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Association between hospital procedure volume and risk of revision after total hip arthroplasty: a population-based study within the Nordic Arthroplasty Register Association database

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SUMMARY

Objective: Outcome after total hip arthroplasty (THA) depends on several factors related to the patient, the surgeon and the implant. It has been suggested that the annual number of procedures per hospital affects the prognosis. We aimed to examine if hospital procedure volume was associated with the risk of revision after primary THA in the Nordic countries from 1995 to 2011.

Design: The Nordic Arthroplasty Register Association database provided information about primary THA, revision and annual hospital volume. Hospitals were divided into five volume groups (1–50, 51–100, 101–200, 201–300, >300). The outcome of interest was risk of revision 1, 2, 5, 10 and 15 years after primary THA. Multivariable regression was used to assess the relative risk (RR) of revision.

Results: 417,687 THAs were included. For the 263,176 cemented THAs no differences were seen 1 year after primary procedure. At 2, 5, 10 and 15 years the four largest hospital volume groups had a reduced risk of revision compared to group 1–50. After 10 years RR was for volume group 51–100 0.79 (CI 0.65–0.95), group 101–200 0.76 (CI 0.61–0.95), group 201–300 0.74 (CI 0.57–0.96) and group >300 0.57 (CI 0.46–0.71). For the uncemented THAs an association between hospital volume and risk of revision were only present for hospitals producing 201–300 THAs per year, beginning at years 2 through 5 and in all subsequent time intervals to 15 years.

Conclusion: Hospital procedure volume was associated with a long term risk of revision after primary cemented THA. Hospitals operating 50 procedures or less per year had an increased risk of revision after 2, 5, 10 and 15 years follow up.

Introduction

The incidence of THA is increasing[1]. Although THA is considered to be a safe and successful procedure still about 5–10% of patients are revised or sustain complications within the first 10 years after primary THA[2].

A number of patient, implant and surgery related factors have previously been identified as risk factors for revision surgery following primary THA[3–11]. During the last decade health care

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provider related factors such as annual surgeon and hospital THA volume have been increasingly in focus leaving the impression that larger hospital volumes decrease the risk of various adverse events[12–22]. In a recent register-based study Singh *et al.* demonstrated positive relationship between larger hospital procedure volume and lower rate of 1-year mortality for both hip and knee arthroplasty[21]. A similar association between hospital THA volume and 90 days mortality after THA has been shown by Soohoo *et al.*[22] The occurrence of other short-term adverse events after THA such as readmission, dislocations, thromboembolic events, infections and even short-term risk of revision have been shown to be associated with procedure volume[17,19,21,22]. Only a few studies examined the association between hospital procedure volume and long term risk of revision, and none of them found such an association[14,18,20,23]. Even though these four studies are large, population-based and with follow-up times between 1 and 12 years, different geographical settings and healthcare systems impede the generalizability of their results.

The aim of our study was to investigate the association between hospital procedure volume and risk of implant revision surgery after primary THA in patients suffering from osteoarthritis (OA) in the Nordic countries from 1995 to 2011 using the Nordic Arthroplasty Register Association database (NARA). The investigation included revision due to all causes, specific causes and in relation to fixation type.

Patients and methods

Data sources

The NARA database was established in 2007. It holds merged individual-based data concerning diagnosis, primary surgery, type of implant and revision from the Danish, Finnish, Norwegian and Swedish hip and knee arthroplasty registers[24,25]. On a regular basis all uniform variables from each national register are re-coded according to common definitions and anonymized and then merged into the NARA database. The linkage between primary procedure and subsequent revision or death on individual data is performed in each national register before merged into the NARA database. Each of the four national registers holds data from both public and private hospitals.

Study population

All primary THAs due to primary OA between 1st January 1995 and 31st of December 2011 were included. Hip resurfacing arthroplasties were excluded while other metal on metal THAs were included. Bilateral THAs were included. No age restriction was made. THAs with missing information on primary hospital were excluded ($n = 5$). In total 417,687 primary THAs were included in this study. The characteristics of the study population according to hospital volume groups are presented in Table I.

Exposure – hospital volume

Each procedure was entered into one of five hospital THA volume groups according to the number of primary THAs due to primary OA at the hospital in the year of the procedure. The volume groups were 1–50, 51–100, 101–200, 201–300 and >300 primary THAs per year. Hospitals with fluctuating procedure volume contributed to more than one volume group. Thus, a hospital performing 188 procedures in 2010 and 204 in 2011 contribute to volume group 101–200 in 2010 and to volume group 201–300 in 2011.

Outcome – revision

The primary outcome of interest was first time implant revision from all causes. Revision was defined as any new surgical procedure including both partial and complete change and/or removal of a primary implant. Each primary THA was linked to the following first time revision, if present, using the patients civil personal registration number. Follow-up started on the day of primary surgery and ended on day of revision, patient death with the implant *in situ* or December 31st, 2011 whichever came first.

Statistical analysis

The descriptive statistics included median age at primary THA, sex and type of fixation. For the primary outcome of interest cumulative incidence estimation in the presence of death as a competing risk was calculated and visualized graphically. The Pseudo Value Approach[26–28] taking death as a competing risk into account was used to assess the relative risk (RR) of revision from all causes 1, 2, 5, 10 and 15 years after primary surgery. We adjusted for the following confounding factors; age at primary procedure (in categories 10–49, 50–59, 60–69, 70–79 and 80+ years) and sex. Type of fixation was – using both the Wald Test and the Likelihood Ratio Test at 10 years follow up on revision from all causes – tested to be an effect modifier (for both tests $P < 0.00$). Therefore, analyses were made on cemented THA and uncemented THA separately. Hybrids were, to keep it simple, omitted when looking at association between hospital volume and risk of revision in relation to type of fixation. Sensitivity analysis using the same statistical approach was made on first time implant revision from specific causes (aseptic loosening, dislocation and deep infection) 2 and 10 years after primary surgery. In all analyses, the group with the lowest primary THA volume (annual volume of 1–50 THAs) acted as the reference group. Due to both the age of the patient at primary surgery and the long expected survival of the implant death is to be considered as a competing risk to revision[29,30]. By doing so we avoid overestimating the risk of revision as would be the case with standard survival analysis. A possible correlation among patients treated in the same hospital (case mix related to hospitals) is dealt with by correcting for clustering using robust estimates of the variance. Risk estimates were presented with 95% CI and *P*-values relative to volume group 1–50. For the sensitivity analyses only adjusted RR was presented. *P*-values <0.05 were taken to donate statistical significance.

The analyses were performed using the Stata Statistical Software; Release 12.0, StataCorp LP.

Ethics

Permission to the study was obtained from the Danish Data Protection Agency (reference number: 2012-41-06636). As both individuals and hospitals were anonymized before entering the NARA database, it was not possible to identify both on an individual basis in the NARA database.

Results

The annual number of THAs increased almost two-fold from 16,501 in 1995 to 31,328 in 2011 (Fig. 1). During the period from 1995 to 2011 the annual number of primary THAs increased in the three largest volume groups – most pronouncedly in the largest annual hospital volume group (volume of >300 THAs), whereas the annual number of primary THAs in the two smallest hospital volume groups decreased. Number of THAs at risk for revision was