Injury, Int. J. Care Injured 50 (2019) 950–955

Contents lists available at ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

The impact of time to surgery after hip fracture on mortality at 30- and 90-days: Does a single benchmark apply to all?

L.A. Beaupre[a,*], H. Khong[b], C. Smith[b], S. Kang[b], L. Evens[b], P.K. Jaiswal[c], J.N. Powell[d]

[a] Department of Physical Therapy, University of Alberta, Canada
[b] Alberta Bone and Joint Health Institute, Canada
[c] Royal Free London NHS Foundation Trust, Canada
[d] Department of Surgery, University of Calgary, Canada

ARTICLE INFO

Keywords:
Hip fracture
Surgical delay
Mortality

ABSTRACT

Introduction: Delays to surgery after hip fracture have been associated with mortality Uncertainty remains as to what timing benchmark should be utilized as a marker of quality of care and how other patient factors might also influence the impact of time to surgery on mortality. The goal of this study was to determine how time to surgery affects 30- and 90-day mortality by age and to explore the impact of preoperative comorbid burden and sex.

Participants: We used population-based administrative data from a Canadian province collected from 01April2008 to 31March2015. Of 12,713 Albertans 50-years and older who experienced a hip fracture and underwent surgery within 100 h of admission, 11,996 (94.8%) provided data.

Methods: Time to surgery was analyzed in hours from admission to surgery. Age and the interaction between age and time to surgery were evaluated using logistic regression. Charlson co-morbidity score and sex were also considered in the analysis. Survival was evaluated at 30-and 90-days post hip fracture using a provincial registry.

Results: The average age of the cohort was 79.6 ± 11.2 years and 8,412 (70.1%) were female. Overall, 586 (4.9%) patients died within 30-days and 1,023 (8.5%) died within 90-days of hip fracture. Mortality increased significantly with increasing time to surgery (30-day mortality odds ratio [OR] = 1.03; 95%CI 1.01-1.05: 90-day mortality OR = 1.03; 95% CI 1.01–1.04). Mortality also increased substantially with increasing age; those ≥85 years were 19.63 (95% CI 6.83–67.33) and 15.66 (95%CI 7.20–37.16) times the odds more likely to die relative to those between 50–64 years of age at 30-days and 90-days postoperatively respectively. Further, those who were ≥85 years were more significantly affected by increasing time to surgery than those who were 50–64 years of age at both 30-days ($p = 0.04$) and 90-days ($p = 0.025$) post-fracture. Males and those with a higher comorbid burden also had higher odds of dying after controlling for time to surgery ($p < 0.001$)

Conclusion: Time to surgery following hip fracture may have a differential effect on 30- and 90-day survival dependent on age. Older patients appear to be at higher risk of dying with surgical delays than younger patients.

Introduction

Hip fractures are common fractures, particularly in older adults, and are associated with substantial mortality [1]. Delays to surgery after a hip fracture has been extensively studied as a factor that affects patient survival [2–10]. Despite recent large cohort studies and older meta-analyses, uncertainty remains as to what benchmark should be utilized as a marker of quality of care to improve patient outcomes. In Canada, surgery within 48-hours of admission has been set as the national benchmark by the Canadian Institute for Health Information (CIHI), with the most recent data showing that 86% of Canadians with hip fractures receive surgery within this benchmark [11]. However, recent international guidelines have suggested that 24- or 36-hours may be more appropriate clinical benchmarks for timing of surgery to improve patient outcomes [12,13]. The evidence supporting these new recommendations for earlier time to surgery is currently limited.

Time to surgery is only one factor that may affect survival after hip fracture. Others have noted that increasing age is strongly

* Corresponding author at: 6-110 Clinical Sciences Building, University of Alberta, Edmonton, AB, T6G 2G3, Canada.
E-mail address: lauren.beaupre@ualberta.ca (L.A. Beaupre).

https://doi.org/10.1016/j.injury.2019.03.031
0020-1383/

associated with mortality after hip fracture [14]. Other patient characteristics are also associated with lower survival after hip fracture; those with higher disease burden and males also have increased post-fracture mortality [14,15].

To our knowledge, no study to date has examined if the impact of time to surgery on survival after hip fracture might vary among patient sub-groups. Access to operating theatres in a timely manner is a challenge in many healthcare systems [16–19]. Understanding how patient characteristics affect outcomes may be one way to more appropriately prioritize sub-groups of patients awaiting surgery, such that the most urgent patients wait the shortest time possible, while other patients wait slightly longer for surgery without substantial negative impact to their outcome.

The primary objective of this population-based analysis was to determine the impact of time to surgery in hours on mortality at 30- and 90-days post-fracture in different age groups. In addition, we also explored how time to surgery affected survival amongst those with higher comorbid burden and males relative to females. This study was approved by the institutional Health Research Ethics Panel (Pro00055968).

Patients and methods

Study design

This was a population-based retrospective cohort study using patient-level data extracted from the provincial administrative data repositories that were available to the Alberta Bone and Joint Health Institute (ABJHI).

Setting

Alberta is the fourth largest Canadian province in both geographical size and population with approximately four million residents distributed across more than 600,000 square kilometres. All residents have universal healthcare coverage with hip fracture surgery provided in 15 surgical hospitals across the province. Because of the geographical distribution of patients and surgical hospitals, which can delay time to surgery, there was an opportunity to evaluate the impact of variable time to surgery on mortality post-operatively.

Participants

We examined discharge abstracts of all patients who were 50-years or older on admission admitted between 01April2008 and 31March2015 and were a resident of the province. Those who met the definition for hip fracture and received surgery within 100 h of admission were eligible for inclusion. The rationale for selecting adults over 50 years of age was that this group was more likely to represent those who had a low energy fragility fracture. Likewise, time to surgery was limited to those who received surgery within 100 h as we wanted to examine the impact of early benchmarks on survival across differing age groups. [20] Only a small proportion of patients (n = 512; 3.96%) did not receive surgery within 100 h, which reflected more than two standard deviations from the mean time to surgery of the overall cohort and a median time to surgery of 142.99 (Interquartile Range [IQR] 114.82, 245.18) hours. Eligible patients had a most responsible, pre-admit or service transfer diagnosis of hip fracture as defined using International Classification of Disease Version 10 (diagnosis codes [ICD10-CA] S720, S721, S722, and received surgery as defined by ICD-10 procedure coding system [ICD-10-PCS] 1VA74, 1VA53, 1VC74, 1SQ53). Those with a post-admit diagnosis of hip fracture, procedural codes of revisions, procedures in centers other than surgical hospital, or whose fracture was managed non-operatively were excluded. Patients who were missing outcome (i.e. vital status) data were also excluded from analysis.

Data sources

Data were extracted from the Discharge Abstract Database (DAD), the National Ambulatory Care Reporting System (NACRS) and the Alberta Patient Registry. The DAD contains all hospital admission and discharge data including diagnostic and procedural codes. The NACRS contains all ambulatory care visits including visits to the Emergency Department. Using unique patient identifiers, the DAD and NACRS systems were linked using CIHI definitions of transfers [21,22], to create a single episode of care such that the time to surgery, our primary variable of interest, would capture all preoperative time including ambulatory care time in emergency departments or non-surgical hospitals. Thus, preoperative time started at the point of care at the first hospital site and concluded at the start of operating theatre time.

In addition to preoperative time, we also collected age at time of hip fracture and sex from the DAD. Age was compared across four categories: 50–64 years, 65–74 years, 75–84 years and 85 years and older. We created a Charlson Co-morbidity Score from comorbidity data entered as secondary diagnoses in the DAD at the time of hospital admission. The Charlson co-morbidity index is a validated index for assessing mortality risk associated with each of 22 potential conditions [23]. Conditions are assigned a score of one (e.g., previous myocardial infarction), two (e.g., moderate to severe kidney disease), three (e.g., moderate to severe liver disease), or six (e.g., malignant tumour or metastasis) dependent upon the risk of dying associated with each condition; the total aggregate score is used to predict mortality. For this study, patients were formed into three groups according to their aggregate score (Charlson score of zero, one, two or more).

Outcomes

The outcomes of interest were mortality at 30- and 90-days post hip fracture, which were ascertained using the Alberta Patient Registry; this registry contains all provincial live births and deaths.

Statistical analysis

We compared patient characteristics and time to surgery by survival at 30- and 90-days post fracture. We created two multivariable binary logistic regression models with an interaction effect between time to surgery and age, one with 30-day and one with 90-day mortality as the outcome. In each model examining time to surgery, we adjusted for age in four categories (50–64 years [reference group]), sex (females [reference group]), and Charlson Comorbid score as a categorical variable (zero [reference group]). Using the estimated probability for both outcomes from logistic regression model, we performed the spline and smoothing interpolation method with 0.05 as smoothing parameter to visualize the results for better understanding. After performing the spline and smoothing interpolation, we generated contour plots (projection onto 2-dimensional space) to see how the estimated probability of outcomes changed by time to surgery and age. We also explored this relationship stratified by sex and Charlson co-morbidity. Finally, we examined the multilayer perceptron neural network to compare variable importance, where 70% of records were randomly assigned as training data, and 30% of records were used as test data. All tests were two-tailed and level of significance was set at $p < 0.05$. All data were analyzed using SAS (Version 9.4, SAS Institute, Cary, NC), IBM SPSS Statistics (Version 25, IBM Corporation, New Orchard Road Armonk, New

York), The R-project for Statistical Computing (Version 3.5), and NCSS (Version 12, NCSS LLC, 329 North 1000 East, Kaysville, UT).

Results

Participants

There were 12,713 Albertans 50-years and older who experienced a hip fracture and underwent surgery within 100 h, admitted between 01April2008 and 31March2015 who were potentially eligible for inclusion. Of these, 717 were missing outcome data, leaving 11,996 (94.8%) patients available for analysis.

The average age of participants was 79.6 ± 11.2 years and 8,412 (70.1%) were female. Overall, 586 (4.9%) died within 30 days of hip fracture, which increased to 1,023 (8.5%) patients within 90-days of hip fracture. In unadjusted analyses, mortality increased with increasing time to surgery, age, and comorbid burden at both 30- and 90-days post-fracture (Table 1). Males were also more likely to die than females at both time periods (Table 1).

30- & 90-day adjusted mortality

When measured in hours, time to surgery was significantly associated with mortality at both 30- and 60-days post hip fracture. As expected, increasing age, higher Charlson Comorbidity score and being male were also associated with significantly higher mortality at both assessment periods even after controlling for time to surgery (Table 2). These results were also supported by the multilayer perceptron neural network evaluating variable importance. In this cohort, age predicted 55.7%, Charlson comorbidity score 19.1%, time to surgery 13.1% and male sex 12.2% of 30-day mortality. At 90-days, age predicted 44.1%, Charlson Comorbidity score 31.3%, time to surgery 16.2% and male sex 8.4% of mortality.

We also noted an interaction between age and time to surgery with those who were 85 years and older less likely to survive if surgery was delayed compared those who were 50–64 years of age (Table 2). Fig. 1a and b demonstrates the differential impact that delays to surgery have on survival based on patient age. Time to surgery affects survival fairly soon after fracture (i.e., before 20 h) in older patients, particularly those who are older than 80 years of age. In contrast, time to surgery does not show an impact on survival until well after 40 h for those who are 60 years or younger. In particular, surgical delays >40 h appear to have a profound impact on 30-day survival in those who are 80 years and older.

Our exploratory analysis of the relationship between age and time to surgery stratified by sex and Charlson Comorbidity score suggests that these factors may also be differentially affected by time to the OR with males and those with higher comorbid burden experiencing higher mortality with surgical delay (Fig. 1a and b).

Discussion

Many countries have established time to surgery benchmarks as measures to reflect quality of care that improves patient outcomes, including survival after hip fracture. Surgery within 48 h is the national benchmark in Canada while the UK revised their benchmark to state that surgery should occur within 36 h. Further, recent work has suggested that surgery within 24 h may be an important inflection point affecting survival after hip fracture [7]. To our knowledge, our analysis is the first cohort study to examine if a single benchmark is an appropriate quality indicator for the adult hip fracture patient population. We found that increasing

Table 1
Patient Characteristics.

Mortality	Variable		Mortality No	Yes	Total	p-value
30-days mortality	N		11410 (95.1)	586 (4.9)	11,996 (100)	N/A
	Sex	Female	8066 (70.7)	346 (59.0)	8412 (70.1)	<.001
		Male	3344 (29.3)	240 (41.0)	3584 (29.9)	
	Age	50-64yrs	1512 (13.3)	15 (2.6)	1527 (12.7)	<.001
		65-74yrs	1805 (15.8)	40 (6.8)	1845 (15.4)	
		75-84yrs	3724 (32.6)	154 (26.3)	3878 (32.3)	
		85 ≥ yrs	4369 (38.3)	377 (64.3)	4746 (39.6)	
	Age (Mean, STD)		79.3 (11.3)	86.1 (8.8)	79.6 (11.2)	<.001
	Time to OR	<24hrs	4380 (38.4)	157 (26.8)	4537 (37.8)	<.001
		24-36hrs	2609 (22.9)	123 (21.0)	2732 (22.8)	
		36-48hrs	2066 (18.1)	122 (20.8)	2188 (18.2)	
		≥48hrs	2355 (20.6)	184 (31.4)	2539 (21.2)	
	Time to OR (Mean, STD)		33.7 (19.3)	39.7 (21.4)	34.0 (19.5)	<.001
	Charlson Comorbidity Score	0	5821 (51.0)	126 (21.5)	5947 (49.6)	<.001
		1	2931 (25.7)	164 (28.0)	3095 (25.8)	
		≥2	2658 (23.3)	296 (50.5)	2954 (24.6)	
90-days mortality	N		10973 (91.5)	1023 (8.5)	11,996 (100)	N/A
	Sex	Female	7783 (70.9)	629 (61.5)	8412 (70.1)	<.001
		Male	3190 (29.1)	394 (38.5)	3584 (29.9)	
	Age	50-64yrs	1499 (13.7)	28 (2.7)	1527 (12.7)	<.001
		65-74yrs	1767 (16.1)	78 (7.6)	1845 (15.4)	
		75-84yrs	3604 (32.8)	274 (26.8)	3878 (32.3)	
		85 ≥ yrs	4103 (37.4)	643 (62.9)	4746 (39.6)	
	Age (Mean, STD)		79.0 (11.3)	85.7 (8.8)	79.6 (11.2)	<.001
	Time to OR	<24hrs	4251 (38.7)	286 (28.0)	4537 (37.8)	<.001
		24-36hrs	2512 (22.9)	220 (21.5)	2732 (22.8)	
		36-48hrs	1988 (18.1)	200 (19.6)	2188 (18.2)	
		≥48hrs	2222 (20.2)	317 (31.0)	2539 (21.2)	
	Time to OR (Mean, STD)		33.5 (19.2)	39.4 (21.3)	34.0 (19.5)	<.001
	CharlsonComorbidity Score	0	5716 (52.1)	231 (22.6)	5947 (49.6)	<.001
		1	2802 (25.5)	293 (28.6)	3095 (25.8)	
		≥2	2455 (22.4)	499 (48.8)	2954 (24.6)	

Table 2
Logistic linear regression with interaction between Time to Surgery and Age.

Outcome	Parameter	Estimate	SE	Odds ratio			p-value
				OR	Lower	Upper	
30-days mortality	Intercept	−6.610	0.571				<.001
	Time (to OR)	0.031	0.011	1.031	1.008	1.053	0.006
	Age (65-74yrs)	1.570	0.660	4.805	1.389	18.808	0.017
	Age (75-84yrs)	1.968	0.594	7.153	2.404	25.151	0.001
	Age (85 ≥ yrs)	2.977	0.579	19.625	6.826	67.330	<.001
	Gender (Male)	0.648	0.091	1.911	1.598	2.282	<.001
	Charlson:1	0.750	0.122	2.117	1.668	2.692	<.001
	Charlson:≥2	1.405	0.111	4.074	3.284	5.081	<.001
	Time*Age (65-74yrs)	−0.023	0.014	0.978	0.952	1.004	0.092
	Time*Age (75-84yrs)	−0.019	0.012	0.981	0.959	1.004	0.102
	Time*Age (≥85yrs)	−0.023	0.011	0.977	0.956	1.000	0.041
90-days mortality	Intercept	−5.732	0.409				<.001
	Time (to OR)	0.026	0.008	1.027	1.009	1.043	0.002
	Age (65-74yrs)	1.423	0.474	4.147	1.683	10.868	0.003
	Age (75-84yrs)	1.696	0.428	5.451	2.445	13.198	<.001
	Age (85 ≥ yrs)	2.751	0.417	15.657	7.204	37.155	<.001
	Gender (Male)	0.572	0.072	1.772	1.537	2.040	<.001
	Charlson:1	0.766	0.093	2.152	1.796	2.581	<.001
	Charlson: ≥2	1.413	0.086	4.109	3.479	4.865	<.001
	Time*Age (65-74yrs)	−0.018	0.010	0.982	0.963	1.002	0.069
	Time*Age (75-84yrs)	−0.014	0.009	0.986	0.970	1.004	0.126
	Time*Age (≥85yrs)	−0.019	0.009	0.981	0.965	0.998	0.025

time to surgery does affect survival at both 30- and 90-days postoperatively, but that the impact of increased delay to surgery appears to affect older patients more significantly than younger patients. There may also be a differential impact of delays to surgery on survival after hip fracture based on other patient characteristics, with males and those with a higher comorbid burden more likely to die with increasing time to surgery.

Despite several previous meta-analyses, the evidence around the impact of time to surgery has been limited by the quality of evidence including heterogeneity in definitions of 'early' surgery and lack of risk adjustment in outcome [5,8,9]. Most studies use a dichotomous approach to analyzing time such that the early group is captured within a short post-fracture time period and the late group has a much more extended range of times and contains all the patients who had substantial delays for surgery due to medical conditions [3,5,8–10]. This analytical approach limits the ability to determine how mortality changes as time increases. Recent studies from the United Kingdom (UK) and Canada examined the probability of mortality based upon time to surgery in hours or 12-hour intervals. Pincus et al. (2017) evaluated time to surgery in hours in more than 42,000 Canadian patients and found that delays greater than 24 h were associated with increased 30-day mortality and postoperative complications [7]. Bretherton et al. (2015) reported that surgery within 12 h was associated with reduced mortality at 30-days while Morrissey et al (2017) suggested that 30-day mortality did not change significantly until after a 24-hour delay in surgery [6,20]. Although these recent studies adjusted for age, sex and comorbidity, they did not examine whether the time to surgery had a differential impact based on these characteristics.

In this analysis, we examined whether a single benchmark of time to surgery applies to all adults over age of 50 years who experience a hip fracture. Although increasing time to surgery was associated with increasing mortality, there was a differential effect by age group with surgical delays more strongly associated with mortality in the oldest age group. This group is also at higher risk of poor recovery and requiring institutional care after hip fracture. Our results suggest that there should be increased priority to early surgery for these older patients within the hip fracture cohort, as younger patients with hip fracture appear less likely to die with small delays in surgery. Our results are, perhaps, not surprising as increasing age is noted to be an immutable factor associated with mortality after hip fracture. In more exploratory analyses, we also noted that males and those with increasing comorbid burden were also more negatively affected by increasing time to the OR. Reducing time to surgery preferentially in the frailest group of patients with hip fractures may increase their likelihood of survival and improved recovery after hip fracture, although more work is required to determine if others find similar results.

Recent attention has been focused on process and care indicators, including hospital and surgeon volumes [18], to determine how these factors affect patient outcomes, with increasing recognition that special attention and care is required to successfully manage the frail geriatric patient to optimize their recovery after hip fracture [24,25]. Although patients with hip fracture patients are often considered to be universally frail, there are sub-groups of patients with hip fracture who are younger, with fewer co-morbidities, and still actively living in the community who are likely at lower risk of mortality after a hip fracture. This is not to suggest that younger, healthier hip fracture patients can experience prolonged surgical delays without adverse effect, but rather, that in a time where many surgical centres struggle with excess surgical volume, sub-prioritization of patients within the hip fracture patient cohort should occur based on individual patient characteristics rather than a global benchmark. This stratification could allow centres to meet quality of care standards by having varying benchmarks based on patient characteristics.

This was a large, population-based cohort with outcome ascertainment at 30- and 90-days post-fracture using a validated administrative mortality index and the ability to measure time to surgery in hours from first presentation in acute care. Because of our provincial population distribution and surgical service access, we had a broad distribution of patients with varying characteristics and variable time to surgery, which allowed us to examine the impact of patient characteristics and time to surgery. We were also able to accurately measure time to surgery in hours from presentation at the initial emergency department to entrance to the operative theatre.

However, this is a retrospective review of administrative data with the inherent biases associated with these data. Our risk adjustment may have missed other factors such as perioperative care or pre-fracture functional status that could affect outcomes.

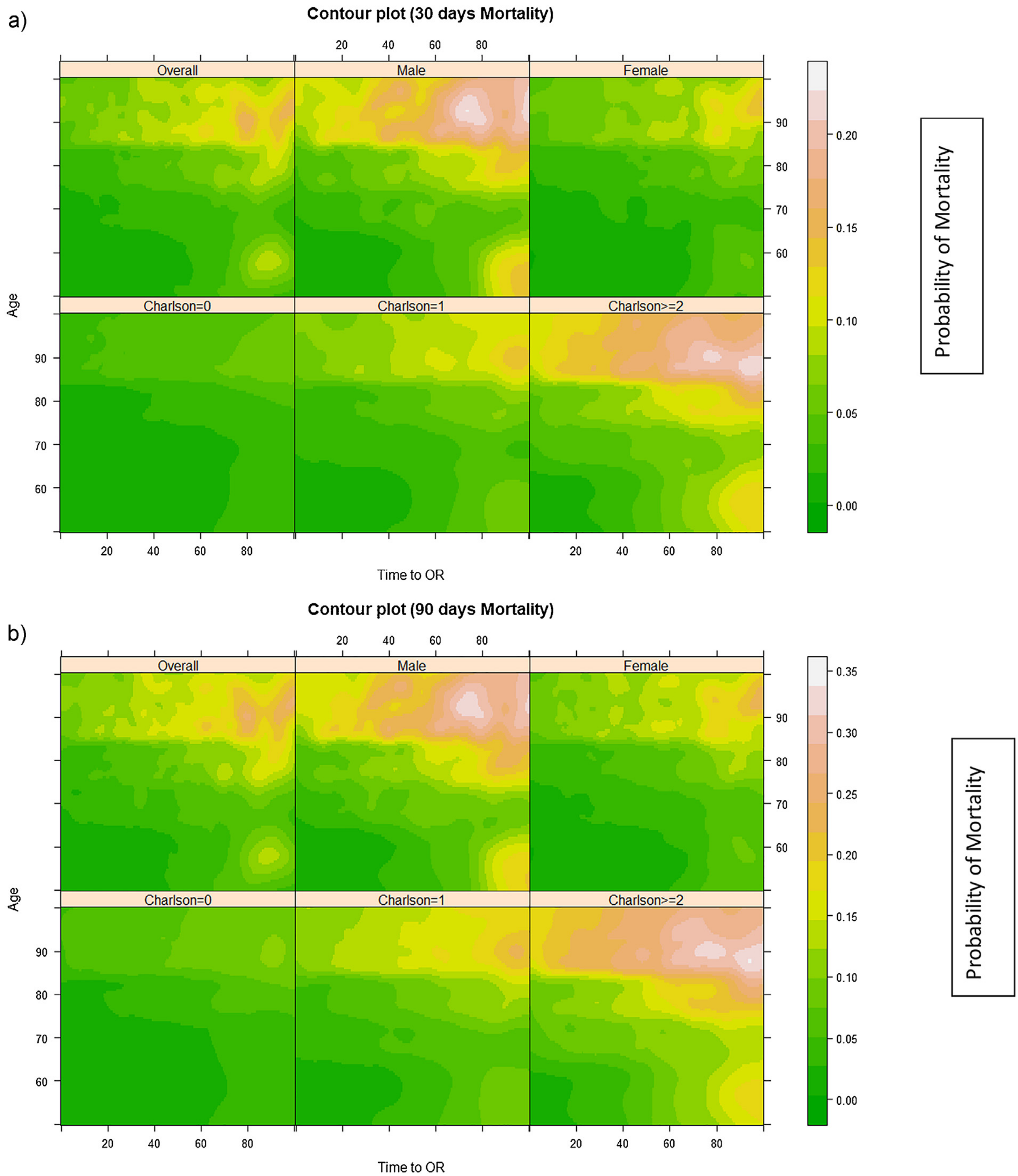

Fig. 1. a) This figure depicts the increasing probability of mortality at 30-days after hip fracture with surgical delay and increasing age. The first plot within the first row indicates the overall cohort results. The second 2 plots in the first row indicates sex-specific results. The second row depicts the impact of increasing Charlson Comorbidity score (0, 1 or 2 or more). b) This figure depicts the increasing probability of mortality at 90-days after hip fracture with surgical delay and increasing age. The first plot within the first row indicates the overall cohort results. The second 2 plots in the first row indicates sex-specific results. The second row depicts the impact of increasing Charlson Comorbidity score (0, 1 or 2 or more).

Similar to Bretherton et al. (2015) [20], we also truncated the time for inclusion to those who received surgery within 100 h, so that we could evaluate the impact of time to OR on survival in those who did not experience excessive delays due to either medical or process delays.

Further, we only examined the impact of surgical delay on mortality. A recent study from the Netherlands reported that although time to surgery was associated with mortality, there was a stronger association with increased costs (primarily related to increased length of stay) as time to surgery increased [2]. We were also unable to discern all factors that affected the clinical decision of when to take patients for surgery. Finally, our stratified results, that explored the further impact of sex and comorbid burden, are only presented pictorially, and thus, should be interpreted with caution; further work in other centres is needed to reproduce our findings.

Conclusion

In summary, our analysis of 11,996 patients suggests that delaying time to surgery after a hip fracture leads to an increase in mortality at both 30- and 90-days post-fracture. However, we also found that increased time to surgery had a differential impact based on age, with those who were 85 years and older more likely to die with increased surgical delay than those who were 50–64 year of age. Males and those with a higher comorbid burden may also be more negatively affected by increasing surgical delay. Our results suggest that decision-making for surgical priority should be based on patient characteristics rather than a global benchmark, but further work is required to determine appropriate benchmarks for differing mortality risk profiles.

Funding sources

This work was supported in-kind by the Alberta Bone and Joint Health Institute. LA Beaupre receives salary support from the Faculty of Rehabilitation Medicine as the Dr. David Magee Endowed Chair for Musculoskeletal Research.

Conflict of interest statement

All of the above-named authors claim no conflicts of interest for the work reported in this article. 28Feb19.

References

[1] Haentjens P, Magaziner J, Colon-Emeric CS, Vanderschueren D, Milisen K, Velkeniers B, et al. Meta-analysis: excess mortality after hip fracture among older women and men. Ann Intern Med 2010;152(6):380–90.
[2] Kempenaers K, Van CB, Vandoren C, Sermon A, Metsemakers WJ, Vanderschot P, et al. Are the current guidelines for surgical delay in hip fractures too rigid? A single center assessment of mortality and economics. Injury 2018;49(6):1169–75.
[3] Khan SK, Kalra S, Khanna A, Thiruvengada MM, Parker MJ. Timing of surgery for hip fractures: a systematic review of 52 published studies involving 291,413 patients. Injury 2009;40(7):692–7.
[4] Lewis PM, Waddell JP. When is the ideal time to operate on a patient with a fracture of the hip? : a review of the available literature. Bone Joint J 2016;98-B (12):1573–81.
[5] Moja L, Piatti A, Pecoraro V, Ricci C, Virgili G, Salanti G, et al. Timing matters in hip fracture surgery: patients operated within 48 hours have better outcomes. A meta-analysis and meta-regression of over 190,000 patients. PLoS One 2012;7(10):e46175.
[6] Morrissey N, Iliopoulos E, Osmani AW, Newman K. Neck of femur fractures in the elderly: Does every hour to surgery count? Injury 2017;48(6):1155–8.
[7] Pincus D, Ravi B, Wasserstein D, Huang A, Paterson JM, Nathens AB, et al. Association between wait time and 30-Day mortality in adults undergoing hip fracture surgery. JAMA 2017;318(20):1994–2003.
[8] Shiga T, Wajima Z, Ohe Y. Is operative delay associated with increased mortality of hip fracture patients? Systematic review, meta-analysis, and meta-regression. Can J Anaesthes 2008;55(3):146–54.
[9] Simunovic N, Devereaux PJ, Sprague S, Guyatt GH, Schemitsch E, Debeer J, et al. Effect of early surgery after hip fracture on mortality and complications: systematic review and meta-analysis. CMAJ 2010;182(15):1609–16.
[10] Weller I, Wai EK, Jaglal S, Kreder HJ. The effect of hospital type and surgical delay on mortality after surgery for hip fracture. J Bone Joint Surg 2005;87B (3):361–6.
[11] Canadian Institute of Health Information. Benchmarks for treatment and wait time in Canada: hip fracture. Accessed 24 January 2018 Available at. 2017. http://waittimes.cihi.ca/All/fracture.
[12] Australian and New Zealand Hip Fracture Registry (ANZHFR) Steering Group. Australian and New Zealand guideline for hip fracture care - improving outcomes in hip fracture management of adults. Accessed 24 January 2018 Available at. 2014. https://www.clinicalguidelines.gov.au/portal/2393/australian-and-new-zealand-guideline-hip-fracture-care-improving-outcomes-hip-fracture.
[13] National Institute for Health and Care Excellence. Timing of surgery. Accessed 24 January 2018Available at. 2011. https://www.nice.org.uk/guidance/cg124/chapter/Recommendations#timing-of-surgery.
[14] Hu F, Jiang C, Shen J, Tang P, Wang Y. Preoperative predictors for mortality following hip fracture surgery: a systematic review and meta-analysis. Injury 2012;43(6):676–85.
[15] Elliott J, Beringer T, Kee F, Marsh D, Willis C, Stevenson M. Predicting survival after treatment for fracture of the proximal femur and the effect of delays to surgery. J Clin Epidemiol 2003;56(8):788–95.
[16] Ahmed I, Khan MA, Nayak V, Mohsen A. An evidence-based warfarin management protocol reduces surgical delay in hip fracture patients. J Orthop Traumatol 2014;15(1):21–7.
[17] Anthony CA, Duchman KR, Bedard NA, Gholson JJ, Gao Y, Pugely AJ, et al. Hip fractures: appropriate timing to operative intervention. J Arthroplasty 2017;32 (11):3314–8.
[18] Malik AT, Panni UY, Masri BA, Noordin S. The impact of surgeon volume and hospital volume on postoperative mortality and morbidity after hip fractures: a systematic review. Int J Surg 2018;54(Pt B):316–27.
[19] Metcalfe D, Davis WA, Olufajo OA, Rios-Diaz AJ, Chaudhary MA, Harris MB, et al. Access to post-discharge inpatient care after lower limb trauma. J Surg Res 2016;203(1):140–4.
[20] Bretherton CP, Parker MJ. Early surgery for patients with a fracture of the hip decreases 30-day mortality. Bone Joint J 2015;97-B(1):104–8.
[21] Sheehan KJ, Sobolev B, Guy P, Bohm E, Hellsten E, Sutherland JM, et al. Constructing an episode of care from acute hospitalization records for studying effects of timing of hip fracture surgery. J Orthop Res 2016;34(2):197–204.
[22] Sobolev B, Guy P, Sheehan KJ, Kuramoto L, Bohm E, Beaupre L, et al. Time trends in hospital stay after hip fracture in Canada, 2004-2012: database study. Arch Osteoporos 2016;11:13.
[23] Charlson M, Szatrowski TP, Peterson J, Gold J. Validation of a combined comorbidity index. J Clin Epidemiol 1994;47(11):1245–51.
[24] Auais M, Morin S, Nadeau L, Finch L, Mayo N. Changes in frailty-related characteristics of the hip fracture population and their implications for healthcare services: evidence from Quebec. Canada. Osteoporos Int 2013;24 (10):2713–24.
[25] De RM Veronese N, Manzato E, Sergi G. Role of comprehensive geriatric assessment in the management of osteoporotic hip fracture in the elderly: an overview. Disabil Rehabil 2013;35(9):758–65.