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COMPLICATIONS OF TOTAL HIP ARTHROPLASTY IN PATIENTS WITH ANKYLOSING SPONDYLITIS

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Abstract

Background—To compare the risks of complications of primary total hip arthroplasty (THA) between patients with ankylosing spondylitis (AS) and those without AS.

Methods—In this population-based study, we examined U.S. Medicare beneficiaries (< 75 years old) with AS and a comparison group without AS who had primary THA in 1999 – 2013. Complications were based on the 2013 Centers for Medicare & Medicaid Services THA Complication Measure, which included myocardial infarction, pneumonia, and sepsis within 7 days; surgical site bleeding, pulmonary embolus, or venous thrombosis within 30 days; and mechanical complications or local infection within 90 days. In addition, mortality within 90 days, revision arthroplasty within one year, long length of stay, discharge to a care facility, and readmission within 90 days were examined.

Results—The study included 2773 patients with AS and 107,341 patients without AS who had THA. Perioperative, 30-day complications, and local infections were rare (< 1%) in both groups. Mechanical complications and revision arthroplasty were uncommon in both groups. Ninety-day mortality was lower among patients with AS (0.36% versus 0.7%). Patients with AS were more likely to be discharged to a care facility, and slightly more likely to have a long length of stay. Likelihood of a long stay was lower at hospitals that performed ≥ 100 THA per year, but other complications were not associated with hospital volume.

Conclusions—Complications after primary THA are uncommon in patients with AS and similar in frequency to those without AS. Ninety-day mortality was lower among patients with AS.

Keywords

ankylosing spondylitis; total hip arthroplasty; complications; mortality

Total hip arthroplasty (THA) is an effective treatment for the functional limitations and pain of chronic hip arthritis that may occur in patients with ankylosing spondylitis (AS) [1–6]. After 30 years of AS, 12% to 25% of patients with AS will have had a THA [7]. Studies of the outcomes of THA in patients with AS have largely focused on long-term implant survival and need for revision arthroplasty [5,6,8–15]. Many of these studies also reported

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generally low risks of perioperative complications, but did not include a comparison group of patients without AS [2–6,8–15]. Given evidence that patients with rheumatoid arthritis (RA) have higher perioperative morbidity with major arthroplasties than patients without inflammatory arthritis, similar concerns extend to patients with AS [16].

Two recent studies reported higher risks of complications of THA in patients with AS compared to those without AS. A study of 1002 U.S. Medicare beneficiaries with AS reported risks of perioperative wound complications, cellulitis, and prosthesis breakage to be 1.5 to 2.5 times higher in patients with AS than controls, as well as increased risks of dislocations, revision arthroplasties, and wound complications over two years postoperatively [17]. Importantly, the comparisons were not adjusted for comorbidities or patient socioeconomic status, both of which are associated with increased risks of THA complications [18,19]. A study of the U.S. Nationwide Inpatient Sample reported two-fold or higher risks of postoperative cardiac, peripheral vascular, thrombotic, and central nervous system complications, as well as increased risks of wound complications and mortality, following THA in patients with AS compared to patients with osteoarthritis [20]. However, because this database only includes information from the index hospitalization, preoperative comorbidities and post-discharge complications were unknown. Both studies used only a single occurrence of a diagnosis code for AS to identify their cohorts, which may have limited specificity.

In this study, we compared postoperative complications of primary THA among U.S. Medicare beneficiaries with AS to those without AS, using strict criteria to ensure specificity of the AS cohort. The study also examined if risks of complications were lower among hospitals that performed more THAs, as has been suggested for THA in other conditions [21–23]. The null hypothesis was that risks of post-operative complications were not higher among patients with AS than among patients without AS.

METHODS

Data source and study design

This was a retrospective cohort study based on 100% Medicare Part A (hospitalization) and Part B (provider) fee-for-service data from 1999 to 2013. Inpatient hospitalization data included fields for up to 25 diagnoses and 25 procedures for surgeries and other interventions per hospitalization. Part B data included information on outpatient visits, with up to 12 possible diagnosis codes per encounter. Diagnoses and procedures were coded using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9) codes. Data were provided by the Centers for Medicare & Medicaid Services (CMS) through a data use agreement. The study protocol was approved by the National Institute of Arthritis and Musculoskeletal and Skin Diseases institutional review board.

AS cohort

The study group of interest was patients with AS undergoing primary THA. We included patients younger than 75 years who had two or more inpatient or outpatient diagnosis claims for AS (ICD-9 720.0) on face-to-face visits with a physician at least 7 days apart during their

tenure in Medicare and had full-year coverage with Part A and Part B. Two validation studies of administrative data reported that this definition had positive predictive values for AS of 1.0 and 0.89, respectively [24,25]. We excluded patients who had diagnosis codes for RA (714.0) or psoriatic arthritis (696.0) to further increase the specificity of the AS group. We also excluded those whose first two hip procedures were revision arthroplasties (ICD-9 codes 00.70, 00.71, 00.72, 00.73, or 81.53) because they were not at risk for primary THA, and those with hip fracture at the time of THA (ICD-9 code 820.X). Patients age 75 or older were excluded because THA at these ages may be more likely related to osteoarthritis than AS [26].

The cohort included all age-eligible patients with AS in 1999 and new enrollees with AS in subsequent years as they became Medicare-eligible, making this a dynamic cohort. Of 211,332 Medicare beneficiaries in 1999–2013 with at least one ICD-9 diagnosis code for AS, 121,649 were excluded because they did not have a second claim with a code for AS. Of the remaining 89,683 patients, exclusions for age, other inflammatory arthritis diagnoses, prior THA, hip fractures, and full-year coverage resulted in an AS cohort of 52,568 patients. Among these, 2773 patients had one or more primary THA (ICD-9 code 81.51) during the study years. We randomly selected one THA hospitalization per patient for analysis.

Comparison cohort

The comparison group consisted of a 20% random sample of Medicare beneficiaries in 1999, to which were added 5% random samples of persons entering Medicare in subsequent years, to mimic the dynamic nature of the AS cohort. The same age, coverage, and procedure restrictions were applied as in the AS group, but matching was not used. From this group, we excluded patients with diagnosis code for AS throughout their tenure in Medicare. Among 4,617,179 patients in the comparison group, 107,341 patients had one or more primary THA during the study years. Again, we randomly selected one THA hospitalization per patient for analysis.

Complications

We used the 2013 CMS Total hip arthroplasty/Total knee arthroplasty Complication Measure to compare perioperative and postoperative complications between groups [27]. This measure includes eight different potential complications of elective primary THAs, selected because they represented clinically meaningful complications that can be temporally and specifically attributed to a particular surgery. The measure was developed and validated using Medicare data, and is used by CMS for public reporting of THA complications at individual hospitals on its Hospital Compare website.

The measure is designed for use with administrative data, and provides ICD-9 diagnosis codes for each complication, along with a time frame for qualifying as a postoperative complication. The complications include: acute myocardial infarction, pneumonia, and sepsis, during the index hospitalization or within 7 days of the hospitalization; surgical site bleeding, pulmonary embolus, or death, during the index hospitalization or within 30 days; and mechanical complications (including prosthesis loosening, dislocation, or peri-prosthetic fracture) or joint or wound infection, during the index hospitalization or within 90 days. A

list of the ICD-9 codes associated with each complication is provided in the Supplement. For analysis, we modified the mortality indicator to be death during or within 90 days of hospitalization to capture more deaths. We also added deep venous thrombosis (ICD-9 451.1X, 451.2, 453.4X) during the index hospitalization or within 30 days as a complication, as this complication has been included in other studies [17,20]. We also tallied all perioperative (7-day), 30-day, and 90-day complications.

We included four additional measures as indicators of post-operative complications: revision hip arthroplasty (ICD-9 code 81.53) within 1 year, long length of stay during the THA hospitalization, discharge to a rehabilitation hospital, nursing home, or intermediate care facility (hereafter "care facility"), and readmission for any reason within 90 days. Length of stay was classified as long if it exceeded the 90th percentile of stays for primary THA in the same calendar year among Medicare beneficiaries age 65 to 74.

Covariates

Covariates included patient age, sex, race/ethnicity, low income status, and comorbidities. Patients were classified as low income if they were recorded as having received state subsidies for medical care during the year of THA. We recorded the presence or absence of eight comorbid conditions (coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, chronic kidney disease, cancer, stroke, and dementia) cumulatively from the patient's entry in Medicare to the time of THA, based on the CMS Chronic Condition Warehouse [28]. This algorithm uses a combination of diagnosis codes and treatments to identify the presence of a particular comorbidity, and has been extensively validated.

For associations with hospital volume, we computed the number of primary THAs done in each hospital among Medicare beneficiaries in each calendar year, and sorted hospitals by annual THA volume into approximate tertiles (1–44; 45–99; ≥ 100).

Statistical analysis

We computed the frequency of each complication by study group, and used logistic regression to compute odds ratios (OR) for the association between AS and each complication. Multivariable logistic regression models included patient age, sex, race, low income, and indicator variables for the eight comorbidities as covariates. To account for the clustering of THAs within hospitals, the logistic models were implemented using generalized estimating equations. In a sensitivity analysis, analyses were repeated after removing patients with any physician-based claim with a diagnosis of RA or psoriatic arthritis from the comparison group, because inclusion of these patients could possibly reduce differences between groups.

To examine the association between frequency of complications and hospital THA volume, we examined trends in complications using chi-square tests. We also tested if the likelihood of a complication by hospital THA volume tertile differed between patients with AS and those in the comparison group by testing the interaction between these variables in multivariable logistic regression models.

SAS programs (version 9.4, SAS Institute, Cary NC) were used for analysis. Significance was set at alpha = 0.05, two-tailed. Because of the large sample, effect sizes provide a more meaningful indicator of differences than p values. Based on conventional criteria for events with a frequency of 1%–3%, an OR of 1.6 (or 0.625) was considered to represent a small effect, an OR of 3.0 (or 0.33) was considered to represent a medium effect, and an OR of 5.0 (or 0.2) was considered to represent a large effect [29].

RESULTS

Patient groups

The study included 2773 patients with AS and 107,341 patients without AS who had primary THA. Patients with AS included a higher proportion of men and a slightly lower proportion who were low income, compared to the group without AS (Table 1). Despite being younger, the frequency of several comorbidities were slightly higher in patients with AS. Fifty-three percent of patients with AS had been treated by a rheumatologist, with 40% having a rheumatology visit prior to THA. Only 2.7% were treated with tumor necrosis factor-alpha inhibitors at the time of THA.

Frequency of complications

Perioperative acute myocardial infarction, pneumonia, and sepsis were rare, and any perioperative complication occurred in less than 1.5% of patients (Table 2). The association between AS and sepsis did not vary by age (adjusted odds ratio (OR) 0.51, 95% confidence interval (CI) 0.15, 1.64 among patients < age 65, and adjusted OR 0.52, 95% CI 0.16, 1.68 among patients age 65 or older). Bleeding or thrombotic complications within 30 days of THA were also rare, and occurred similarly in both groups. Mechanical complications occurred in 2.3% and 2.5% of patients in the AS and comparison group, respectively, while 3.3% and 2.8% had revision arthroplasty within one year. Risks of these outcomes did not differ between groups after adjustment for demographic characteristics and comorbidities.

Ninety-day mortality was rare, but lower among patients with AS. The adjusted OR of 0.48 was consistent with a small-to-medium effect. The protective association was slightly stronger among patients age 65 or older (adjusted OR 0.41, 95% CI 0.17, 0.92) than those < age 65 (adjusted OR 0.61, 95% CI 0.22, 1.70). Long length of stay was marginally more frequent among patients with AS. The crude proportions of patients discharged to a care facility was similar in both groups (41.3% and 40.0%), but after adjustment, the likelihood of discharge to a care facility was higher among those with AS. The magnitude of this association approached a small effect. Readmission within 90 days occurred at similar frequencies in both groups.

Among the 11 individual complications for which multivariable models were estimable (excluding the perioperative, 30-day, and 90-day summary measures), the presence of congestive heart failure and chronic kidney disease were significantly associated with 10 complications, dementia was associated with 8 complications, and diabetes mellitus and chronic obstructive pulmonary disease were each associated with 7 complications in the multivariable models. The strongest associations were between coronary artery disease and

perioperative acute myocardial infarction (OR 2.35), chronic obstructive pulmonary disease and perioperative pneumonia (OR 2.25), congestive heart failure and chronic kidney disease with perioperative sepsis (OR 2.33 and 2.37, respectively), and congestive heart failure and chronic kidney disease with 90-day mortality (OR 2.28 and 2.20, respectively). Low income was associated with a higher likelihood of eight complications.

Sensitivity analysis

In this analysis, 11,920 patients with diagnosis claim codes for either RA or psoriatic arthritis were excluded from the comparison group, because potentially higher frequencies of post-operative complications in these patients might have reduced differences with the AS group. The characteristics of patients in the sensitivity analysis were similar to the parent group (Table 1). Frequencies of complications were also very similar to the parent comparison group, as were the ORs with respect to patients with AS (Table 3).

Associations with hospital volume

There was a graded association between annual hospital THA volume and the frequency of long lengths of stay among patients with AS, with long stays being 33% less frequent at high volume hospitals (Table 4). Mortality within 90 days, and any 90-day complication, were also less frequent at high volume hospitals, but because these complications were rare, trends were not significant.

Among patients without AS, discharge to a care facility had a graded association with hospital volume (44%, 39%, 37% at low, medium, and high-volume hospitals, respectively), whereas among patients with AS, the frequency of discharge to a care facility did not vary with hospital volume (39.6%, 42.2%, 42.0%, respectively) (p for interaction < 0.0001). Other associations between the frequency of complications and hospital THA volume were not significantly different between patients with and without AS.

DISCUSSION

In this study of older patients with AS who underwent primary THA, medical and surgical complications in the perioperative and near-term post-operative period were rare, and generally not different in frequency from those observed in patients without AS. Our results differ from those of two previous studies [17,20]. Blizzard et al also analyzed THA complications among Medicare beneficiaries, and reported higher risks of broken prostheses and wound complications within 90 days of surgery, and higher risks of hip dislocation, revision arthroplasty, and wound complications over two years, compared to controls [17]. Relative risks for these complications ranged from 1.42 (THA revision) to 2.54 (broken prosthesis). They also reported lower risks of acute myocardial infarction and higher risks of pneumonia, but did not analyze mortality, length of stay, or disposition. Several factors may account for the differences between these results and our findings, most notably the lack of adjustment for comorbidities and low income in the study of Blizzard and colleagues. Thirty percent of their sample was age 75 or older, and 39% were women. Differences in the samples may have also contributed, if THA complications occur particularly more frequently in patients with AS older than age 75. Differences in diagnosis coding between

studies may have also contributed to the differences in results. However, the absolute frequencies of complications were similar between studies. For example, revision arthroplasty was reported in 6.4% of patients over 2 years in their study, compared to 3.3% over 1 year in the present study.

In an analysis of the Nationwide Inpatient Sample, Schnaser et al reported low frequencies of THA complications in patients with AS [20]. However, risks of in-hospital mortality, wound complications, and cardiac, peripheral vascular, thrombotic, central nervous system, and gastrointestinal complications were higher among patients with AS than those with osteoarthritis. The sample included all ages, and analyses adjusted for comorbidities, but due to the nature of this database, complications and comorbidities were limited to those recorded during the THA hospitalization.

An issue pertaining to both previous studies relates to the construction of the AS cohort. Previous studies included patients with a single diagnosis code for AS, which may result in misclassification due to coding errors [30,31]. In identifying our analytic sample, 57% of patients with any AS claim had only a single claim, indicating poor specificity of a single claim. We identified patients using claims throughout their tenure in Medicare. Patients who had codes for RA and psoriatic arthritis were also excluded from the AS cohort. Inclusion of these patients in the AS group in previous studies may have falsely inflated the complication frequencies.

The lower mortality frequency among patients with AS may reflect differences in patient selection. Although we controlled for major comorbidities, residual confounding by differences in the severity of these conditions, or by other comorbidities, might account for the mortality difference we observed. Concerns about difficulty with anesthesia or respiratory complications due to a rigid chest wall may discourage patients with advanced AS from electing THA, whereas these would not be concerns for most patients without AS [32]. Patients with AS had higher odds of being discharged to a care facility after THA than those without AS. This may reflect a need for additional rehabilitation and gait training due to postural instability and increased risk of falling [33–35].

The results provided only limited evidence of an association between hospital THA volume and complication frequency. Patients at high-volume hospitals were less likely to have a long length of stay, possibly reflecting greater hospital efficiency. Long length of stay is also an indirect indicator of complications [36,37]. Ninety-day mortality was also one-third lower among patients whose THA was at high-volume hospitals. These results provide some indication to favor high-volume hospitals when considering THA. Trends with hospital THA volume were similar between patients with AS and those without AS for all complications except discharge to a care facility, which was similar across THA volume categories among patients with AS. This may reflect a recognized need for extended post-operative care in a higher proportion of patients with AS.

This study has several limitations. Although the study was population-based, the dataset does not include many younger patients, and we excluded those aged 75 or older. Complications were short-term, and did not examine long-term implant survival. Because

laterality of the THA was not known, we cannot be certain that a revision arthroplasty was related to the index THA or an earlier contralateral THA. However, this uncertainty applied equally to the AS and comparison groups. Random selection of one procedure for inclusion for those patients who had bilateral THA may have resulted in a slight overestimation of complication frequencies compared to an analysis of only the first THA, because those who elected to have a second THA may be more likely to have done well after their first THA. Because the same approach was used in both study groups, this would not be expected to bias the comparisons. Finally, although we took steps to increase the specificity of the AS group, some misclassification of diagnosis may be present.

These results suggest that perioperative and near-term post-operative complications of THA are uncommon in patients with AS. In contrast to other recent reports, the frequency of complications was no greater in these patients than in patients without AS. This information can be used by patients and physicians to aid their decision-making regarding THA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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SIGNIFICANCE AND INNOVATION

- This is the first study to use CMS validated measures to study complications of hip arthroplasty in ankylosing spondylitis, and to adjust for important clinical confounders.
- This is the first study to examine if the frequency of complications for this procedure vary with hospital volume.

Table 1

Patient characteristics.

	Ankylosing Spondylitis (N = 2773)	Comparison Group (N = 107,341)	Comparison Group excluding patients with rheumatoid and psoriatic arthritis (N = 95,421)
Age, years*	61.1 ± 10.8	69.0 ± 7.3	69.1 ± 7.2
Men, %	69.4	40.2	40.7
White, %	89.8	90.4	90.9
Black, %	6.0	7.5	7.2
Other, %	4.2	2.1	1.9
Low income, %	10.4	14.3	13.6
Coronary artery disease, %	42.2	38.7	38.1
Congestive heart failure, %	18.9	16.4	15.9
Chronic obstructive pulmonary disease, %	24.8	24.5	23.6
Diabetes mellitus, %	25.3	23.8	23.6
Chronic kidney disease, %	12.8	10.3	10.1
Cancer, %	11.4	11.2	11.3
Stroke, %	7.1	6.8	6.7
Dementia, %	4.0	3.4	3.3

*Mean ± standard deviation

Table 2

Association of ankylosing spondylitis with complications after primary total hip arthroplasty. Odds ratios represent the odds of occurrence in patients with ankylosing spondylitis versus the comparison group. CI = confidence interval. NE = not estimable.

	Number (Percent) affected		Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)*
	Ankylosing Spondylitis (N = 2773)	Comparison Group (N = 107,341)		
Perioperative				
Acute myocardial infarction	13 (0.47)	388 (0.36)	1.30 (0.75, 2.24)	1.29 (0.74, 2.23)
Pneumonia	23 (0.83)	862 (0.80)	1.03 (0.68, 1.56)	0.93 (0.61, 1.43)
Sepsis	6 (0.22)	365 (0.34)	0.64 (0.29, 1.40)	0.51 (0.22, 1.15)
Any perioperative complication	40 (1.44)	1485 (1.38)	1.05 (0.76, 1.43)	0.93 (0.67, 1.28)
30 Day Complications				
Wound bleeding	0	6 (0.01)	NE	NE
Pulmonary embolus	12 (0.43)	383 (0.36)	1.21 (0.68, 2.15)	1.28 (0.71, 2.31)
Deep venous thrombosis	8 (0.29)	250 (0.23)	1.24 (0.61, 2.51)	1.15 (0.55, 2.37)
Any 30 day complication	20 (0.72)	623 (0.58)	1.24 (0.79, 1.94)	1.24 (0.78, 1.96)
90 Day Complications				
Mechanical	65 (2.3)	2648 (2.5)	0.95 (0.74, 1.22)	0.86 (0.66, 1.11)
Surgical site infection	0	29 (0.03)	NE	NE
Death within 90 days	10 (0.36)	749 (0.70)	0.51 (0.27, 0.96)	0.48 (0.25, 0.90)
Any 90 day complication	75 (2.3)	3373 (2.5)	0.85 (0.67, 1.08)	0.77 (0.60, 0.99)
Revision arthroplasty within 1 year	91 (3.3)	3001 (2.8)	1.18 (0.95, 1.46)	1.01 (0.81, 1.26)
Long length of stay	329 (11.9)	10310 (9.6)	1.27 (1.13, 1.43)	1.15 (1.02, 1.30)
Discharged to care facility	1146 (41.3)	42940 (40.0)	1.07 (0.99, 1.16)	1.52 (1.40, 1.65)
Readmission within 90 days	342 (12.3)	12381 (11.5)	1.08 (0.95, 1.21)	0.95 (0.84, 1.08)

*Adjusted for age, sex, race, low income, and presence of coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, chronic kidney disease, cancer, stroke, and dementia.

Table 3

Association of ankylosing spondylitis with complications after primary total hip arthroplasty, after excluding patients with rheumatoid or psoriatic arthritis from the comparison group. Odds ratios represent the odds of occurrence in patients with ankylosing spondylitis versus the comparison group. CI = confidence interval. NE = not estimable.

	Number (Percent) affected		Crude Odds Ratio (95% CI)	Adjusted Odds Ratio (95% CI)*
	Ankylosing Spondylitis (N = 2773)	Comparison Group excluding patients with rheumatoid or psoriatic arthritis (N = 95,421)		
Perioperative				
Acute myocardial infarction	13 (0.47)	345 (0.36)	1.30 (0.75, 2.24)	1.27 (0.73, 2.20)
Pneumonia	23 (0.83)	767 (0.80)	1.03 (0.68, 1.56)	0.91 (0.59, 1.40)
Sepsis	6 (0.22)	320 (0.34)	0.66 (0.30, 1.42)	0.51 (0.22, 1.15)
Any perioperative complication	40 (1.44)	1318 (1.38)	1.05 (0.76, 1.44)	0.91 (0.66, 1.26)
30 Day Complications				
Wound bleeding	0	5 (0.01)	NE	NE
Pulmonary embolus	12 (0.43)	345 (0.36)	1.20 (0.67, 2.13)	1.25 (0.69, 2.27)
Deep venous thrombosis	8 (0.29)	226 (0.24)	1.22 (0.60, 2.46)	1.11 (0.53, 2.29)
Any 30 day complication	20 (0.72)	562 (0.59)	1.23 (0.78, 1.91)	1.20 (0.75, 1.90)
90 Day Complications				
Mechanical	65 (2.3)	2225 (2.3)	1.00 (0.78, 1.29)	0.88 (0.68, 1.15)
Surgical site infection	0	27 (0.03)	NE	NE
Death within 90 days	10 (0.36)	687 (0.72)	0.50 (0.26, 0.93)	0.46 (0.24, 0.88)
Any 90 day complication	75 (2.3)	2892 (2.3)	0.89 (0.70, 1.12)	0.78 (0.61, 1.00)
Revision arthroplasty within 1 year	91 (3.3)	2543 (2.7)	1.24 (1.00, 1.53)	1.04 (0.83, 1.30)
Long length of stay	329 (11.9)	9032 (9.5)	1.28 (1.14, 1.44)	1.15 (1.02, 1.30)
Discharged to care facility	1146 (41.3)	37570 (39.4)	1.09 (1.01, 1.18)	1.54 (1.42, 1.67)
Readmission within 90 days	342 (12.3)	10705 (11.2)	1.11 (0.99, 1.25)	0.97 (0.85, 1.10)

*Adjusted for age, sex, race, low income, and presence of coronary artery disease, congestive heart failure, chronic obstructive pulmonary disease, diabetes mellitus, chronic kidney disease, cancer, stroke, and dementia.

Table 4

Frequency of complications among patients with ankylosing spondylitis, by annual hospital volume of primary total hip arthroplasties (THA) performed among all Medicare beneficiaries.

	Low volume hospitals (1 – 44 THA per year)	Medium volume hospitals (45 – 99 THA per year)	High volume hospitals (≥ 100 THA per year)	Relative Difference: High vs. Low	P trend
Number of patients	843	963	967		
Any perioperative complication, %	1.30	1.56	1.45	+11.5%	0.82
Any 30 day complication, %	0.47	1.00	0.62	+31.9%	0.76
Any 90 day complication, %	3.20	2.60	2.38	−25.6%	0.29
Revision arthroplasty within 1 year, %	3.56	3.22	3.10	−12.9%	0.59
Death within 90 days, %	0.47	0.31	0.31	−34.0%	0.56
Long length of stay, %	13.9	12.7	9.3	−33.0%	0.003
Discharged to care facility, %	39.6	42.2	42.0	+6.1%	0.33
Readmission within 90 days, %	12.3	12.8	11.9	−3.2%	0.76