Registration in the Danish Hip Arthroplasty Registry

Completeness of total hip arthroplasties and positive predictive value of registered diagnosis and postoperative complications

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Background There are few publications regarding the validity of data in hip arthroplasty registers. The Danish Hip Arthroplasty Registry (DHR) is a nationwide clinical database of THAs and revisions in Denmark.

Patients and methods We assessed the completeness of registration of primary total hip arthroplasties (THAs) and revisions in the DHR from 1995–2000. In addition, the positive predictive value (PPV) of registered data for diagnoses in patients undergoing primary THA and postoperative complications was analyzed. Completeness was assessed using the Danish National Registry of Patients (NRP) as a reference, which is a nationwide and population-based registry of all somatic hospital admissions since 1977. The positive predictive value of registered data was assessed by review of medical records and preoperative radiographs from samples of randomly selected patients registered in the DHR using a standardized form.

Results The overall completeness of registration for primary THAs and/or revisions was 94% (26 129 patients registered in both NRP and DHR and 27 757 patients registered in the NRP). There was a lower degree of completeness for revisions than for primary THAs (81% versus 94%). The completeness did not vary substantially according to gender and age. Completeness of registration was lower for university hospitals than for other hospitals (91% versus 95%), and for low-volume hospitals (87%) relative to those with medium (92%) and high volumes (96%). Overall, the diagnoses in patients undergoing primary THA could be confirmed in 84% (387/459) of the patients who were reviewed. The diagnosis of fresh fracture of the proximal femur was confirmed in only one third (22/73) of the cases. Postoperative complications were confirmed in two-thirds (36/54) of the patients reviewed. The specificity of the registration of postoperative complications was, however, only one-third (8/26).

Interpretation We conclude that the Danish Hip Arthroplasty Registry is a potentially valuable tool for quality improvement and research due to the high degree of completeness of registrations regarding THA, and its moderate-to-high positive predictive value of registration for diagnoses in patients undergoing primary THA. However, information on several diagnoses for primary THA and on postoperative complications should be used with caution.

Detailed data on the use of THA in everyday clinical practice are important for planning, prediction of prognosis, monitoring and improvement of quality, and also research (Sorensen 1997). Such data can be obtained from properly designed clinical databases. A number of clinical databases on THA have been initiated in recent years in several countries, including Sweden, Norway, Finland, Australia, Hungary, New Zealand and Canada (Malchau et al. 2002).

Although knowledge of the validity of the data is crucial to the use of a clinical database as a valuable tool for answering clinical, administrative and

research questions (Goldberg et al. 1980), there have been few publications or data concerning this issue (Espehaug et al. 1999, Soderman et al. 2000).

We examined the validity of data, including the completeness of registration of primary THAs and/or revisions, the positive predictive value of registered data for diagnosis in patients undergoing primary THA, and the positive predictive value of postoperative complications in the Danish Hip Arthroplasty Register, a nationwide clinical database of THAs in Denmark.

Materials and methods

The National Health Service in Denmark provides tax-supported healthcare for all inhabitants, allowing free access to general practitioners and hospitals. Through the use of a civil registry number, which is unique to every Danish citizen and encodes sex and date of birth, a complete hospital discharge history can be established for each individual, and unambiguous linkages between population-based registers can be made.

This study was approved by the National Board of Health and the Danish Data Protection Agency.

Data sources

The Danish Hip Arthroplasty Registry (DHR). DHR was initiated by the Danish Orthopaedic Society on January 1, 1995 (Lucht 2000). The objective of the register is to examine the epidemiology of THA procedures in Denmark, including both primary operations and revisions, and to facilitate continuous improvement of the outcome of hip replacement surgery at both national and local levels. In order to fulfil this objective, detailed clinical data on all primary THAs, revisions, and follow-up examinations in Denmark are collected on a prospective basis. All orthopedic departments in Denmark (n = 48) report to the register, including 4 departments located at private hospitals. Registration of primary procedures and revisions is compulsory, whereas recording of follow-up examinations is voluntary. However, patients can be followed for several years after THA, depending on the protocol of the hospital.

The data registered include preoperative, perioperative and postoperative information (Lucht 2000). This information is collected using a standard form. The perioperative data are filled in by the operating surgeon immediately after surgery.

The Danish National Registry of Patients (NRP). The NRP was established in 1977, and records 99.4% of all discharges from public somatic hospitals in Denmark (Andersen et al. 1999). The registry contains information about the civil registry number, the dates of admission and discharge, the surgical procedures performed, and up to 20 diagnoses for every discharge, classified according to the Danish version of the International Classification of Diseases, eighth (ICD-8) and tenth editions (ICD-10). In order to examine the completeness of registration of THA procedures in the DHR, we identified all patients registered with the following surgical procedure codes for primary THA (ICD-8 70032-70036, 70039, 70232-70236, 70239, 70432-70436, 70439, 70632-70636 and ICD-10 NFB20, NFB30, NFB40, NFB59) or revision (ICD-8 70132-36, 70139, 70332-36, 70339, 70532-36, 70539, 70732-36 and ICD-10 NFC20-22, NFC29, NFC30-32, NFC39, NFC40-42, NFC49, NFC59) in the NRP.

Review of medical records and radiographs. Medical records and preoperative radiographs of the hip and pelvis, from a randomly selected sample of patients registered in the DHR with one of the diagnoses for primary THA, were retrieved and reviewed by a single physician (ABP). A detailed standard form, designed in close collaboration with 3 consultants (UL, KS, SO) with extensive experience in the field of hip surgery, was used. The criteria used to define the presence of diagnoses and postoperative complications were also established in collaboration with these consultants, and in accordance with existing literature (Greenspan 1992, Trousdale et al. 1995, Cooganard and Urbaniak 1997, Frandsen and Hvid 1998). All cases with an uncertain diagnosis based on the available information were discussed with the consultants.

Study population

Completeness. A total of 37 764 THA procedures, both primary and revisions, were registered in the DHR. We excluded from this analysis patients whose surgery occurred before January 1, 1995 and after December 31, 2000 (n = 3 529), patients

who underwent more than one THA procedure (n = 5 187), and patients who were operated at private hospitals (n = 1 534), or one specific county hospital (n = 438), as they did not report to the NRP and the DHR, respectively, throughout the study period. After these exclusions, 27 076 THA procedures registered in the DHR (71.7% of the initial 37 764) remained in the study. 32 925 THA procedures were registered in the NRP. After the exclusion of patients operated on before and after the study period (n = 82), patients who underwent more than one THA procedure (n = 4 322), and those surgeries at the hospital that did not report to the DHR (n = 764), 27 757 THA procedures registered in the NRP (84.3% of the initial 32 925) remained in the study. Patients with an invalid civil registry number (n = 51 and n = 45 in the DHR and NRP, respectively), and patients for whom age at surgery could not be calculated (n = 5 and n = 8 in the DHR and NRP, respectively) due to invalid date of birth, date of operation, or date of admission to hospital, were excluded from the analyses of gender and age.

Positive predictive value (PPV). The analysis of the PPV for diagnosis registration in patients undergoing primary THA was based on stratified samples of randomly selected patients from the following 6 categories of primary THA diagnoses: (1) primary arthrosis, (2) fresh fracture of the proximal femur, (3) sequelae after trauma, i.e. late sequelae from fracture of proximal femur, fracture of the acetabulum and traumatic hip dislocation, (4) atraumatic necrosis of the femoral head, (5) inflammatory diseases i.e. rheumatoid arthritis and Mb. Bechterew, and (6) hip disorders in childhood, i.e. congenital hip dislocation, Mb. Calve-Legg-Perthes, epiphysiolysis and acetabular dysplasia. A random sample of 100 patients was selected for each of these 6 categories (n = 600). Medical records and preoperative radiographs could be retrieved for 89% (533/600) and 82% (490/600) of the randomly sampled patients, respectively. Both medical records and preoperative radiographs could be retrieved for 77% (459/600) of the patients. The analysis of PPVs for registration of postoperative complications was based on 100 randomly selected patients with follow-up examinations. Medical records could be retrieved for 89% (89/100) of the patients. All hospitals were included in the PPV analyses.

Analyses

Completeness. The completeness of registration for the primary THAs and revisions in the DHR was assessed using the NRP as a reference. Completeness was defined as the proportion of patients subject to primary THA or revision registered in both the NRP and the DHR, over the total number of patients subject to primary THA or revision registered in the NRP (Sorensen et al. 1996). We assessed the completeness of registration of THAs and revisions in the DHR in combination, and separately. Furthermore, we examined the completeness for the entire DHR, as well as according to gender, age (< 50, between 50 and 70, and > 70), type of hospital (university or other hospitals) and hospital volume of THA. Hospital volume was defined as the total number of primary THAs and/or revisions registered in the DHR from January 1, 1995 to December 31, 2000. Low, middle, and high-volume hospitals, respectively, were defined as having reported 1-499, 500-799, and > 800 THA procedures to the registry during the study period.

Positive predictive value. The positive predictive value of the registered diagnoses in patients undergoing primary THA in the DHR was assessed using the review of medical records and radiographs as a reference. The PPV was calculated as the probability of being confirmed with a specific diagnosis after review of medical records and preoperative radiographs, using the above-mentioned diagnosis criteria as the gold standard.

The PPV was estimated in two ways: firstly, when both medical records and preoperative radiographs for the patient could be retrieved, and secondly, when either medical record or preoperative radiographs could be retrieved. We examined the PPV for the registration of postoperative complications in the same way, i.e. medical records were reviewed for information on postoperative complications including superficial and deep infection, hematoma, wound rupture, one or several dislocations, fracture or fissure of femur, deep-vein thrombosis, paralysis of peroneal nerve, or other complications. Postoperative complications were registered with a standard form during the follow-up period at the hospital where the surgery occurred. We estimated the specificity of the follow-up questionnaire as the number of

Table 1. The degree of completeness of registration in the DHR of primary THAs and/or revisions (absolute numbers in parentheses) according to gender, age, and type of hospital

	Degree of completeness % (N)	95% CI (%)
Overall	94.1 (26,129 /27,757)	93.9–94.4
Male	95.1 (11,099 /11,665)	94.7–95.5
Female	93.5 (15,004 /16,047)	93.1–93.9
Age < 50	95.6 (1,814/1,896)	94.6–96.5
Age ≥ 50 and < 70	95.1 (11,076 /11,641)	94.6–95.4
Age ≥ 70	92.9 (13,210 /14,212)	92.5–93.4
University hospitals	90.7 (5,309 /5,851)	90.0–91.5
Other hospitals	94.8 (20,780 /21,906)	94.3–95.0

Table 2. The degree of completeness of registration in the DHR of primary THAs and/or revisions (absolute numbers in parentheses) according to hospital volume

Hospital volume	Degree of completeness % (N)	95% CI (%)
Low	86.7 (5,080 /5,859)	85.8–87.6
Middle	91.7 (11,958/13,045)	91.2–92.1
High	95.8 (8,489 /8,853)	95.5–96.3

patients without any postoperative complications registered in the DHR and with no postoperative complications identified after review of the medical records, divided by the total number of patients in our random sample without any postoperative complications in the medical records.

Statistics

To estimate confidence intervals and compare proportions, we relied on the normal approximation of the binominal distribution. Analysis was done using the SPSS 11.0 software package.

Results

Completeness. The overall completeness of registration for primary THAs and/or revisions in the DHR was 94.1% (Table 1). We found modest differences in the completeness of registration according to gender and age. The degree of completeness was highest for males below 50 years of age, and decreased with increasing age.

A lower degree of completeness for primary THAs and/or revisions was found for university hospitals (90.7%) when compared with other hospitals (94.8%) (Table 1). The degree of completeness was 85.5% or lower for 3 of 9 university hospitals and between 87.5–95.4% for the other university hospitals. The completeness for university hospitals was lowest in 1995 (84.1%) and increased gradually until 1997 (93.4%), but dropped again to 88.9% in 2000. 35% of primary THAs and/or revisions were performed in low-volume hospitals, and 46% and 19% were performed in middle and high-volume hospitals, respectively. A lower degree of completeness of registration of primary THAs and/or revisions was found for low-volume hospitals (86.7%) compared to middle (91.7%) and high-volume (95.8%) hospitals (Table 2).

The completeness of registration of primary THAs and revisions separately was 93.9% and 81.4%, respectively. The completeness of registration of revisions was lower in females (77.6%) than in males (86.2%), lower for patients greater than 70 years of age (77.5%) compared to patients below 50 years of age (88.5%), and lower for patients whose surgery was performed in low-volume hospitals (60.7%) as compared to middle (79.1%) and high-volume hospitals (85.6%). However, there was no difference in degree of completeness of registration of revisions between university hospitals and other types of hospital.

It was not possible to conduct an analysis of completeness of registration of primary THAs and/or revisions according to the diagnoses for each procedure, due to the large discrepancy between classification of the diagnoses in the DHR and the ICD-coding system used in the NRP.

PPV of the registered diagnoses. The overall PPV was 84% (387/459) after review of both medical records and preoperative radiographs. The overall PPV was 85% (455/533) and 75% (366/490), respectively, after review of medical records only or preoperative radiographs only.

Table 3 shows the PPV for twelve diagnoses in patients undergoing primary THA which are registered in the DHR. The primary arthrosis was confirmed in 66 of the 78 cases. Among the 12 reviewed patients in whom the diagnosis of primary arthrosis could not be confirmed, we iden-

Table 3. Positive predictive value of diagnoses registered in the Danish Hip Arthroplasty Registry based on both medical records and preoperative radiographs

Diagnosis recorded in DHR	Total N	Verified	PPV(%)	95% CI
Primary arthrosis (1)	78	66	85	75–92
Fresh fracture of proximal femur (2)	73	22	30	20–42
Sequelae after trauma				
Late sequelae from fracture of proximal femur (3)	70	67	96	88–99
Fracture of acetabulum (4)	8	7	88	47–100
Traumatic hip dislocation (5)	2	2	100	16–100
Atraumatic necrosis of femoral head (6)	80	79	99	93–100
Inflammatory diseases				
Rheumatoid arthritis (7)	63	63	100	94–100
Mb. Bechterew (8)	7	7	100	59–100
Hip disorders in childhood				
Congenital hip dislocation (9)	31	29	94	79–99
Mb. Calve-Legg-Perthes (10)	10	9	90	56–100
Epiphysiolysis (11)	11	11	100	72–100
Acetabular dysplasia (12)	26	21	81	61–93

PPV = positive predictive value.

tified cases of late sequelae from fracture of the proximal femur (n = 1), rheumatoid arthritis (n = 1), congenital hip dislocation (n = 1), atraumatic necrosis of the femoral head (n = 3), acetabular dysplasia (n = 3) and other diagnosis of unknown origin (n = 3). Sequelae after trauma (diagnoses 3, 4, 5 in Table 3) were confirmed in 76 of the 80 cases. Atraumatic necrosis of the femoral head was confirmed in 79 of the 80 cases. The inflammatory diseases (diagnoses 7, 8 in Table 3) were confirmed in all 70 cases. The hip disorders in childhood (diagnoses 9, 10, 11, 12 in Table 3) were confirmed in 70 of the 78 cases, with high PPVs being seen for the individual diagnoses in this category, although based on relatively few reviewed cases (Table 3).

In contrast, the PPV for fresh fracture of the proximal femur was low, with confirmation of the diagnosis in only 22 of the 73 patients reviewed. Among the 73 cases registered with a diagnosis of fresh fracture of the proximal femur, we identified cases of late sequelae from fracture of the proximal femur (n = 41), primary arthrosis (n = 2), rheumatoid arthritis (n = 1), congenital hip dislocation (n = 1) and fracture of the femur shaft around a prosthesis (n = 6).

PPV of the registered postoperative complications. Among 89 reviewed medical records, the overall PPV for postoperative complications, which included specific complications and complications due to other causes, was 57 of the 75 cases. The specific postoperative complications were registered in 54 cases and verified in 36 cases. However, among the 89 reviewed patients we also identified 18 cases of postoperative complications that were not registered in the DHR, i.e. one or several hip dislocations (n = 8), deep vein thrombosis (n = 3), hematoma (n = 2), wound rupture (n = 2), superficial infection (n = 1), paralysis of the peroneal nerve (n = 1) and fracture or fissure of the femur (n = 1). The sensitivity and specificity of the follow-up questionnaire used for registration of postoperative complications was 0.9 (57/63) and 0.3 (8/26), respectively. In the group of postoperative complications due to other causes, we identified a large variety of complications not relevant to the THA database, such as gallstones, sepsis, pulmonary infection and embolus, gastritis, superficial phlebitis, retention of urine or infection, spinal headache, stroke or transient ischemic attack, cardiac arrhythmias, muscle pain, impairment of kidney function, fracture of the tibia after a fall, amputation of the tibia after gangrene, hallucinations, fracture of cement, and dizziness.

Discussion

Our study has a number of strengths which should be taken into account when interpreting the results. Several validation studies of the nationwide and population-based NRP, which was used as a reference in our study of completeness, have been undertaken and show a moderate-to-high quality of administratively collected hospital discharge data on a number of different diagnoses and procedures (Andersen et al. 1987, Vestberg et al. 1997, Mosbech et al. 1995, Madsen et al. 2003). Furthermore, availability of the unique civil registry number for linkage of records at the individual level makes the NRP a useful reference (Andersen et al. 1999). In our examination of the PPV of the registered diagnoses and postoperative complications in the DHR, we found no systematic pattern among the records and radiographs that were lacking when analyzing patient characteristics or hospital types. Furthermore, the risk of information bias was probably low since medical records and preoperative radiographs were systematically reviewed using a standard form. The high statistical precision for the analysis of completeness of the DHR and the moderate-to-high statistical precision for most estimates of the PPVs of diagnoses and postoperative complications indicate that the findings were unlikely to be influenced by random variation.

Our study has a several limitations, however. For example, lack of registration to the NRP (Madsen et al. 2003) and inconsistent coding practices may have influenced our results, since we cannot exclude the possibility that these factors may have been associated with specific patient characteristics or hospital types. We did, in fact, identify a number of patients in the DHR (n = 947) who were not registered in the NRP, indicating that the NRP is not a complete reference.

Medical records and preoperative radiographs could not be retrieved for all randomly selected patients. Furthermore, the estimates of the PPVs were based on few cases for several of the diagnoses, e.g. 4,5,8,10,11, resulting in statistical imprecision, as indicated by the confidence intervals in Table 3.

The high overall completeness of registration of THA procedures in the DHR appears to be in agreement with reports from other studies on the completeness of clinical databases for THA (Espehaug et al. 1999, Fender et al. 2000, Soderman et al. 2000, Puolakka et al. 2001). However, it is difficult to ascertain from these reports whether the analyses were made on an individual or a group level. It is important to note that comparisons on a group level may result in misleading estimates of completeness, since it is not assured that specific patients are registered in both data sources.

The lower completeness of registration of revisions, compared with primary THAs, in our study could be related to use of different definitions for revision, although such ambiguity is unlikely. However, we observed that some hospitals registered patients with an initial hemi-arthroplasty, followed by a total hip arthroplasty as revisions in the NRP, although typically these patients were registered appropriately in the DHR as a primary operation (n = 549). Such misclassifications would lead to a lower completeness of registration of revisions in the DHR. This coding practice may be related to financial incentives, since the payment to the hospital is higher for a revision than for a primary THA (http://drg.sst.dk/dkdrg2003/main.htm).

The lower completeness of registration for primary THAs and revisions separately, compared with overall completeness for THA procedures in the DHR, is due to nondifferential misclassification of patients, i.e. is independent of surgical status. The misclassification occurs simultaneously in both directions. That is, in both the DHR and the NRP, primary THAs may be incorrectly classified as revisions and, conversely, revisions may be classified as primary THAs. This leads to bias toward the null value of the estimates.

The absolute differences in completeness of registration of primary THA and/or revisions according to gender and age were small and probably not clinically important.

A lower degree of completeness of registration for university hospitals when compared with other hospitals appears to be explained by low reporting rates from three university hospitals which had a degree of completeness below 85.5%. One reason for this difference could be a lack of communication and information about the DHR between the permanently employed orthopedic surgeons and the large number of young surgeons in the second part of their orthopedic training at the university

hospitals. In general, completeness of registration decreased with decreasing number of THA procedures, although we did not find any association between type of hospital and operating volume. However, efforts should be made to identify reasons for the lower degree of completeness of registration at low-volume hospitals.

It is not possible to compare our estimates of a moderate-to-high PPV of the registered diagnosis in patients undergoing THA procedures with the estimates from other studies since, to our knowledge, such data have not been reported previously. However, Fender et al. (2000) reported the percentage of incorrect or incomplete data in the Trend Regional Arthroplasty Register in England to be in the range 0.7% to 1.8%, depending on the type of data. The variables examined included date of birth, date of operation, operative side and type of prosthesis.

The low PPV of the diagnosis of fresh fracture of the proximal femur found in our study may be explained by the use of various definitions of this diagnosis in clinical practice. We applied this diagnosis to cases where the THA was performed within three months of a fracture of the proximal femur, provided that the patient had not been subjected to internal fixation or hemi-arthroplasty for the same fracture before. However, from the review of the original medical records and radiographs, it was evident that there was confusion about the distinction between the diagnosis of fresh fracture of the proximal femur and late sequelae from fracture of the proximal femur.

The relatively low PPV of postoperative complications found in our study was not due to the voluntary nature of follow-up registration, since we only reviewed medical records of patients who were registered in the DHR with follow-up examinations. Furthermore, we identified a considerable number of postoperative complications that were not registered in the DHR. Thus, the follow-up questionnaire does not correctly identify patients with and without postoperative complications, and should probably be revised.

In conclusion, the completeness of registration of THA procedures in the DHR was high and the overall PPV of the registered diagnoses and postoperative complications in patients undergoing primary THA was satisfactory for most of the diagnoses. The lower completeness of registration for revisions in low-volume hospitals and some university hospitals demonstrates that there is still room for improvement. The diagnosis of a fresh fracture of the proximal femur in the DHR should only be used when combined with other sources of information, because of its low PPV. Our validation study of the DHR has demonstrated that the registry is a potentially valuable tool for quality improvement and research, which may be able to provide answers to questions that would otherwise be practically or economically difficult to assess. However, it is important to ensure a high quality of data in the registry on a continuous basis.

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