (53 %)	0.006*
≥ 48 h	25 (71 %)	201 (47 %)	
Implant type, n (%)			
Cannulated hip screws	1 (3 %)	16 (4 %)	0.423
Dynamic hip screw	14 (40 %)	173 (40 %)	
Uncemented semiarthroplasty			
Unipolar	9 (26 %)	60 (14 %)	
Bipolar	7 (20 %)	128 (30 %)	
Cemented hemiarthroplasty			
Unipolar	1 (3 %)	4 (1 %)	
Bipolar	0 (0 %)	8 (2 %)	
Intramedullary fixation	3 (9 %)	43 (10 %)	
Preoperative Hb in g/dl, mean ± SD	11.2±1.9	12.1±1.7	<0.001*
Postoperative Hb in g/dl, mean ± SD	9.4±1.9	9.9±1.9	0.07

Hb haemoglobin

*Significant

[a] Time to surgery data missing in five patients in group 2

Table 4 Univariate and multivariate risk factors for early mortality between the 30-day mortality cohort (group 1) and survivors (group 2)

Variable	Univariate *P* value	Multivariate results (logistic regression)		
		Odds ratio	95 % confidence interval	*P* Value
Time to surgery ≥ 48 h	0.006	2.19	0.99–4.79	0.051
History of cardiac disease	<0.001	3.31	1.60–6.88	0.001
Admission source other than own home	<0.001	3.56	1.71–7.42	0.001

failure have both been recognised as common determinants of mortality after HFS [22]. This was also observed in our cohort, in which over 30 % of deaths within 30 days were due to acute MI. A previous retrospective study in a cohort of more than 1,200 HFS patients shows perioperative MI to have occurred in 13.8 % of patients within seven days of surgery, with a subsequent fourfold increase in 30-day mortality [23]; three fourths of those patients were asymptomatic. Recommendations have therefore been made for the routine use of postoperative troponin measurements, despite the absence of symptoms, as an in-hospital preventative strategy to reduce MI related mortality [23–26]. We found a moderate correlation between pre-existing cardiac disease and early death from acute MI in our cohort of patients. All deaths within 48 hours of surgery were due to acute MI. This finding supports the use of cardiac markers in the early postoperative period, especially in high-risk patients. This should be undertaken with a view to providing early medical and intensive care intervention in patients with elevated cardiac enzymes.

We aimed to determine predictors of early mortality after HFS and found three variables to be independent predictors of 30-day mortality: surgical delay of hours or more 48, admission from a source other than own home and a previous history of cardiac disease. Nettleman et al. show that a previous history of angina and congestive heart failure increased the odds of dying within three days of HFS by a factor of over 25 [8]. Researchers also attempted to validate a scoring system to predict 30-day mortality after HFS [7]. In doing so, they identified low-admission haemoglobin concentration, living in an institution and the number of comorbidities as three of seven independent predictors of death. Although our findings are similar in some respects, that study only looked at a select group of comorbidities and did not include surgical delay as a variable. We show that surgical delay of 48 hours or more is a significant predictor for early death. Our findings are supported by studies suggesting that earlier surgery is associated with lower mortality and a lower risk of postoperative pneumonia in elderly HFS patients [27, 28]. One can therefore infer that surgical delay predisposes these bedridden patients to a higher risk of hospital-acquired infections and subsequent death. Our results suggest that care-dependent patients are at a much higher risk of early death. Hu et al. similarly show that residence within a nursing home or care facility is a strong predictor of mortality in HFS patients [1]. Patients living in their own homes are more likely to be socially independent and mobile [29] and therefore have improved outcomes due to a better rehabilitation potential after surgery.

Our study is limited by its retrospective design; however, we included a large sample size and cross referenced all variables collected through multiple data sources. We realise that the determinants of mortality after HFS are multifactorial, and we therefore analysed a number of parameters. In addition, we used a national database (NHFD) to identify patients for inclusion into the study.

We conclude that the predominant causes of early mortality after HFS are infectious and cardiac in nature. Patients at greatest risk of dying within 30 days of their hip operation are those who are care dependant prior to injury, have a history of CVD and have a delay of over 48 hours from admission to surgery. More than 72 % of patients with all the above risk factors survived the month postsurgery, which reinforces the notion that surgery may well provide them with a fighting chance. Surgical delay is an avoidable determinant of early mortality, and efforts to minimise it should be made whenever possible. The correlation seen between a previous history of CVD and death from acute MI in the early postoperative period may well provide the rationale for routinely monitoring markers of MI in selected high-risk patients. We recommend a multidisciplinary postoperative assessment aimed at optimising cardiorespiratory function and providing early intervention in patients with signs of cardiovascular compromise or infection.

Conflict of interest None.

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