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Factors Associated With 30-Day Readmission After Primary Total Hip Arthroplasty

Analysis of 514 455 Procedures in the UK National Health Service

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IMPORTANCE Thirty-day readmission to hospital after total hip arthroplasty (THA) has significant direct costs and is used as a marker of hospital performance. All-cause readmission is the only metric in current use, and risk factors for surgical readmission and those resulting in return to theater (RTT) are poorly understood.

OBJECTIVE To determine whether patient-related predictors of all-cause, surgical, and RTT readmission after THA differ and which predictors are most significant.

DESIGN, SETTING, AND PARTICIPANTS Analysis of all primary THAs recorded in the National Health Service (NHS) Hospital Episode Statistics database from 2006 to 2015. The effect of patient-related factors on 30-day readmission risk was evaluated by multilevel logistic regression analysis. The analysis comprised all acute NHS hospitals in England and all patients receiving primary THA.

MAIN OUTCOMES AND MEASURES Thirty-day readmission rate for all-cause, surgical (defined using *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision* primary admission diagnoses), and readmissions resulting in RTT.

RESULTS Across all hospitals, 514 455 procedures were recorded. Seventy-nine percent of patients were older than 60 years, 40.3% were men, and 59.7% were women. There were 30 489 all-cause readmissions (5.9%), 16 499 surgical readmissions (3.2%), and 4286 RTT readmissions (0.8%); 54.1% of readmissions were for surgical causes. Comorbidities with the highest odds ratios (ORs) of RTT included those likely to affect patient behavior: drug abuse (OR, 2.22; 95% CI, 1.34-3.67; $P = .002$), psychoses (OR, 1.83; 95% CI, 1.16-2.87; $P = .009$), dementia (OR, 1.57; 95% CI, 1.11-2.22; $P = .01$), and depression (OR, 1.52; 95% CI, 1.31-1.76; $P < .001$). Obesity had a strong independent association with RTT (OR, 1.46; 95% CI, 4.45-6.43; $P < .001$), with one of the highest population attributable fractions of the comorbidities (3.4%). Return to theater in the index episode was associated with a significantly increased risk of RTT readmission (OR, 5.35; 95% CI, 4.45-6.43; $P < .001$). Emergency readmission to the hospital in the preceding 12 months increased the risk of readmission significantly, with the association being most pronounced for all-cause readmission (for >2 emergency readmissions, OR, 2.33; 95% CI, 2.11-2.57; $P < .001$). Hip resurfacing was associated with a lower risk of RTT when compared with cemented implants (OR, 0.69; 95% CI, 0.54-0.88; $P = .002$) but for other types of readmission, implant type had no significant association with readmission risk. Increasing age and length of stay were strongly associated with all-cause readmission.

CONCLUSIONS AND RELEVANCE Many patient-related risk factors for surgical and RTT readmission differ from those for all-cause readmission despite the latter being the only measure in widespread use. Clinicians and policy makers should consider these alternative readmission metrics in strategies for risk reduction and cost savings.

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Supplemental content

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The Hospitals Readmissions Reduction Program was introduced in 2012 as part of the Affordable Care Act (ACA).[1] For specified conditions, the Centers for Medicare and Medicaid Services penalize hospitals with excess risk-adjusted all-cause 30-day readmission rates. Since 2015, elective total hip and knee arthroplasty have been included. With the population aging, demand for these procedures continues to rise, and the estimated annual number of total hip arthroplasty (THA) procedures in the United States by 2030 is 572 000.[2] Understanding factors associated with readmission may enable preemptive strategies to mitigate risk and, with direct costs of each THA readmission exceeding $17 000, significant cost savings.[3-5]

The reliability of all-cause readmission as a marker of hospital performance after surgery has been questioned.[6-9] There is growing interest in defining readmissions that occur from "surgical" causes or result in return to theater (RTT) as a more accurate reflection of preventability.[10-15] However, the relationship between patient factors and the risk of surgical readmission is unclear. Many studies are from single centers, combine different procedures, or use Medicare data, so may not be generalizable to other populations.[16-18]

England's national hospital administrative database, Hospital Episode Statistics (HES), comprises more than 125 million admitted patient, outpatient, and emergency department records from the UK National Health Service (NHS) annually and includes all patients regardless of demographics.[19] Because each episode of care is coded using *International Statistical Classification of Diseases and Related Health Problems, Tenth Revision (ICD-10)* diagnostic codes and Office of Population Censuses and Surveys procedure codes, it is possible to assess which readmissions are owing to surgical complications and, of these, which resulted in RTT.[15] Return to theater is associated with patient morbidity and significant additional hospital expenditure, and thus, identifying factors associated with RTT readmission is important.[20] Moreover, RTT after THA appears to be heavily determined by surgeon-related factors and so may be a useful quality indicator.[15] Our aim was to assess and compare patient-related predictors of 30-day all-cause, surgical, and RTT readmission after elective primary THA, using HES data.

Key Points

Question Which patient factors are most strongly associated with 30-day readmission after primary total hip arthroplasty, and is there a difference between predictors of all-cause, surgical, and return-to-theater readmissions?

Findings In this study of 514 455 patients from the UK National Health Service, we found that key predictors of each type of total hip arthroplasty readmission were different.

Meaning All-cause readmission is the only metric in widespread use but overlooks important information that enables readmission risk to be understood; focus on surgical and return-to-theater readmission may facilitate risk reduction and cost savings.

Methods

This study was approved by the London South East Ethics Committee. Informed consent was waived under Section 251 of the NHS Act 2006. We combined 10 years of HES data from April 2006 to March 2016. All elective procedures carried out at acute NHS hospital Trusts were extracted using the Office of Population Censuses and Surveys procedure codes that identified primary THA (eAppendix 1 in the Supplement).

Each admission to an NHS hospital is assigned a primary *ICD-10* diagnostic code in HES by trained clinical coders who determine this to be the primary reason why the patient is being treated. Secondary *ICD-10* codes relate to comorbidities or complications during the admission.

We considered 3 separate categories of hospital readmission:

1. All-cause readmissions: any readmission occurring within 30 days of discharge.
2. Surgical readmissions: readmissions occurring within 30 days of discharge with a primary *ICD-10* readmission code related to the surgical site. These were determined by 2 of us (A. B. and A. A.) in conjunction with a senior clinical coder (eAppendix 2 in the Supplement).
3. Return-to-theater readmissions: readmissions occurring within 30 days of discharge where the patient returned to theater during the readmission episode. This uses our published algorithm for RTT.[15]

Readmission diagnoses were also categorized according to established Clinical Classification Software diagnostic groups devised by the Agency for Healthcare Research and Quality. These are established aggregates of clinically homogeneous conditions within *ICD-10* that facilitate analysis.

Patients were categorized according to the parameters described in eTable 1 in the Supplement, with the group in brackets in the following list taken as the reference group for that variable, ie, odds ratio (OR) of readmission of 1: age (60-64 years), sex (female), racial/ethnic group (white), socioeconomic status (upper quintile, ie, least deprived), type of hip replacement (cemented), year (2006), number of emergency admissions to hospital in the preceding year (0), RTT during index admission (no), index length of stay (2 nights), and individual comorbidities (compared with comorbidity not present. A full list is shown in eTable 2 in the Supplement).

Statistical Analysis

For each type of readmission, adjusted ORs were obtained using multiple multilevel logistic regression analysis. A 2-sided *P* value of less than .05 was taken as statistically significant throughout. Analyses were conducted using SAS, version 9.4 software (SAS Institute). We report ORs from the regression models, and for factors with the highest ORs, we also provide numbers needed to harm and the population attributable fraction (PAF).

Results

We recorded 514 455 procedures (16 297 resurfacing, 76 267 hybrid, 218 451 cemented, and 203 440 uncemented). There

Table 1. Readmission Diagnoses by CCS Group

CCS Group	Description	Readmissions, No. (%)
211	Other connective tissue disease, includes M79.8, "other specified soft tissue disorders" (14.6%) and M79.6, "pain in limb" (4.9%). These include patients who presented with limb swelling or pain but were not given a further diagnosis, eg, hematoma, infection, or fracture.	6042 (19.8)
237	Complication of device, implant or graft, includes T84.0, "mechanical complication of internal joint prosthesis" including dislocation (10.1%); T84.5, "infection and inflammatory reaction due to internal joint prosthesis" (3.5%); and T84.8, "other complications of internal orthopaedic prosthetic devices, implants and grafts" (2.7%).	5261 (17.3)
238	Complications of surgical procedures or medical care includes T81.0, "hemorrhage and hematoma complicating a procedure NEC" (2.7%); T81.3, "disruption of operation wound NEC"; T81.4, "infection following a procedure NEC" (4.0%); T81.8, "other complications of procedures NEC"; and M96.6, "fracture of bone following insertion of orthopaedic implant, joint prosthesis, or bone plate."	2975 (9.8)
118	Phlebitis, thrombophlebitis, and thromboembolism	1286 (4.2)
204	Other nontraumatic joint disorders	1192 (3.9)
197	Skin and subcutaneous tissue infections	959 (3.1)
103	Pulmonary heart disease	776 (2.5)
102	Nonspecific chest pain	732 (2.4)
259	Residual codes, unclassified	633 (2.1)
153	Gastrointestinal hemorrhage	512 (1.7)
200	Other skin disorders	512 (1.7)
159	Urinary tract infections	427 (1.4)
163	Genitourinary symptoms and ill-defined conditions (includes urinary retention)	412 (1.4)
122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	402 (1.3)
106	Cardiac dysrhythmias	343 (1.1)

Abbreviation: CCS, Clinical Classification Software.

were 30 489 all-cause readmissions (5.9%), 16 499 surgical readmissions (3.2%), and 4286 RTT readmissions (0.8%). Of all readmissions, 54.1% were for surgical causes, and 14.1% resulted in RTT. eTable 2 in the Supplement shows the characteristics of all patients and those in each readmission group.

The top 3 *ICD-10* readmission categories, accounting for 46.9% of readmissions, were related to surgical site complications (**Table 1**). The most common reason for RTT was "closed reduction of dislocated total prosthetic replacement of hip joint," accounting for 23.3% of RTT readmissions.

eTable 2 in the Supplement shows the results of the multiple logistic regression analysis for factors associated with each readmission type. Increasing age was associated with a significant and progressive increase in the risk of all-cause readmission for all age groups older than 65 years when compared with the group aged 60 to 64 years. For RTT readmissions, the only age group with significantly increased risk was the group aged 85 to 89 years (OR, 1.24; 95% CI, 1.05-1.46; $P = .01$).

Men had a significantly higher risk of readmission for all readmission types, with the effect most pronounced for RTT readmission (OR, 1.38; 95% CI, 1.05-1.46; $P < .001$). Race/ethnicity had no significant effect on any type of readmission other than reduced risk for all readmission types in the "ethnicity not stated" group (OR, 0.69; 95% CI, 0.66-0.72; $P < .001$). Lower socioeconomic status was associated with an increased risk of readmission, reaching significance across all groups in the fourth and fifth (most deprived) quintiles (OR, 1.09; 95% CI, 1.05-1.13; $P < .001$ and OR, 1.17; 95% CI, 1.12-1.22; $P < .001$, respectively). Hip resurfacing was associated with a significantly lower risk of RTT readmission when compared with cemented implants (OR, 0.69; 95% CI, 0.54-0.88; $P = .002$). For all other types of readmission, type of implant had no significant effect on readmission risk. The number of emergency readmissions in the preceding 12 months for any reason was strongly associated with all types of readmission but more so for all-cause and then surgical readmission (for >2 emergency readmissions: all-cause OR, 2.33; 95% CI, 2.11-2.57; $P < .001$ and surgical OR, 1.78; 95% CI, 1.54-2.06; $P < .001$).

Return to theater during the index admission was strongly associated with all types of readmission, in particular of a readmission requiring further return to theater (RTT, OR, 5.35; 95% CI, 4.45-6.43; $P < .001$).

Increased length of stay was associated with increased risk of readmission. For RTT readmission, length of stay only conferred significantly increased risk when more than 5 nights (for 6 nights: OR, 1.22; 95% CI, 1.04-1.43; $P < .02$), but risk increased rapidly beyond this until reaching a similar plateau to that for all-cause readmission (peaking at 9 nights when OR, 1.77; 95% CI, 1.45-2.15; $P < .001$). In contrast, for surgical readmission, the odds rose for stays greater than 2 nights but fell back after around 2 weeks (OR, 1.36; 95% CI, 1.22-1.51; $P < .001$).

For each type of readmission, **Table 2** shows the 5 comorbidities with the highest OR for each type of readmission, with the numbers needed to harm and population attributable fraction for each. The comorbidities with the highest ORs had a low PAF. For RTT readmissions, depression had the third highest PAF of any comorbidity (1.6%) after hypertension (PAF, 7.0%) and obesity (PAF, 3.4%). For all-cause and surgical readmissions, chronic pulmonary disease had both a high OR (1.31; 95% CI, 1.27-1.35; $P < .001$ and 1.28; 95% CI, 1.22-1.33; $P < .001$, respectively) and the highest PAF of any comorbidity (3.7% and 3.5%). Other than hypertension (PAF, 3.0% for all-cause and PAF, 3.2% for surgical readmissions), arrhythmia (all-cause PAF, 1.2%), and obesity (surgical PAF, 1.6%), all other comorbidities had a PAF of less than 1%.

Discussion

This study evaluated patient-related factors associated with 30-day readmission for 514 455 primary THAs performed in the UK National Health Service over a 10-year period. To our knowledge, this is the largest reported study of readmission after THA. It is also the first to determine factors associated with surgical readmission and the subset of these resulting in RTT.

Table 2. Comorbidities With the Highest Odds Ratio for Each Type of Readmission With Numbers Needed to Harm and Population Attributable Fraction for Each

	OR (95% CI); *P* Value; NNH; PAF[a]		
Comorbidity	All-cause Readmissions	Surgical Readmissions	RTT Readmissions
Coagulopathy	1.61; <.001; 31; 0.3%	1.73; <.001; 45; 0.3%	NA
Psychoses	1.51; <.001; 36; 0.1%	1.73; <.001; 45; 0.1%	1.83; .009; 153; 0.1%
Drug abuse	NA	NA	2.22; .002; 104; 0.1%
Metastases	1.47; <.001; 39; 0.7%	NA	NA
Paraplegia	1.32; .002; 57; 0.1%	1.45; .002; 73; 0.1%	NA
Dementia	NA	NA	1.57; .01; 222; 0.2%
Depression	NA	NA	1.52; <.001; 243; 1.6%
Chronic pulmonary disease	1.31; <.001; 62; 3.7%	1.28; <.001; 120; 3.5%	NA
Obesity	NA	1.27; <.001; 121; 1.6%	1.46; <.001; 275; 3.4%

Abbreviations: NA, not applicable; NNH, numbers needed to harm; OR, odds ratio; PAF, population attributable fraction.

[a] The PAF is the proportion of the incidence rate in the whole population that is owing to exposure. In our study, the calculation for obesity, for example, includes the proportion of patients having a THA who are obese and the adjusted odds ratio for obesity from the regression model. It is therefore seen as the proportion of readmissions after THA that are owing to obesity (assuming a causal relation between obesity and readmission).

Several comorbidities had different associations with all-cause, surgical, and RTT readmission risk. Substance abuse had the strongest independent association with RTT readmission in terms of the size of its odds ratio, although it had a low PAF. While it has previously been reported to increase the risk of all-cause readmission, we found no significant association with all-cause or surgical readmission risk.[12] Other comorbidities likely to be associated with patient behavior, including psychoses, depression, and dementia, also had stronger associations with RTT than all-cause or surgical readmission, suggesting that patient behavior may be a key factor associated with the risk of RTT specifically. Indeed, poor compliance with postoperative instructions may be a contributing factor to events such as dislocation, periprosthetic fracture, and wound dehiscence.[21,22] Given the significant costs associated with RTT, mitigating risk for these patients is important, particularly in the case of depression which had a relatively high PAF.

While obesity has been identified as a risk factor for all-cause readmission, we found that the risk conferred was greater for surgical and even more so for RTT readmission, with obese patients being 46% more likely to require RTT.[23-27] To our knowledge, this has not been previously reported. Moreover, the PAF for RTT readmission was higher for obesity than for almost any other comorbidity. Given the increasing prevalence of obesity, this has significant cost implications and should be considered in addition to the higher direct medical costs and increased length of stay associated with the condition.[28]

Coagulopathy was strongly associated with both all-cause and surgical readmission, possibly owing to increased susceptibility to hematoma formation and wound problems as previously described.[5,29,30] However, it was not associated with RTT readmission, suggesting that many of these complications were treated nonoperatively. Pulmonary disease was strongly associated with all-cause and, to a lesser extent, surgical and RTT readmission, consistent with previous studies.[12,14,26,31] Our results also show that it had the highest PAF of any comorbidity for all-cause and surgical readmissions. In terms of the numbers of readmissions associated with our comorbidities, it would be more important to reduce the risk of readmission for comorbidities with the highest PAF such as chronic pulmonary disease. However, for a surgeon facing a patient with a given comorbidity, the OR is a more useful metric, and in this regard, the presence of comorbidities, such as substance abuse or dementia, confers a substantial increase in the risk of readmission for that individual.

Hip resurfacing arthroplasty has attracted increasing attention in the last decade as a minimally invasive form of THA, and our results suggest that it has a significantly lower rate of RTT readmission but similar rates of all-cause and surgical readmission at 30 days.[32] Emergency readmission to the hospital in the preceding 12 months and RTT during the index admission, parameters that to our knowledge have not been previously described, had strong independent associations with all-cause and RTT readmission, respectively.

The mean all-cause 30-day readmission rate was 5.9% (5.4% in 2015), similar to the pooled all-cause rate from a 2015 meta-analysis reported as 5.6%.[16,33] A little more than 54% of readmissions were classified as "surgical," with rates for the leading surgical diagnoses correlating with those reported elsewhere.[24,34]

Limitations

This study has several limitations principally arising from use of an administrative database with heterogeneity in coding accuracy, although HES data have been shown to have an accuracy of 96% and 97% for primary diagnostic and operation codes respectively.[35] Our study reflects pragmatic use of the *ICD-10* system and is therefore of relevance to the United States, where *ICD-10* was introduced in October 2015. However, the organization of the US and UK health care systems differ considerably, and thus, the effect of comorbidities on readmission risk and threshold for readmission may differ. Moreover, the PAF is dependent on population prevalence, so the effect of specific comorbidities at a system level may vary.

We did not assess the effect of hospital- and surgeon-related factors such as hospital volume, location, and level of experience. We also did not analyze whether individual surgical causes of readmission had separate risk factors. The term *surgical readmission* refers to the nature of the readmission diagnosis and is not an attribution of blame. For example, if a patient returns following a periprosthetic fracture, we cannot infer whether this is owing to a problem with the initial surgery, premature discharge while at risk of falls, or an unintentional injury occurring after discharge. This level of detail would require access to hospital records, which is not possible using HES.

Conclusions

In summary, we present what is, to our knowledge, the largest reported analysis of patient-related factors associated with 30-day hospital readmission after THA. Using the *ICD-10* classification system, we show that associations with all-cause, surgical, and RTT readmission differ. These alternative metrics should be considered by physicians and policy makers seeking to understand how to most effectively reduce readmission rates and thereby improve quality and reduce costs.

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Concept and design: Ali, Loeffler, Bottle.
Acquisition, analysis, or interpretation of data: Ali, Aylin, Bottle.
Drafting of the manuscript: Ali, Aylin, Bottle.
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