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The impact of cement fixation on early mortality in arthroplasty for hip fracture

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Aims
Cementing in arthroplasty for hip fracture is associated with improved postoperative function, but may have an increased risk of early mortality compared to uncemented fixation. Quantifying this mortality risk is important in providing safe patient care. This study investigated the association between cement use in arthroplasty and mortality at 30 days and one year in patients aged 50 years and over with hip fracture.

Methods
This retrospective cohort study used linked data from the Australian Hip Fracture Registry and the National Death Index. Descriptive analysis and Kaplan-Meier survival curves tested the unadjusted association of mortality between cemented and uncemented procedures. Multilevel logistic regression, adjusted for covariates, tested the association between cement use and 30-day mortality following arthroplasty. Given the known institutional variation in preference for cemented fixation, an instrumental variable analysis was also performed to minimize the effect of unknown confounders. Adjusted Cox modelling analyzed the association between cement use and mortality at 30 days and one year following surgery.

Results
The 30-day mortality was 6.9% for cemented and 4.9% for uncemented groups (p = 0.003). Cement use was significantly associated with 30-day mortality in the Kaplan-Meier survival curve (p = 0.003). After adjusting for covariates, no significant association between cement use and 30-day mortality was shown in the adjusted multilevel logistic regression (odd rati0 (OR) 1.1, 95% confidence interval (CI) 0.9 to 1.5; p = 0.366), or in the instrumental variable analysis (OR 1.0, 95% CI 0.9 to 1.0, p=0.524). There was no significant between-group difference in mortality within 30days (hazard ratio (HR) 0.9, 95% CI 0.7to 1.1; p = 0.355) or one year (HR 0.9 95% CI 0.8 to 1.1; p = 0.328) in the Cox modelling.

Conclusion
No statistically significant difference in patient mortality with cement use in arthroplasty was demonstrated in this population, once adjusted for covariates. This study concludes that cementing in arthroplasty for hip fracture is a safe means of surgical fixation.

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Keywords: hip fracture, arthroplasty, hemiarthroplasty, total hip replacement, cement, surgery, mortality

Introduction
Fractures in older people place considerable stress on individuals, communities, and healthcare systems globally. Across Australia, over 18,000 people present annually with hip fractures,[1-3] and mortality following hip fracture within 30 days of surgery averages 7%, with most of these deaths occurring during the index hospitalization for the injury.[2] As falls and fractures become more prevalent with advancing age, the ongoing burden of hip fracture is expected to increase.[3-5]

Most people presenting with hip fracture in Australia undergo surgery as definitive management. However, variation in surgical practice exists. Undisplaced intracapsular femoral fractures are often treated with internal fixation to stabilize the fracture, whereas hemiarthroplasty (partial hip arthroplasty) or total hip arthroplasty (THA)

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Table I. BCIS classification, associated incidence, and mortality.[18,22]

Grade	Definition	Incidence, %	30-day mortality rate, %	One-year mortality rate, %
0	No BCIS	72	5.2	25.2
1	Moderate hypoxia (arterial oxygen saturation < 94%) or hypotension (decrease in SAP > 20%)	21	9.3	29.9
2	Severe hypoxia (arterial oxygen saturation < 88%) or hypotension (decrease in SAP > 40%)	5.1	35	48.1
3	Cardiovascular collapse requiring cardiopulmonary resuscitation	1.7	88	94.1

BCIS, bone cement implantation syndrome; SAP, systolic arterial pressure.

are more common when the fracture is displaced.[6-8] This decision between fixation and arthroplasty of the femoral head is partly attributed to the risk of developing femoral head avascular necrosis and nonunion secondary to compromised blood supply as a result of the fracture.[6,7] In addition to type of implant, there is substantial variation in the use of cement for the femoral stem, with hospital use of cement fixation in Australia varying from 38% to 86% in arthroplasty procedures for intracapsular femoral fracture.[2]

Cemented arthroplasty is associated with less pain, improved mobility, and reduced need for revision surgery.[9-13] For these reasons, cemented implants for surgical arthroplasty are recommended for people with hip fracture.[7,8,10,11,14,15] However, using cement fixation is not without its risk. Bone cement implantation syndrome (BCIS) is an important complication associated with cement fixation due to the potential formation of fat emboli, which may cause hypoxia, loss of consciousness, systemic hypotension, pulmonary hypertension, cardiac arrest, or death secondary to massive pulmonary emboli.[11,16,17] The severity of BCIS can vary, as shown in Table I. The observed incidence of BCIS after cemented femoral stem insertion is up to 28%; however, this is mostly a mild occurrence, with only 1.7% of cases leading to cardiovascular collapse.[10,18] While the mortality risk of BCIS has been associated with poorer perioperative survival within the first day of surgery,[10] studies have also demonstrated no excess mortality risk with cement use in people with hip fracture at 90 days or one year.[19,20] Given these inconsistencies in research findings, and the potential for increased risk of early mortality, especially in those people considered medically complex, the safety of cement use in arthroplasty for femoral neck fracture warrants further investigation.[16,21]

The primary aim of this study was to determine the association between cement use in arthroplasty and 30-day mortality for people aged 50 years and older with intracapsular femoral neck fracture in an Australia population. The secondary aim was to analyze this association over the first year following surgery.

Methods

Study design and data sources. This is a retrospective cohort study using linked data from the Australian Hip Fracture Registry (AHFR) and the Australian Institute of Health and Welfare (AIHW) National Death Index (NDI). The AHFR collects individual and facility level data on hip fracture hospitalizations across Australia, with the purpose of driving improvement in clinical care and ultimately patient outcomes.[1] People are eligible for inclusion if they are aged 50 years and older and are admitted to hospital with a low trauma hip fracture. Currently, the AHFR contains more than 64,890 records from 81 hospitals, representing almost three quarters of Australian public hospitals that operate on hip fracture.[1] In addition, the AHFR undertakes an annual linkage of the Australian hospital dataset with the AIHW NDI, creating a linked resource for mortality following hip fracture.[8]

Case selection. The study cohort comprised people aged 50 years and older admitted to an Australian hospital with an intracapsular femoral neck fracture and treated with an arthroplasty (both THA and hemiarthroplasty) with or without cemented fixation between 1 January 2016 and 31 December 2020.

Stastical analysis. The primary outcome of interest was mortality within 30 days of surgery and the secondary outcome was mortality within one year of surgery.

Covariates that have been shown to be associated with mortality in hip fracture were selected, including age group, sex, American Society of Anaesthesiologists (ASA) classification, usual place of residence, preadmission cognitive status, and preadmission walking ability. These variables were based on clinician review of data variables available through the AHFR and informed by other studies.[23]

Descriptive analysis was undertaken using SAS 8.3 Enterprise Guide (SAS Institute, USA) to show between group differences in mortality based on use of cement at the time of the surgical procedure. Kaplan-Meier survival analysis was used to show the unadjusted difference in mortality between groups within 30 days and one year from date of surgery.

The primary analysis used multilevel logistic regression to test the association (expressed as an odds ratio (OR) and 95% confidence interval (CI) between cement use and 30-day mortality, adjusted for covariates and hospital-level clustering. Given the known institutional variation, an instrumental variable analysis was performed using

Table II. Descriptive characteristics for neck of femur fractures receiving arthroplasty in AHFR dataset in patients aged 50 years and over from 2016 to 2020 (n = 15,405).

Variable	Stem cemented, n (%)	Stem uncemented, n (%)	Total cohort, n (%)	Missing, n (%)	Test statistics*
Cohort size	13,827 (89.8)	1,578 (10.2)	15,405		
Sex					
Female	9,366 (67.8)	1,060 (67.2)	10,426 (67.7)	9 (< 0.1)	X^2 = 2.391, df = 1, p = 0.625
Male	4,452 (32.2)	518 (32.8)	4,970,(32.3)		
Age, yrs					
Mean (SD)	82.1 (9.3)	78.7 (10.9)	81.8 (9.6)	0 (0.0)	t = 12.1, df = 1,853, p < 0.0001
50 to 64	687 (5.0)	176 (11.2)	863 (5.6)		X^2 = 223.8, df = 4, p < 0.0001
65 to 74	2,136 (15.5)	395 (25.0)	2,531 (16.4)		
75 to 84	4,682 (33.8)	455 (28.8)	5,137 (33.3)		
85 to 94	5,462 (39.5)	470 (30.0)	5,932 (38.5)		
95 and over	860 (6.2)	82 (5.2)	942 (6.1)		
Place of residence					
Private residence (including unit in retirement village)	9,767 (71.4)	1,248 (80.0)	11,015 (72.3)	161 (1.0)	X^2 = 51.3, df = 1, p < 0.0001
Residential aged care facility	3,916 (28.6)	313 (20.0)	4,229 (27.7)		
Premorbid level of function					
Usually walks without walking aids	6,334 (47.7)	926 (59.1)	7,434 (48.9)	202 (1.3)	X^2 = 80.0, df = 3, p < 0.0001
Usually walks with either a stick or crutch	1,614 (11.8)	177 (11.3)	1,791 (11.8)		
Usually walks with two aids or frame (with or without assistance of a person)	5,102 (37.4)	427 (27.3)	5,529 (36.4)		
Usually uses a wheelchair/bed-bound	413 (3.0)	36 (2.3)	449 (2.9)		
Preadmission cognitive function					
Normal cognition	8,160 (60.8)	1,083 (70.9)	9,243 (61.8)	448 (2.9)	X^2 = 59.4 df = 1, p < 0.0001
Impaired cognition or known dementia	5,269 (39.2)	445 (29.1)	5,714 (38.2)		
Type of arthroplasty					
Hemiarthroplasty	11,060 (80.0)	943 (59.8)	12,003 (77.9)	0 (0.0)	X^2 = 15,405 df = 3, p < 0.0001
THA	2,767 (20.0)	635 (40.2)	3,402 (22.1)		
ASA grade					
1	184 (1.5)	46 (3.3)	230 (1.6)	1,336 (0.9)	X^2 = 85.3 df = 4, p < 0.0001
2	2,076 (16.4)	335 (23.9)	2,411 (17.1)		
3	7,500 (59.2)	723 (51.5)	8,223 (58.5)		
4	2,864 (22.6)	291 (20.7)	3,155 (22.4)		
5	41 (0.3)	9 (0.6)	50 (0.4)		
Mortality at 30 days					
Survival	12,508 (93.1)	1,470 (95.1)	13,978 (93.3)	426 (2.8)	X^2 = 8.6, df = 1, p = 0.003
Death	925 (6.9)	76 (4.9)	1,001 (6.7)		
Mortality at one year					
Survival	7747 (76.8)	1,003 (81.8)	8,780 (77.3)	4091 (26.6)	X^2 = 15.7, df = 1, p < 0.001
Death	2,341 (23.2)	223 (18.2)	2,564 (22.7)		

*Please note the following abbreviations have been used in this table: Chi squared test (X^2); degrees of freedom (df); and p-value (p) .
AHFR, Australian Hip Fracture Registry; ASA, American Society of Anesthesiologists; SD, standard deviation.

hospital preference for cement fixation as the instrument and individual 30-day mortality as the outcome. This was conducted in R Environment for Statistical Computing (R Foundation for Statistical Computing, Austria). Instrumental variable analysis does not rely on the assumption of no unmeasured confounding and allows casual inference from observational data. To further explore the association within the 30-day period, Cox proportional hazard modelling was used (expressed as hazard ratio (HR) and 95% CI), adjusted for covariates.

Analyses were performed to explore whether the findings of the model continued at one year. Cox's proportional hazard modelling was used to test the association (expressed as HR and 95% CI) between cement use and mortality within one year following surgery, adjusting for the covariates listed above. A p-value < 0.05 was

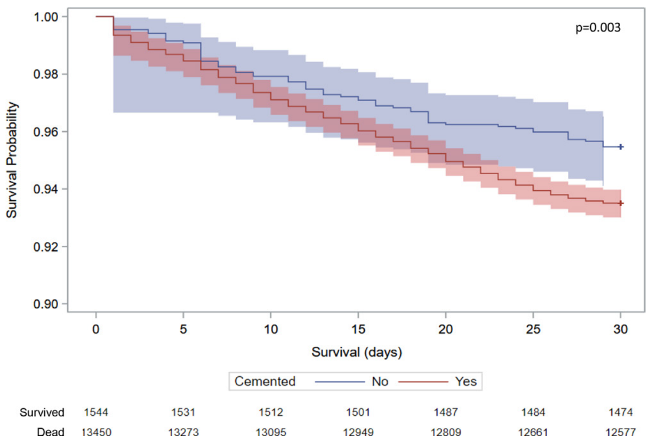

Fig. 1

Patient mortality in cemented and uncemented groups within 30 days of date of surgery (95% confidence interval; p = 0.003).

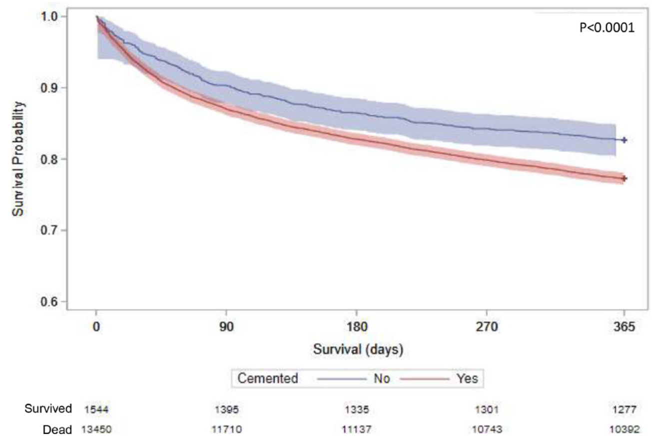

Fig. 2

Patient mortality in cemented and uncemented groups within one year of date of surgery (95% confidence interval; p < 0.0001).

considered statistically significant for all analyses in this study.

This study was granted ethical approval by the University of New South Wales Human Research Advisory Panel (HC210482).

Results

The study included 15,405 records of cases undergoing arthroplasty surgery for hip fracture. The significant differences in demographic characteristics between the cemented and uncemented groups are shown in Table II. The mean age was 81.8 years (standard deviation 9.6), 10,426 (67.7%) were female, and 11,015 (72.3%) were from private residence. Overall, 25 cases were excluded as the date of death preceded the date of hospital presentation. In this study, 12,003 (77.9%) underwent hemiarthroplasty, and the remaining 3,402 cases (22.1%) underwent a THA. Of the cases undergoing hemiarthroplasty, 11,060 (92.2%) were cemented, and of the cases undergoing THA, 2,767 (81.3%) were cemented. Cemented stem fixation was statistically more likely in people who were older, living in residential aged care facilities, requiring an assistive device to walk, cognitively impaired, and had a higher ASA score (Table II). There was no difference in use of cement fixation and sex.

As shown in Figure 1, the Kaplan-Meier survival curve demonstrated a significant difference in 30-day mortality following surgery with cement use (p = 0.003). As shown in Figure 2, there was no significant difference in mortality within one year of surgery (p = 0.0001).

In the unadjusted regression model, there was a significant increase in 30-day mortality following arthroplasty for patients receiving cemented compared to uncemented fixation (925 (6.9%) vs 76 (4.9%), respectively (p = 0.003). The one-year mortality following arthroplasty was also increased for patients receiving cemented fixation (2,341 (23.2) vs 223 (18.2), respectively (p < 0.0001, in the unadjusted regression model).

The primary analysis looking at 30-day mortality using adjusted multilevel logistic regression demonstrated no significant difference in mortality for the cemented group compared to the uncemented group (OR 1.1, 95% CI 0.9 to 1.5; p = 0.366) (Table III). The adjusted Cox proportional hazard modelling for patient mortality at 30 days showed no significant difference (HR 0.9, 95% CI 0.7 to 1.1; p = 0.355).

Instrumental variable analysis of 15,017 observations revealed that cement use was not significantly associated with 30-day mortality (OR 1.0, 95% CI 0.9 to 1.0; p = 0.524). The test for weak instrument had a very low p-value (p < 0.001), meaning that hospital preference was a strong predictor of cement use and therefore suitable for use as the instrument in this analysis.

The multilevel logistic regression demonstrated no significant difference at one year between the two intervention groups (OR 1.2, 95% CI 1.0 to 1.5; p = 0.107 (n = 9,766). Adjusted Cox regression showed no significant difference in mortality between groups at one year (HR 0.9, 95% CI 0.8 to 1.1; p = 0.328 (n = 9,751).

Discussion

This study has demonstrated that use of a cemented stem in arthroplasty following hip fracture is not associated with an increase in 30-day or one year mortality following surgery, when adjusting for known and unknown covariates.

The main findings are consistent with recent studies.[14,19,20] Pedersen et al[19] similarly showed, in a population of 188,606 THA patients, an increased rate in cumulative mortality when comparing cement use within 90 days; however, once adjusted for covariates, there was no significant between group difference in mortality within 14, 30, or 90 days. Fernandez et al[14] demonstrated,

Table III. Adjusted multilevel logistic regression (n = 13,007) and adjusted Cox's proportional hazards (n = 12,992) regression modelling of the association between 30-day mortality, and individual characteristics for neck of femur fractures receiving arthroplasty in AHFR dataset in people aged 50 years and over.

Variable	Adjusted multilevel logistic regression		Adjusted Cox's proportional hazards regression	
Cement use	**OR (95% CI)**	**p-value**	**HR (95% CI)**	**p-value**
Uncemented	Ref			
Cemented	1.1 (0.9 to 1.5)	0.366	0.9 (0.7 to 1.1)	0.355
Sex				
Female	Ref			
Male	2.2 (1.9 to 2.5)	< 0.0001	2.0 (1.8 to 2.3)	< 0.0001
Age, yrs				
50 to 64	Ref			
65 to 74	1.8 (0.9 to 3.5)	0.103	1.7 (0.9 to 3.4)	0.105
75 to 84	2.2 (1.1 to 4.2)	0.019	2.2 (1.1 to 4.1)	0.019
85 to 94	3.1 (1.6 to 5.9)	0.0007	2.9 (1.6 to 5.5)	0.0008
95 and over	3.9 (2.0 to 7.7)	0.0001	3.5 (1.8 to 6.7)	0.0002
Place of residence				
Private residence (including unit in retirement village)	Ref			
Residential aged care facility	2.1 (1.7 to 2.5)	< 0.0001	1.9 (1.6 to 2.3)	< 0.0001
Premorbid level of function				
Usually walks without walking aids	Ref			
Usually walks with either a stick or crutch	1.5 (1.1 to 1.9)	0.007	1.4 (1.1 to 1.8)	0.007
Usually walks with two aids or frame (with or without assistance of a person)	1.5 (1.3 to 1.9)	< 0.0001	1.5 (1.2 to 1.8)	< 0.0001
Usually uses a wheelchair/bed-bound	1.4 (1.0 to 2.0)	0.081	1.5 (1.2 to 1.8)	0.079
Preadmission cognitive function				
Normal cognition	Ref			
Impaired cognition or known dementia	1.6 (1.3 to 1.9)	< 0.001	1.5 (1.3 to 1.8)	< 0.0001
ASA grade				
1	Ref			
2	0.4 (0.2 to 1.1)	0.075	0.4 (0.2 to 1.1)	0.071
3	1.1 (0.4 to 2.8)	0.852	1.1 (0.5 to 2.7)	0.799
4	2.8 (1.1 to 7.1)	0.031	2.6 (1.1 to 6.3)	0.034
5	5.2 (1.6 to 16.6)	0.0006	4.8 (1.7 to 13.6)	0.004

AHFR, Australian Hip Fracture Registry; ASA, American Society of Anesthesiologists; CI, confidence interval; HR, hazard ratio; OR, odds ratio.

in a population of 1,225 patients, that mortality did not differ significantly with cement use in hemiarthroplasty at one year. Further to this, a Cochrane review of 15 studies (3,727 participants) by Lewis et al[24] demonstrated a reduction in the risk of mortality at 12 months with the use of cement in hemiarthroplasty.

This differs from Costain et al[25], in a study of approximately 25,000 cases, that demonstrated an associated 1.7-times higher day one mortality in cemented monoblock hemiarthroplasty compared to uncemented. This increase in mortality risk with cement use was not present at one week, one month, and at one year cement use was associated with lower mortality compared to uncemented hemiarthroplasty.[25] The cause of this early day one increase in mortality may be attributed to BCIS occurrence; however, cause of death was not reported.[25]

BCIS has been observed to be common in cemented arthroplasty, and although severe BCIS is considered uncommon, it has been associated with an increased risk of early mortality. Rassir et al,[16] in a study of 3,294 procedures, demonstrated severe BCIS in 8.4% of arthroplasty and 5% of THA cases performed, with a hazard ratio of 3.46 (95% CI 2.07 to 5.77) of death within 30 days in these cases. While recognizing that cause of death was not known in this study, the Kaplan-Meier survival analysis in this study did not reveal any such point in time where mortality rate increased between the two groups to suggest a role of BCIS. However, despite the established increased risk of BCIS in patients with poor cardiorespiratory reserve and higher ASA classification,[10] this study revealed a tendency towards cement use in patients who were significantly older with lower function and independence pre-morbidly. The reasons for this surgical choice cannot be determined by this study, but may be related to poorer bone quality in this patient group and the desire to minimize risk of periprosthetic fracture, femoral implant loosening, and reoperation. In our study, these patient factors were not associated with a higher risk of mortality when comparing cement use despite their association with severe BCIS in other studies.[10,16]

Although our results did not suggest an increase in early perioperative mortality secondary to BCIS in patients undergoing cemented arthroplasty, strategies to minimize the risk of BCIS in this group should be acknowledged.[15,26]

The strengths of the study include the large population-based design with a national cohort. This eliminates selection and recall biases, as well as those lost to follow-up. Furthermore, the findings of this study are generalizable to the Australian population. The study is also strengthened by the consistent findings using different analytic methods, including logistic regression and Cox regression. Instrumental variable analysis based on hospital preference for use of cement identified no causal effect of cement use in arthroplasty on mortality, further strengthening the findings of the analyses in this study. The effect of unknown confounders is minimized by the instrumental variable analysis. The limitations of this study include the retrospective, observational nature of the data. Assessment data validity from the AHFR was not possible, thus some data may be subject to clinical judgement, such as ASA classification or premorbid cognitive status. Limited information was available regarding patient morbidity, cause of death, and admission complications. Assessing data integrity was not possible, thus identifying and excluding misclassified records was carried out where possible. Lastly, data analysis was limited by the availability of data, such as mortality data, which was not available for New Zealand in the study period, limiting the findings to an Australian population. However, given the similar nature of the New Zealand hip fracture population, it would be reasonable extrapolation to suggest that these findings can also be applied to a New Zealand population.

Quantifying the mortality risk of cement use, as demonstrated by the findings of this study, is important as the evidence already establishes that the use of a cemented stem is associated with improved postoperative function in terms of reduced pain, improved mobility, and reduced requirements for surgical revision.[9–14,16,17,24]

In conclusion, there is no significant association between the use of cement in arthroplasty for hip fracture and 30-day or one-year mortality. In this context, and the context of established clinical postoperative benefits of cement use, this study concludes that the use of cement arthroplasty is a safe and effective means of surgical fixation within the hip fracture population. In any case, adopting sensible precautions is recommended to ensure prompt management BCIS should it occur.

Take home message

- This study showed no significant association between the use of cement and mortality at 30 days and one year in arthroplasty for hip fracture.
- Given the established clinical postoperative benefits of cement use, these findings support the use of cement arthroplasty is a safe and effective means of surgical fixation within the hip fracture population.

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