Injury, Int. J. Care Injured 50 (2019) 272–277

Contents lists available at ScienceDirect

Injury

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

Multi-state analysis of hemi- and total hip arthroplasty for hip fractures in the Swedish population—Results from a Swedish national database study of 38,912 patients

Z. Jawad[a,*], S. Nemes[b,c], E. Bülow[b,c], C. Rogmark[b,d], P. Cnudde[a,b,c,e]

[a] Glangwili General Hospital, Trauma & Orthopaedics Department, Carmarthen, Wales, United Kingdom
[b] The Swedish Hip Arthroplasty Register, Registercentrum, Västra Götaland, Gothenburg, Sweden
[c] Institute of Clinical Sciences, Sahlgrenska Academy, University of Gothenburg, Gothenburg, Sweden
[d] Department of Orthopaedics, Lund University, Skåne University Hospital, Lund, Sweden
[e] Prince Philip Hospital, Trauma & Orthopaedics Department, Llanelli, Wales, United Kingdom

ARTICLE INFO

Keywords:
Hip fracture
Arthroplasty
Revision
Mortality
Register
Hemiarthroplasty

ABSTRACT

Introduction: Hip fractures are a common problem of the elderly population with significant mortality and morbidity. The choice between total hip arthroplasty (THA) and hemiarthroplasty depends on multiple factors including comorbidity. The Swedish Hip Arthroplasty Register (SHAR) provides a unique opportunity to study mortality and revision rates in this population. Linkage with government databases allow for in-depth research into the factors that influence risk of revision surgery and death in the hip fracture patient.
Patients and methods: Data was linked between SHAR, Statistics Sweden and the National Board of Health and Welfare. Data was collected on 38,912 patients who received a fracture-related hip arthroplasty between 2005 and 2012. A multistate analysis was performed and three states were identified: primary hip surgery and alive (state 1), revision after primary hip surgery (state 2) and death (state 3). These were marking points in the longitudinal outcome study.
Results: 38,912 patients who received an arthroplasty for an acute hip fracture were included. By the end of the study period 1309 (3.4%) of these patients underwent a revision and 17,365 (45.1%) patients died. Patients with THA had a reduced risk of death from primary operation compared to hemiarthroplasty (HR = 0.49) and a decreased revision risk (HR = 0.69). Female patients had a statistically significant reduced mortality (HR = 0.6) compared to men. There was no statistically significant difference in risk of revision surgery between direct lateral and posterior approach.
Conclusion: We identified an influence of type of surgery, sex, age and Elixhauser Comorbidity Index (ECI) on risk of revision and mortality. Males, greater comorbidity burden and older patients had higher mortality risks. The posterior approach did not have a significant influence on revision risk. Further research could include all patients who had reoperation(s) to further strengthen our findings. Patients who had a THA had lower revision rate and mortality. The latter is likely due to selection.

Introduction

Hip fractures are a common problem in the ageing population and are associated with significant rates of mortality and morbidity [1,2]. The treatment of choice for the displaced intracapsular hip fractures in the elderly population is hip arthroplasty [3]. The decision between a total hip arthroplasty (THA) and hemiarthroplasty is based on multiple factors with comorbidity, frailty, pre-injury mobility and functional demand being very important in the decision-making process [4]. There is a significant difference between the hip fracture population and those admitted for elective hip arthroplasty with regards to demographics, life expectancy, functional demands and outcomes [5]. The hip fracture population tend to suffer worse outcomes due to being elderly, their frailty and comorbidities. Ideally, patients would be able to live their life without further need for surgery on the operated hip. In spite of improvements in implants and surgical technique, there remains a small risk of failure of hip arthroplasties and revision surgery may be indicated at some stage after the

* Corresponding author at: Trauma & Orthopaedics, University Hospital of Wales, Cardiff, United Kingdom, CF14 4XW.
E-mail address: zmj990@icloud.com (Z. Jawad).

https://doi.org/10.1016/j.injury.2018.12.022
0020-1383/

initial procedure. The influence of factors such as age, socioeconomic status, comorbidities and sex on mortality and revision are not fully understood, although there have been previous observational studies to this population [6,7].

The inclusion of hemiarthroplasties in the Swedish Hip Arthroplasty Register (SHAR) since 2005, provides an opportunity to study mortality and revision in a large group of hip fracture patients as the data on procedures gets collected on a national level [8,9]. Mortality in the hip fracture population has been extensively described, but few have researched the different path patients can follow post arthroplasty for acute hip fracture using a multistate analysis. The development of life-history models is becoming more mainstream as a result of the increased availability and quality of longitudinal data [10,11]. We aim to describe the hip-related timeline or probability of both revision surgery and mortality following arthroplasty surgery for an acute hip fracture using the techniques of multistate analysis. Our secondary aim is to represent the transition probabilities and hazard ratios (HR) for the different covariates at different stages following the surgery.

Ethical review approval was granted by the regional ethical review board in Gothenburg (Sweden) on the 9th of April 2014 (Dnr 271-14).

Patients and methods

Since 2005, all hip fracture patients undergoing THA or HA have been routinely registered in SHAR. This information is collected prospectively. For this study we used a linked database that comprised data from the SHAR, Statistics Sweden, and the National Board of Health and Welfare. The Swedish Personal Identity Number (PIN) allows linkage of the SHAR data with governmental databases to add information on comorbidity and socioeconomic status at patient level as well as to assess data validity [12]. We identified 38,912 patients who received hip arthroplasty for hip fracture between 2005-01-01 and 2012-12-31 (Fig. 1). Patient- and surgery-specific and socioeconomic data were available for the purpose of analysis, using the proposed hierarchy of data elements for arthroplasty registries [13]. The variables used are represented

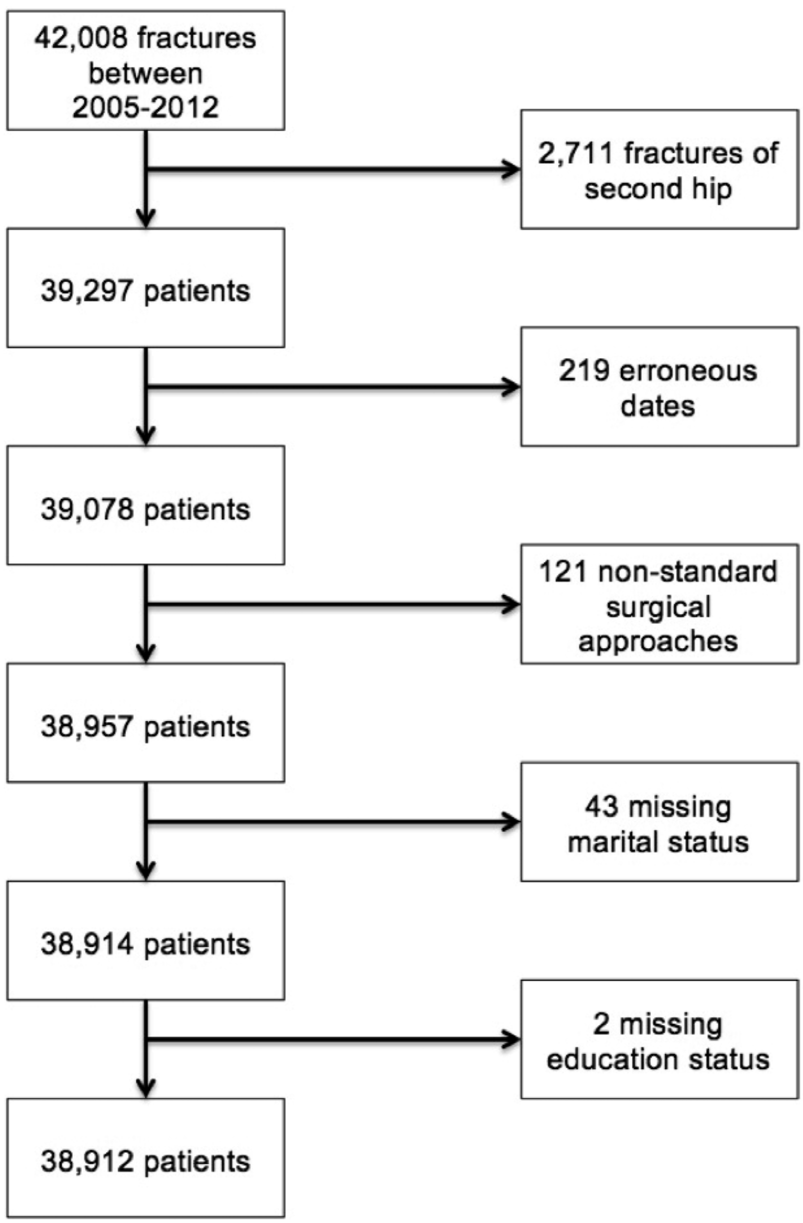

Fig. 1. Flowchart of missing population.

Table 1
Variable list using proposed hierarchy of data elements for arthroplasty registries [20].

patient-specific	personal id age sex date of death	Elixhauser comorbidity index	
surgery -specific	date of surgery date of revision date of censoring prosthesis type	surgical approach	
socioeconomic			education marital status

in Table 1. Education history was subdivided into “Low” (up to secondary school level), “Middle” (up to college level) and “High” (university or equivalent). All patients were followed up until death or the end of the study period (2012-12-31). All deaths are recorded via the Swedish Tax authorities and recorded in SHAR. Revision procedures are defined as exchange or removal of any part of an implant, and reported by the orthopaedic departments and linked to the primary procedure and the PIN number by the register coordinators.

Statistics

Continuous variables were summarized as means and standard deviations (SD), categorical variables as counts and percentages.

We modelled the association between covariates and transitions between a series of discrete states in continuous time with an illness–death model. This model included 3 states: 1) primary arthroplasty surgery after first hip fracture, 2) revision after primary hip fracture surgery and 3) dead [14]. These states were used as marking points during the longitudinal outcome study. We also considered a more complex model with hip fracture on the second hip and its revision as well. The resulting 5-state illness–death model with multiple transition possibilities proved to be unstable.

The measure of interest was the transition intensities. If we denote by $X(t)$ that state that the patient occupies at time t, then the transition intensity q_{sr} represents the instantaneous risk of moving from state s to state r and is defined as $q_{sr} = P(X(t+\delta t) = r|)X(t) = s)$ for a small $\delta > 0$.

The observed transition intensity (q_{rs}) was assumed to be proportional to the baseline transition intensity ($q_{rs}^{(0)}$). Using the proportionality principle, we assumed that the covariates act multiplicatively on the baseline transition intensity as

$$q_{rs}(t) = q_{rs}^{(0)}(t)e^{\sum \beta x}.$$

Here $e^{\Sigma \beta x}$ is the hazard rate for a patient with covariate vector coefficients β. The HR indicates the relative increase or decrease in the transition intensity. The instantaneous transition rate at any given time point during the follow-up is HR higher (or lower) among exposed patients compared to controls.

Transition intensity was modelled as a function of age and sex, hospital type (university, county, rural and private), type of surgery (THA versus HA), surgical approach, Elixhauser comorbidity index (ECI), achieved level of education and marital status.

Statistical analyses were conducted with R computing environment [15] and the ‘survival’ and ‘msm’ [16] packages.

Results

During the study period 38,912 patients who received an arthroplasty for an acute hip fracture were included. By the end of the study period 1309 (3.4%) of these patients had underwent a revision and 17,365 (45.1%) patients had died. The follow-up ranged from 0 to 7 years with a median of 3.5 years (1281 days), 70% of patients were female (Table 2). The number of patients at risk during the study period are graphically presented in supplementary data (Fig.S1).

Table 2
Demographics of the study population.

	level	Overall
n		38912
Age (mean (sd))		81.51 (8.83)
Sex (%)	Male	11681 (30.0)
	Female	27231 (70.0)
Education (%)	low	22006 (56.6)
	middle	11485 (29.5)
	high	5421 (13.9)
Marital status (%)	Single	3766 (9.7)
	Widowed	17347 (44.6)
	Married	12,686 (32.6)
	Divorced	5113 (13.1)
Prothesis (%)	Hemi	29235 (75.1)
	THA	9677 (24.9)
Surgical approach (%)	Lateral	22588 (58.0)
	Posterior	16324 (42.0)
Elixhauser comorbidity index (mean (sd))		0.81 (1.19)

Patient demographics and surgical data of the study population are presented in Table 2. The age range of the patients at the time of fracture was 17–106 with a mean age of 81.5 years (Fig. 2). 17,347 patients were widowed (44.6%) and 12,686 were married, and the remaining were single or divorced. 22,006 patients had a low education level (56.6%), 11,485 attained a middle education level (29.5%) and 5421 achieved a higher education level (13.9%).

Age and ECI had an influence on a patient’s risk of death, with a HR of 1.05 and 1.25 respectively. We found that probability of death increases across all age groups with increasing ECI, within 1 and 5 years. Female patients had a significantly reduced mortality risk with a HR of 0.59 (Table 4). Males consistently had a higher probability of death within 1 and 5 years compared to their female counter parts.

Patients who underwent revision surgery had a reduced survival probability compared to those who only underwent their primary surgery (Fig. 3). Males and younger patients had higher risk of requiring revision surgery in their lifetime.

Patients with THA had a reduced risk of death from primary operation (HR = 0.49) and from revision surgery (HR = 0.59) in comparison to patients who underwent HA. The THA group also

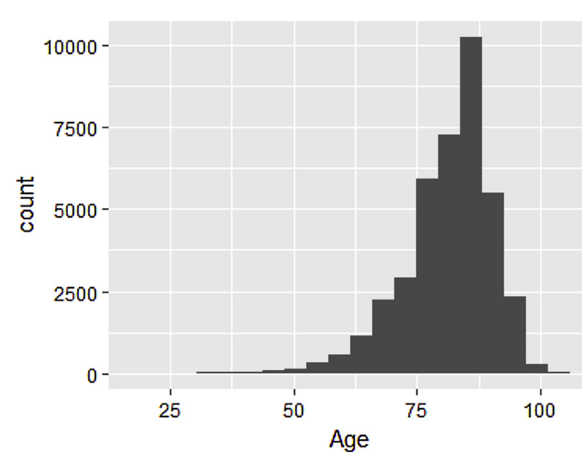

Fig. 2. Age range of the study population at the time of arthroplasty for hip fracture. Note that ages 17–33 were considered as potential outliers.

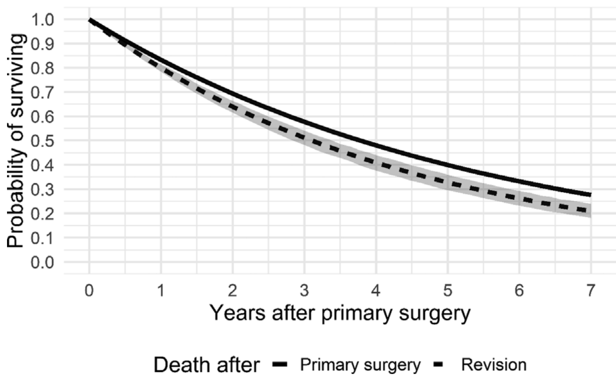

Fig. 3. Adjusted survival model from primary surgery and revision surgery.

had reduced risk of revision surgery compared with the HA group (HR = 0.69). The posterior approach did not alter the risk of requiring revision surgery (Fig. S5).

Fig. 3 presents an adjusted model for survival probability. After calculating the Forest plots (supplementary data) we were able to conclude that surgical approach, marital status and educational level did not add any value to the model. Therefore, the model was simplified to only adjust for sex, age, ECI and prosthesis type.

Transition probabilities for transition between states at 30 and 90-days, 1 and 5 years were calculated and are presented in Table 3 and Fig. 4. State occupation at different times following index surgery has been presented graphically in Fig. 5. The effect of the co-variables (age, ECI, prosthesis type) on the transition probabilities between states are represented in the supplementary data (Fig. S2-4 and Forest plots).

Discussion

Multistate analysis can provide a graphical and easy to understand representation of the transition and state occupation probabilities at different stages following arthroplasty. We have identified an influence of sex, age, Elixhauser comorbidity index and prosthesis type. Despite advances in orthogeriatric care and multi-disciplinary team input, mortality remains high overall when compared with the general population [17,18].

We demonstrated that female patients have an approximately 40% reduced risk of transitioning from one state to another. This is consistent with previous studies that have demonstrated male hip fracture patients are younger with a higher comorbidity burden [19]. A cohort study by Kannegaard et al. using the Danish discharge register found an excess mortality in males even when controlling for comorbidity and medication load [20].

Elderly patients had a higher risk of death and a slightly lower risk of going through revision surgery [21]. Hip fractures are high stress injuries, the elderly patient is less likely to have the reserve to survive such stressors, despite the aim of surgery being to reduce the likelihood of death [22]. The inverse relationship between age and revision risk is a finding that has been noted

Table 3
Transition probabilities between the stages at 30-& 90 days, 1 and 5 years with confidence intervals.

	At 30 days	At 90 days	At 1 year	At 5 years
State 1→2	0.1% (0.1, 0.1)	0.4% (0.3, 0.4)	1.2% (1.2, 1.3)	2.6% (2.4, 2.8)
State 2→3	1.8% (1.7, 2.0)	5.4% (5.0, 5.8)	20% (19, 22)	67% (64.4, 70.3)
State 1→3	1.5% (1.5, 1.5)	4.4% (4.3, 4.5)	17% (16, 17)	60% (60, 61)

Table 4
Hazard ratios for the transition between stages with confidence intervals.

	Male vs Female	Age	Elixhauser	THA vs HA
State 1→2	0.69 (0.62, 0.77)	0.98 (0.98, 0.99)	1.16 (1.11, 1.21)	0.69 (0.60, 0.79)
State 1→3	0.59 (0.57, 0.60)	1.05 (1.05, 1.06)	1.25 (1.23, 1.26)	0.49 (0.46, 0.51)
State 2→3	0.61 (0.51, 0.72)	1.05 (1.04, 1.07)	1.19 (1.12, 1.27)	0.59 (0.46, 0.76)

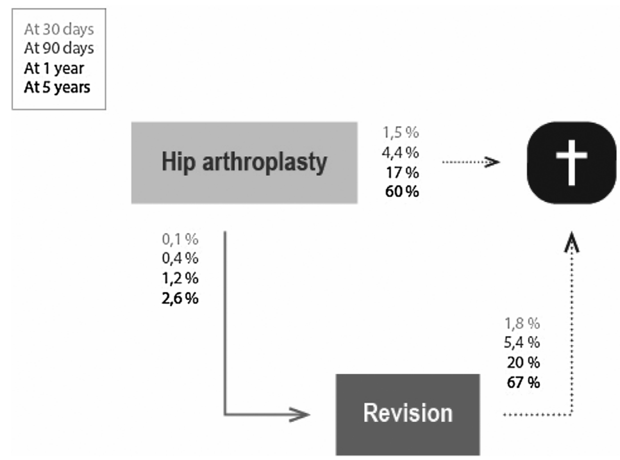

Fig. 4. Model of the multistate analysis with the 3 states and the transition probabilities at 30- and 90-days, 1 and 5 years.

before. Elderly patients are more likely to be frail and the implant less likely to suffer wearing. Therefore, the risk of revision surgery may outweigh any potential benefit and may not get offered, or the patient may choose not to undergo, revision surgery. Similarly, Moerman et al. found that patients over 80 years were significantly less likely to undergo revision regardless of whether they received HA or THA [23].

We used ECI in determining the influence of comorbidity on patient outcomes as this has been identified as being a better predictor of mortality in previous work from the SHAR [24]. We

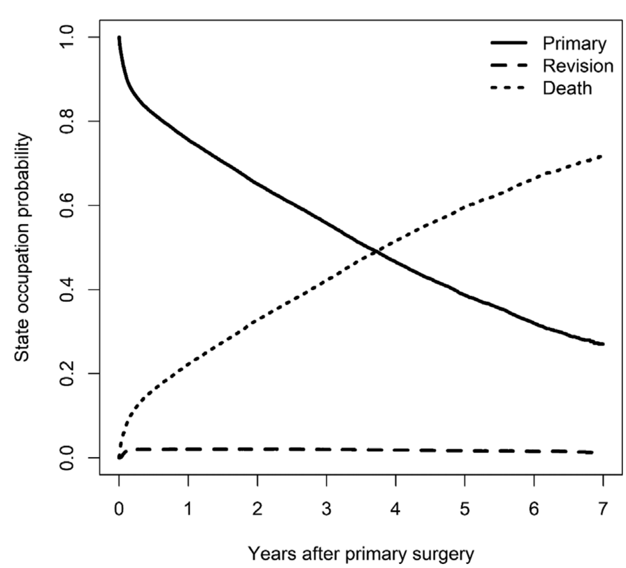

Fig. 5. State occupation probability in years after primary surgery.

found that an increasing ECI was associated with an increasing risk of death, from both primary operation and revision.

Of the socioeconomic factors taken into consideration, we found that married status in particular had an influence on outcomes, notably a reduced risk of mortality. The impact of remaining single into old age has been documented previously [25].

The choice of implant for hip fracture patients is guided by multiple factors. A meta-analysis suggested that healthy, active patients who received THA had better functional outcomes that those treated with HA, and reduced risk of reoperation [4]. Due to the longer duration of THA surgery, and potential risk of bleeding, HA is commonly used for frailer patients [26]. In this study, we demonstrated that patients who received THA had a significantly reduced risk of transition across all states when compared with HA patients. This is likely influenced by selection, as patients who undergo this operation are younger, have less disease burden and probably greater rehabilitation potential. We also note that THA patients who underwent revision surgery had higher mortality compared to non-revised cases, thereby supporting current knowledge [27]. This can be attributed to the burden of undergoing a second operation, increased comorbidity at the time of revision or complications, such as infection, that impact patient outcomes. Finally, we observed that patients who receive THA have a lower revision risk. Patients with HA may undergo revision for different reasons, such as recurrent dislocations and acetabular erosion, particularly in the younger, more active patients [28]. Both complications can be treated with the addition of an acetabular component, i.e. conversion to THA. This finding echoes earlier SHAR research, where patients with THA had lower revision and reoperation risks [22]. In contrast, the Dutch Arthroplasty Register, showed a higher 5-year revision rate of THA than that of HA. However, the groups were not comparable in other risk factors for revision and uncertainty prevailed regarding acetabular erosion; the authors could not state how many underwent revision for this reason [23]. These conflicting findings may be in part due to the definition of "revision", in that there is a wide variation in the term used across registries [29].

A direct lateral approach for fracture related hip arthroplasty is usually recommended [30], due to lesser risk of dislocation compared to posterior approach. [31–34]. Scandinavian register data suggests that direct lateral approach is associated with better prosthesis survival in general as well [35,36].

Our current findings differ from aforementioned register research, as we found similar revision risks between posterior and direct lateral approaches. The difference may be explained by the use of a novel and different statistical technique as the traditional Kaplan-Meier analysis may overestimate the revision rate in studies with high mortality [37]. The multistate analysis we used is a one-way illness-death model, which has the benefits of being able to predict the state a patient could be in at predefined time as both revision and death are considered concomitantly and has less risk of overestimating the cumulative incidence. The multistate analysis can be used as an alternative to Kaplan-Meier analysis if we are looking to find out the specific status of a patient following surgery.

Strengths and limitations

This is an observational study based on a national register. As the completeness of reporting revision surgery to the SHAR is 94% [38], we chose to focus on this outcome in order to reduce the risk of reporting bias. Neither other open secondary surgery nor closed reductions are included in our study. Revision and mortality are only crude markers for success and additional patient reported outcomes measures (PROMs) may add further essential information on outcome. Due to potential recall bias, the SHAR does not collect PROMs in fracture cases. The ECI is based on contact with secondary care in the year preceding the hip fracture admission. This may be an underestimate of the frailty and the level of comorbidity. Such issues arise for example if the patient only had treatment in the primary care setting (detection bias). In Sweden, the vast majority of hip fractures are treated using cemented implants and so, we did not use fixation as a variable for this study.

The data for this research is collected prospectively as part of a well-established nationwide quality register and has been reported as 100% coverage and 98% completeness. The linkage of data between the different databases is reliable and so far only in a handful of cases has this linkage failed [12]. As a result, we are assured that high-quality data has been obtained that has allowed observations to be made with a negligible loss of follow-up (no attrition bias). Research of this nature allows for long-term follow-up to determine outcomes [9]. Use of such registries has been shown to be advantageous in helping to shape guidelines and improving the care patients receive [39,40].

Future research

With some contradicting results between our study and previous research it would be worthwhile revisiting and extending the study group and potentially adding all adverse events and reoperations by using data from the national patient registers.

Conclusions

The multistate analysis has confirmed an influence of operation type, sex, age and Elixhauser comorbidity index on risk of revision and mortality. Patients who have undergone revision surgery have a higher risk of mortality than those who only undergo their primary operation, reiterating the need to develop surgical pathways that minimise the likelihood of complications and avoid revisions. This multi-state analysis, contrary to previous literature on surgical approach, demonstrates that the posterior approach is not significantly associated with a risk of revision surgery, perhaps demonstrating a more accurate reflection of the incidence than with Kaplan-Meier analysis. It is however an area in which there remains much debate, and further register research could seek to answer this question.

Conflict of interest

All authors have no conflicts of interest to declare regarding financial or personal relationships that may influence our research.

Acknowledgements

The authors would like to thank the coordinators and the team for the SHAR for providing the information. We also would like to thank Charlotte Vitse for the help in preparing the graphs for the transition probabilities.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.injury.2018.12.022.

References

[1] Nguyen ND, Ahlborg HG, Center JR, Eisman JA, Nguyen TV. Residual lifetime risk of fractures in women and men. J Bone Miner Res 2007;22(6):781–8.

[2] Frost SA, Nguyen ND, Center JR, Eisman JA, Nguyen TV. Excess mortality attributable to hip-fracture: a relative survival analysis. Bone 2013;56(1):23–9.

[3] Jiang J, Yang CH, Lin Q, Yun XD, Xia YY. Does arthroplasty provide better outcomes than internal fixation At mid- and long-term followup? A meta-analysis. Clin Orthop Relat Res 2015;473(8):2672–9.
[4] Hopley C, Stengel D, Ekkernkamp A, Wich M. Primary total hip arthroplasty versus hemiarthroplasty for displaced intracapsular hip fractures in older patients: systematic review. BMJ 2010;340:c2332.
[5] Le Manach Y, Collins G, Bhandari M, Bessissow A, Boddaert J, Khiami F, et al. Outcomes after hip fracture surgery compared with elective total hip replacement. JAMA 2015;314(11):1159–66.
[6] Baker PN, Salar O, Ollivere BJ, Forward DP, Weerasuriya N, Moppett IK, et al. Evolution of the hip fracture population: time to consider the future? A retrospective observational analysis. BMJ Open 2014;4(4).
[7] Panula J, Pihlajamäki H, Mattila VM, Jaatinen P, Vahlberg T, Aarnio P, 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-.
[8] Kärrholm J. The swedish hip arthroplasty register. Acta Orthop 2010;81(1):3–4. www.shpr.se).
[9] Thygesen LC, Ersboll AK. When the entire population is the sample: strengths and limitations in register-based epidemiology. Eur J Epidemiol 2014;29(8):551–8.
[10] Gillam MH, Ryan P, Salter A, Graves SE. Multi-state models and arthroplasty histories after unilateral total hip arthroplasties: introducing the Summary Notation for Arthroplasty Histories. Acta Orthop 2012;83(3):220–6.
[11] Cnudde PHJ, Nemes S, Bulow E, Timperley AJ, Whitehouse SL, Karrholm J, et al. Risk of further surgery on the same or opposite side and mortality after primary total hip arthroplasty: a multi-state analysis of 133,654 patients from the Swedish Hip Arthroplasty Register. Acta Orthop 2018;89(4):386–93.
[12] Cnudde P, Rolfson O, Nemes S, Karrholm J, Rehnberg C, Rogmark C, et al. Linking Swedish health data registers to establish a research database and a shared decision-making tool in hip replacement. BMC Musculoskelet Disord 2016;17(1):414.
[13] Inacio MC, Paxton EW, Dillon MT. Understanding orthopaedic registry studies: a comparison with clinical studies. J Bone Joint Surg Am 2016;98(1):e3.
[14] Andersen PK, Keiding N. Multi-state models for event history analysis. Stat Methods Med Res 2002;11(2):91–115.
[15] R Core Team. R: a language and environment for statistical computing. Vienna, Austria: R Foundation for Statistical Computing; 2018.
[16] Jackson C. Multi-state models for panel data: the msm package for r. J Stat Softw 2011;38(8):28.
[17] Gosch M, Hoffmann-Weltin Y, Roth T, Blauth M, Nicholas JA, Kammerlander C. Orthogeriatric co-management improves the outcome of long-term care residents with fragility fractures. Arch Orthop Trauma Surg 2016;136(10):1403–9.
[18] Lisk R, Yeong K. Reducing mortality from hip fractures: a systematic quality improvement programme. BMJ Qual Improv Rep 2014;3(1).
[19] Schroder HM, Erlandsen M. Age and sex as determinants of mortality after hip fracture: 3,895 patients followed for 2.5-18.5 years. (0890-5339 (Print)).
[20] Kannegaard PN, van der Mark S, Eiken P, Abrahamsen B. Excess mortality in men compared with women following a hip fracture. National analysis of comedications, comorbidity and survival. Age Ageing 2010;39(2):203–9.
[21] Smith T, Pelpola K, Ball M, Ong A, Myint PK. Pre-operative indicators for mortality following hip fracture surgery: a systematic review and meta-analysis. Age Ageing 2014;43(4):464–71.
[22] Hansson S, Nemes S, Kärrholm J, Rogmark C. Reduced risk of reoperation after treatment of femoral neck fractures with total hip arthroplasty. Acta Orthop 2017;88(5):500–4.
[23] Moerman S, Mathijssen NMC, Tuinebreijer WE, Vochteloo AJH, Nelissen RGHH. Hemiarthroplasty and total hip arthroplasty in 30,830 patients with hip fractures: data from the Dutch Arthroplasty Register on revision and risk factors for revision. Acta Orthop 2018;1–6.
[24] Thompson NR, Fan Y, Dalton JE, Jehi L, Rosenbaum BP, Vadera S, et al. A new elixhauser-based comorbidity summary measure to predict in-hospital mortality. Med Care 2015;53(4):374–9.
[25] Va P, Yang W-S, Nechuta S, Chow W-H, Cai H, Yang G, et al. Marital status and mortality among middle age and elderly men and women in urban Shanghai. PLoS One 2011;6(11) e26600.
[26] Sharma V, Awasthi B, Kumar K, Kohli N, Katoch P. Outcome analysis of hemiarthroplasty vs. Total hip replacement in displaced femoral neck fractures in the elderly. J Clin Diagn Res 2016;10(5) RC11-RC3.
[27] Aynardi M, Pulido L, Parvizi J, Sharkey PF, Rothman RH. Early mortality after modern total hip arthroplasty. Clin Orthop Relat Res 2009;467(1):213–8.
[28] Morsi E, Habib ME, Elseedy A, Eid T. Revision of failed hip hemiarthroplasty. Classification, management, and follow-up. J Orthop 2016;13(2):63–8.
[29] Liebs TR, Splietker F, Hassenpflug J. Is a revision a revision? An analysis of national arthroplasty registries' definitions of revision. Clin Orthop Relat Res 2015;473(11):3421–30.
[30] Rogmark C, Leonardsson O. Hip arthroplasty for the treatment of displaced fractures of the femoral neck in elderly patients. Bone Joint J 2016;98-b(3):291–7.
[31] Enocson A, Tidermark J, Tornkvist H, Lapidus LJ. Dislocation of hemiarthroplasty after femoral neck fracture: better outcome after the anterolateral approach in a prospective cohort study on 739 consecutive hips. Acta Orthop 2008;79(2):211–7.
[32] Svenøy S, Westberg M, Figved W, Valland H, Brun OC, Wangen H, et al. Posterior versus lateral approach for hemiarthroplasty after femoral neck fracture: early complications in a prospective cohort of 583 patients. Injury 2017;48(7):1565–9.
[33] Rogmark C, Fenstad AM, Leonardsson O, Engesæter LB, Kärrholm J, Furnes O, et al. Posterior approach and uncemented stems increases the risk of reoperation after hemiarthroplasties in elderly hip fracture patients. Acta Orthop 2014;85(1):18–25.
[34] Mukka S, Knutsson B, Majeed A, Sayed-Noor AS. Reduced revision rate and maintained function after hip arthroplasty for femoral neck fractures after transition from posterolateral to direct lateral approach. Acta Orthop 2017;88(6):627–33.
[35] Kristensen TB, Vinje T, Havelin LI, Engesæter LB, Gjertsen J-E. Posterior approach compared to direct lateral approach resulted in better patient-reported outcome after hemiarthroplasty for femoral neck fracture: 20,908 patients from the Norwegian Hip Fracture Register. Acta Orthop 2017;88(1):29–34.
[36] Kärrholm JLH, Malchau H, Mohaddes M, Nemes S, Rogmark C. Rolfson O. Swedish hip arthroplasty register 2016. 2018.
[37] Lacny S, Wilson T, Clement F, Roberts DJ, Faris PD, Ghali WA, et al. Kaplan-meier survival analysis overestimates the risk of revision arthroplasty: a meta-analysis. Clin Orthop Relat Res 2015;473(11):3431–42.
[38] SHAR. Svenska Höftprotesregistret, Årsrapport 2017, För Verksamhetsåret 2017 2018.
[39] Neuman MD. How clinical registries can make a difference in hip fracture care. Anaesthesia 2016;71(5):497–501.
[40] Johansen A, Golding D, Brent L, Close J, Gjertsen J-E, Holt G, et al. Using national hip fracture registries and audit databases to develop an international perspective. Injury 2017;48(10):2174–9.