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Geographical variation in surgical care and mortality following hip fracture in England: a cohort study using the National Hip Fracture Database (NHFD)

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Abstract

Purpose

To describe geographical variation in type of operation performed and 30-day mortality among patients with hip fracture in England.

Methods

A prospective cohort study using a national clinical registry; the National Hip Fracture Database (NHFD) which captures data on nearly all over-60 year olds with hip fracture in England. These data were linked to Hospital Episode Statistics (HES), allowing us to explore regional variation in the operations performed for three fracture types (intracapsular, trochanteric and subtrochanteric), and use logistic regression models adjusted for demographic and clinical factors to describe associated 30-day mortality.

Results

NHFD recorded data for 64,211 patients who underwent surgery in England during 2017. Most had an intracapsular (59%) or trochanteric fracture (35%), and we found significant geographical variation across regions of England in use of total hip replacement (THR) (ranging from 10.1 to 17.4%) for intracapsular fracture and in intermedullary nailing (ranging from 14.9 to 27.0%) of trochanteric fracture. Some geographical variation in mortality among intracapsular fracture patients was found, with slightly higher mortality in the East of England (adjusted odds ratio [aOR]: 1.22, 95% CI: 1.02-1.46). Trochanteric fractures showed slightly more variation, with higher 30-day mortality (aOR: 1.40, 95%CI: 1.05-1.88) in the East of England and significantly lower mortality in the North East (aOR: 0.65, 95%CI: 0.46-0.93).

Conclusions

We have identified regional differences in operation type and 30-day mortality among hip fracture patients in England. The relationship between surgical approach and mortality has been explored, but the extent to which differential mortality reflects variation in approach to medical assessment, anaesthesia and other aspects of care warrants further investigation.

Key words: hip fracture, surgery, geographical variation, mortality, epidemiology

Mini Abstract

We describe variation across geographical regions of England in operations undertaken following presentation of hip fracture and in 30-day mortality. Some significant geographic variation in 30-day mortality was observed particularly for patients with trochanteric hip fractures and warrants further investigation of other aspects of post-hip fracture care

Declarations

This work was performed as part of a Royal College of Physicians (RCP) audit programme commissioned by the HealthCare Quality Improvement Partnership (HQIP). This study was also supported by the NIHR Biomedical Research Centre (BRC) at the University Hospitals Bristol NHS Foundation Trust and the University of Bristol, and from the Oxford NIHR Musculoskeletal BRC, Nuffield Orthopaedic Centre, and University of Oxford. The views and opinions expressed herein are those of the authors and do not necessarily reflect those of the NHS or the Department of Health. The funding source had no role in the design and conduct of the study, in the collection, analysis and interpretation of the data, or in the preparation, review or approval of the manuscript.

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Introduction

During 2016 a total of 65,645 hip fracture patients aged 60 years or over presented to 177 hospitals in England, Wales and Northern Ireland, costing the National Health Service (NHS) and social care more than £1 billion per year (1, 2).

The number of patients dying within 30 days of hip fracture has decreased from 10.9% in 2007 to 6.1% in 2018 (3). A number of initiatives have likely been instrumental in this. In 2004 the British Orthopaedic Association (BOA) and the British Geriatrics Society (BGS) collaborated to establish the National Hip Fracture Database (NHFD) (4), to improve hip fracture care through continuous national audit (5), and in 2007 to issue clinical standards for the care of fragility fracture (6). In 2010 the Department of Health developed 'payment by results'; financially rewarding hospitals for each patient whose care met key standards, such as provision of surgery within 36 hours of presentation (7). These initiatives aim to reduce variation in treatment and outcomes for hip fracture patients, and have been shown to lead to reduced hospital-level mortality rates following changes to models of post-hip fracture care (8).

Notwithstanding these advances, variation in hip fracture care persists. Inequalities in the use of total hip arthroplasty for hip fracture has been found between hospitals during 2011-14 using the NHFD (9). Likewise, the likelihood of prompt hip fracture surgery has been shown to vary according to day and time of patient's presentation (10). Furthermore, despite publication of the National Institute for Health and Care Excellence (NICE) guidance on recommendations for anti-osteoporosis drugs following a hip fracture having been shown to be associated with fewer secondary fractures (11), significant geographic variation in prescribing has still been documented in the United Kingdom (UK) (12).

Given this background, this England-based study set out to describe use of different operative procedures in different hospitals and different geographic regions according to hip fracture type, and to describe associated 30-day mortality.

Methods

This prospective cohort study used data collected by the NHFD; the national clinical audit of hip fracture care in England, Wales and Northern Ireland. The analysis was undertaken as part of the NHFD's annual reporting process. Research ethics committee approval was not sought for secondary analysis of administrative data in line with Governance Arrangements for Research Ethics Committee (GAfREC) guidance.

Data sources

The NHFD captures data on over 97% of over 60 year old hip fracture patients in England. Data on patient characteristics, type of hip fracture, surgical care and outcomes are collected and submitted by specialist nurses and other clinical staff who provide care to these patients in each hospital. These data were supplemented with Charlson Comorbidity Score and Index of Multiple Deprivation (IMD) (13) obtained from Hospital Episode Statistics (HES) records, which we linked to NHFD data using patient identifiers and admission date. Each time a patient is admitted to hospital, a record or 'episode' is created and added to the HES database. The Charlson Comorbidity Index is a method of categorising comorbidities of patients based on the International Classification of Diseases (ICD) diagnosis codes. The IMD is an ecological measure of socio-economic status that was linked to the Lower Super-Output Area of the patient's postcode of diagnosis. It is categorised in five groups by quintiles (from 1 'most affluent' to 5 'most deprived'). Patients' details and NHS number were passed to the NHS Personal Demographics Service, who provided the date of death as recorded on patients' death certificates, from the Office for National Statistics.

Study population

This study included all patients aged 60 years or over who presented with hip fracture in England during 2017. Hip fractures were classified as intracapsular, trochanteric and subtrochanteric. Descriptive NHFD data include gender, age (categorised as 60-64, 65-69, 70-74, 75-79, 80-84, 85-89, 90-94, 95-99 and 100 years or more), residence at admission (own home or sheltered housing, not home or missing), previous mobility (ranging from 'freely mobile without aids' to 'some indoor mobility or no functional mobility'), date of presentation, treating hospital, geographical region, time to surgery (categorised as <36 or >36 hours), and length of stay. Physical status is recorded using the American Society of Anaesthesiologists (ASA) grade, which ranges from 1 (healthy) to 5 (moribund, and not expected to live for >24 hours). The outcome of interest was death within 30 days of presentation with a hip fracture.

Statistical analysis

Descriptive statistics were used to summarise patients' demographic and clinical factors; stratified by fracture type and surgical procedure. Geographical variation in surgical procedure

was examined using Chi-squared tests. Geographic region and other risk factors for 30-day mortality were included *a priori* in logistic regression models, including gender, age group, Charlson comorbidity score, Index of Multiple Deprivation, admission source, ASA grade, pre-injury mobility, time to surgery and operation type. These models were run separately according to fracture type, with the largest region (the North West) used as the reference category. Final multivariable models, including all *a priori* covariates as potential confounding factors (14), were conducted using a complete case regression model that accounted for clustering by hospital using generalised estimating equations (GEE) using a population average approach (15). Multivariable logistic regression models were used to generate predicted values for 30-day mortality and the association between these and hospital-level rates of common surgical procedures was assessed using linear regression. Analyses were conducted using STATA v15.1.

Results

The NHFD recorded 64,211 patients presenting with hip fracture in England in 2017 (Table 1). Most had an intracapsular (59%) or a trochanteric fracture (35%). Their mean age was 82.8 years; 71% were female. Most were admitted from their own home or sheltered housing (81%), most had an ASA grade of 3 (56%), most were freely mobile or mobile outdoors with aids (73%), and most received surgery within 36 hours of presentation (71%). The median length of hospital stay was 15 days (inter-quartile range: 9-25 days). We successfully linked NHFD data with the associated HES record for 86% of all patients, to obtain the Charlson comorbidity score, and the IMD.

Intracapsular fractures

Of the 37,617 patients with an intracapsular fracture, 72% received a hemiarthroplasty, 13% a total hip replacement (THR) (Supplementary Table 1), and 12% internal fixation. THR patients were younger than those receiving a hemiarthroplasty or other surgery (median age 74, *cf.* 84 years), and had a lower Charlson co-morbidity index (55% with an index of 0, *cf.* 26%), and were more affluent (45% within quintiles 1 or 2 of the IMD *cf.* 37%) (Supplementary Table 1).

We found significant geographical variation ($p<0.001$) in surgical approach, with the proportion receiving THR ranging from 10.1% to 17.4% (Figure 1a) in different regions; reflecting huge variation (0% to 34%) in different hospitals (Figure 2).

We found a significantly lower 30-day mortality (both before and after case-mix adjustment) for patients receiving a THR (adjusted Odds Ratio (aOR): 0.63, 95% confidence interval [95%CI]: 0.45-0.88) compared with patients receiving hemi-arthroplasty (Supplementary Table 2). Mortality was unsurprisingly much higher if no operation was performed (aOR: 6.84, 95% CI: 5.02-9.32).

At the hospital level we observed a significant association (p=0.006) between rates of THR and predicted 30-day mortality, with a tendency for hospitals performing more THRs to record slightly lower mortality (Figure 3A). However, after adjustment for all factors only minor geographical variation in mortality was apparent between regions, with the East of England region having slightly higher 30-day mortality (aOR: 1.22, 95% CI: 1.02-1.46) compared with the reference region (North West) (Figure 4, Supplementary Table 2). All other factors included in the regression model were significantly associated with 30-day mortality except IMD. Higher mortality was seen in men, older patients, those with comorbidities, those admitted from institutional care, those with higher ASA grade, with poorer mobility or with a time to surgery of more than 36 hours (Supplementary Table 2).

In post-hoc analyses, where 30-day mortality estimates were stratified by gender, results were largely unchanged (Supplementary Figure 3), although these suggested some divergence by gender among intracapsular fracture patients in the South Central (men: aOR:1.48 [95%CI: 0.97-2.27] *vs.* women: aOR: 0.72 [95%CI: 0.46-1.14]) and West Midlands (men: aOR: 1.51 [95%CI: 1.08-2.12] *vs.* women: aOR: 0.87 [95%CI: 0.66-1.13]).

Trochanteric fractures

Of 22,770 patients with a trochanteric fracture, 74% received internal fixation with a sliding hip screw and 22% with an intramedullary nail (Table 1). We found significant regional variation in the surgical approach (p<0.001, Figure 1b), with the proportion receiving intramedullary nails ranging from 14.9% to 27.0% across different regions. Between different hospitals the corresponding ranges were from 0% to 96.4% (Figure 3b).

Surgical approach to trochanteric fractures had no impact on 30-day mortality, either before or after case-mix adjustment (Supplementary Table 2). Again, mortality was much higher if no operation was performed (aOR: 14.51, 95% CI: 8.91-23.63). There was no association between hospitals' 30-day mortality figures and their rate of using intermedullary nails (p=0.67) (Figure 3b).

There was some significant geographical variation (Figure 4), with higher 30-day mortality in the East of England (aOR: 1.40, 95% CI: 1.05-1.88) and significantly lower (aOR: 0.65, 95%CI: 0.46-0.93) in the North East.

Subtrochanteric fractures

Just 3,709 patients (6%) presented with a subtrochanteric fracture. The majority (86%) received internal fixation with an intramedullary nail (Table 1, Supplementary Figure 1A). The North East reported more hemi-arthroplasty operations than expected for this fracture type, although further investigation indicated this was due to a single hospital site having a likely local coding issue that has since been rectified. Mortality was again higher for patients who had no operation (aOR:12.98; 95% CI: 3.99-42.17), but type of operation showed no association with mortality (Supplementary Table 3).

Little geographical variation in mortality was found for patients with subtrochanteric fracture (Figure 4), apart from patients in one region having slightly higher 30-day mortality with borderline statistical significance (aOR: 1.71, 95% CI: 0.99-2.96). There was no association between hospital rates of surgical procedures used and 30-day mortality (Supplementary Figure 1B & 1C). Other factors associated with higher mortality were male gender, older age, comorbidities, poor mobility and ASA grade (Supplementary Table 3).

Discussion

Among a large national cohort of hip fracture patients, we set out to examine geographical variation in both the operations patients receive and in 30-day mortality. We found considerable variation in surgical approach between different hospitals and different geographical regions; specifically in the use of THR for intracapsular fractures, and of intramedullary nails for trochanteric fractures. While some regional differences in 30-day mortality rates were identified for each of the three fracture types, this was generally less pronounced relative to other patient factors examined and evidence for an association between hospital site rates of particular surgical procedures and corresponding 30-day mortality rates was only found for THR usage, with greater usage of THR being associated with slightly reduced 30-day mortality.

The type of hip fracture that a patient has will influence the type of surgery that they receive, such as a partial or total hip replacement, or fixation with plates, screws and rods. The availability of suitably experienced hip surgeons to perform different types of operations may

therefore influence geographic variation in surgery (9). There is variation between surgeons and units such that all types of operations have been used for all types of fractures, even if only occasionally or in smaller numbers. A recent systematic review has summarised many of the factors in the literature which may contribute to geographical variations following hip fracture and summarised their mechanisms (16). For example, patients admitted from a care home are more complex with more comorbidity, and pre-injury mobility is another marker of patient complexity and morbidity. Men, older adults and patients with comorbidities more often require medical stabilisation before surgery.

While the extent of geographical variation in hip fracture surgical procedures has not previously been described in England (in which context our study offers a helpful development), our findings are supported by prior UK reports of inequalities in usage of THR for intracapsular hip fracture (9). Regional variation in surgical practice may be surprising given the presence of clear national guidance from NICE which aims to standardise care, although poor compliance with aspects of this guidance has been previously noted (9). Such variation may also be reinforced through orthopaedic training in the UK usually involving trainees staying in one geographical region throughout their speciality training years and thereby potentially contributing to maintaining regional preferences.

Our finding of site and regional differences in THR rates is especially relevant given current controversy over who should be offered THR for displaced intracapsular fracture. NICE guidance (17) on this topic was supported by a recent meta-analysis of data from five randomised controlled trials (RCTs) (18) which suggested lower mortality amongst patients undergoing THR (RR 0.63, 95% CI 0.38 to 1.04), and estimated a halving of mortality if these results were projected to a propensity matched cohort taken from the NHFD dataset (hazard ratio 0.45, 95% CI 0.37 to 0.54). However, a recently conducted high quality RCT of 1,411 patients reported no improvement for THR versus hemiarthroplasty on mortality (19). However, their endpoints were measured at 2-years and so this potentially has limited bearing on our outcome here measured at 30-days. It should be noted though that this previous RCT did report reduced risk of a secondary hip procedure between 1 and 2-years in those receiving a THR (hazard ratio 0.23 95%CI (0.08 to 0.69)), and a statistically significant functional benefit at 2-years in favour of THR as measured by the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) total score (mean difference, −6.37; 99% CI (−9.18 to −3.56)), which may be clinically meaningful in the more frail and elderly hip fracture patient receiving emergency trauma surgery (19). Our observed reduction in 30-day mortality associated with THR use for intracapsular fractures is therefore an interesting finding and worthy of further investigation. However, given that the mortality reduction we showed was considerably

attenuated by case-mix adjustment (OR=0.15 [95% CI: 0.11-0.19] to aOR=0.62 [95% CI: 0.45-0.87]), it is possible that the remaining effect is a reflection of residual confounding, with THR not being offered to people who are unsuitable or less well, in ways that are not adequately captured by the NHFD dataset. Likewise, a THR maybe more likely to be performed by a consultant experienced in hip arthroplasty, and therefore achieving better outcomes (20, 21), while trainees maybe more likely to perform a hemiarthroplasty.

Our observed variation in regional and hospital-level rates of intramedullary nails for trochanteric fractures is consistent with previous reports of significant and apparently unwarranted variation in these procedures across states in the United States of America (USA) (22), and that use of nails have been increasing over recent decades in both the UK (1) and the USA (23). This is initially concerning given prior analyses showing significantly worse mortality associated with the use of nails (24). NICE recommends the use of a sliding hip screw rather than intra-medullary nail for A1 or A2 trochanteric fractures on the basis of lower cost without evidence of inferior outcome. Despite this, there has been a trend for reduced use of sliding hip screw usage, although in England this is still performed much more commonly than intramedullary nail fixation (approx. 3:1 ratio, Table 1). It is reassuring that we found no overall association between intramedullary nail use and 30-day mortality (Table 2, Figure 3C). This is consistent with a comparative effectiveness study from the US (23), but our study may have been underpowered to detect the moderate size of effect that has previously been estimated (24). While subtype of trochanteric fracture would also have been another factor to explore, unfortunately the small numbers involved would have been inadequate for a multivariable analysis and there are inconsistencies in how these subtypes are coded in some units (25). It should be noted that in England, rehabilitation facilities are based within hospitals so the time spent in them counts towards hospital length of. This contrasts with practice in some other countries, including the USA, where most patients are sent to a separate ‘rehabilitation facility’, so that hospital length of stay will be much shorter.

One of the major strengths of our analysis is its use of a national cohort of patients from the NHFD. The NHFD is a rich data source (1) containing many pertinent clinical and demographic variables with which adjustment can be made in statistical modelling (14) which would not be available in routinely collected electronic medical record databases. This analysis included the specific type of operation performed, residential status prior to admission, pre-injury mobility and ASA grade. Nearly all hip fracture patients presenting in England are recorded in the NHFD, so our sample was large enough to look at regional variation, and the reimbursement

implications of not submitting mandatory NHFD data fields ensure high data quality and completeness.

Various limitations mean that our findings should be interpreted with caution. Patient specific comorbidities are not collected in the NHFD, although this was addressed in this study through HES linkage and derivation of Charlson comorbidity index. Analyses of 30-day mortality were adjusted for various factors, but it is likely that residual unmeasured confounding persisted. Some of these factors would be interesting to explore, but unfortunately decision making processes related to type of surgery are not captured in the NHFD. The sample size for subtrochanteric fractures was much smaller than for the two other fracture types, which may have affected whether statistical significance was found. The seniority of the operating surgeon, length of operation and intra-operative blood loss are not defined in NHFD data and it would be helpful to examine these factors to see if they contribute to observed differences. Smaller sample sizes at the individual hospital level is another limitation. Furthermore, the likely impact of other institutional and national targets makes interpretation of results complex. Notably, additional performance indicators (for example those pertaining to aspects of assessment, care and other clinical outcomes) would need to be considered to give a truly comprehensive assessment of regional variation in hip fracture outcomes, although this is outside the scope of the present work and remains the subject of further investigation.

To give a sense of proportion to the relative risk differences in regional 30-day mortality rates presented in this study (Figure 4), we derived absolute risk differences for the trochanteric fracture patients. These indicated that compared to the reference region (the North West), there were an estimated 24 fewer deaths at 30-days per 1,000 admissions in the North East, but an estimated 26 additional deaths in the East of England. It should be noted that the confidence intervals around the odds ratios mean these absolute risk differences per 1,000 admissions may have been as low as four and three patients, respectively, and so the differences must be interpreted with caution given the likely residual confounding in patient characteristics across the regions.

Conclusions

In this large cohort, including nearly all hip fracture patients in England, we have identified regional differences in usage of THR for intracapsular fracture types and of intramedullary nails for trochanteric fracture types. Some variation in 30-day mortality was also observed, with the relationship between surgical approach explored, but the extent to which variation in

mortality reflects variation in medical assessment, anaesthesia and other aspects of care warrants further investigation.

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Figure legends

Figure 1: Operation performed for hip fracture patients: stratified by geographic region

Figure 2: Variability in THR for intracapsular fractures: by hospital

Figure 3: Association between hospital-specific 30-day mortality* and rates of surgical procedures

Figure 4: 30-day mortality estimates according to fracture type: by region