Effect of the Deyo score on outcomes and costs in shoulder arthroplasty patients

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ABSTRACT

Purpose. To evaluate the effect of preoperative comorbidity status (defined by the Deyo index) on hospital mortality, postoperative complications, length of hospital stay, and hospital costs for shoulder arthroplasty patients.

Methods. The overall mean hospital mortality and postoperative complication rates, and length of hospital stay and hospital costs stratified by the Deyo score were compared using the Pearson Chi squared test and the F-test, respectively. The effects of the Deyo score on hospital mortality and postoperative complications were estimated using multiple logistic regression. The length of hospital stay and hospital costs were estimated using multiple linear regression. The magnitude of the estimated effects of the Deyo score on the 4 outcomes were expressed as crude odds ratios (ORs) and adjusted ORs for age, race, gender, surgeon volume, and hospital volume.

Results. Higher Deyo scores tended to be associated with higher hospital mortality, length of hospital stay, postoperative complications, and hospital costs. Compared with the referent group (Deyo score=0), patients with the highest Deyo scores (5–36) exhibited adjusted ORs of 11.8 for hospital mortality (p=0.011) and 1.1 for developing postoperative complications (p=0.098), and had the highest length of hospital stay (mean, 4.1 days) and hospital costs (mean, US$18 549).

Conclusion. The Deyo score was a predictor of outcomes and costs in the shoulder arthroplasty population. By identifying relevant factors, health care providers can better determine who should be referred for shoulder arthroplasty and what should be considered when assessing risks and benefits.

Key words: arthroplasty, replacement; comorbidity; hospital costs; hospital mortality; postoperative complications; shoulder joint

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INTRODUCTION

Shoulder arthroplasty can improve pain and function of the shoulder and ensures a productive and healthy lifestyle in appropriate candidates. It is technically demanding and risks complications when improper technique is used or when performed with inappropriate indications. Clear definition of who will benefit from this procedure improves the ability of surgeons to assess risks and benefits.

Recognition of factors that affect patient outcomes have increased substantially, as the number of patients having the procedure has increased. Excluding inappropriate candidates may yield a better prognosis. Factors contributing to mortality, complications, and costs as well as studies comparing various types of shoulder arthroplasties (e.g. hemiarthroplasty vs total shoulder arthroplasty) have been reported.

Nonetheless, most studies were of small sample size and failed to account for the surgeon experience, hospital volume, and demographic factors such as race and gender. Only specific findings for subsets of shoulder arthroplasty patients have been reported. So it is difficult to extrapolate such findings to the general population undergoing this procedure. The effects of preoperative comorbidity status on recovery/postoperative complication rate were not studied.

Nationally representative secondary databases have been used to assess the impact of baseline comorbidity status on surgical outcomes and resource use. The Charlson index is a validated comorbidity index initially designed to characterise preoperative comorbidity status for patients entering into longitudinal studies. It was adapted for use with the International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes. Thereby it enables conjunction with administrative and secondary databases for analysing outcomes in various patient populations. This modified Charlson index—the Deyo index—has been used as a means of controlling for confounding by comorbidity status in outcomes studies on shoulder arthroplasty patients, but its use as a predictor of clinical outcomes and hospital costs has not been examined.

We aimed to evaluate the effect of preoperative comorbidity status (defined by the Deyo index) on hospital mortality, postoperative complications, length of hospital stay, and hospital costs for shoulder arthroplasty patients after adjusting for race, age, gender, hospital volume, and surgeon volume. It was hypothesised that a higher Deyo index was associated with an increased risk for hospital mortality, postoperative complications, length of hospital stay, and hospital costs.

MATERIALS AND METHODS

The National Inpatient Sample (NIS) database between 1988 and 2000 was used to assess the effects of the Deyo index on hospital mortality, postoperative complications, length of hospital stay, and hospital costs. The NIS is a part of the Healthcare Research Cost and Utilization Project, sponsored by the Agency for Healthcare Research and Quality. The NIS comprises 20% of stratified randomised samples of 900 to 1000 hospitals from 19 states in the United States and contains records for >7 million in-patient procedures per year. It provides a representative sampling; strata were based on geographic location, teaching status (teaching or non-teaching hospital), bed size (small, medium or large), ownership (public or private), and location (rural or urban). Each hospitalisation was recorded as an independent event. Patient demographics, diagnoses, length of hospital stay, financial background, and admission and discharge information were recorded.

Patients with an ICD-9-CM code indicating a shoulder arthroplastic procedure (81.80 for total shoulder arthroplasty and 81.81 for hemiarthroplasty) were included. Patients were excluded if diagnosed with bone infection, malignancy, pathological fractures involving the shoulder, or complications/revisions associated with prior shoulder arthroplasty. 28 434 procedures were selected (Fig.).

Outcome measures were hospital mortality, postoperative complications, length of hospital stay, and hospital costs (adjusted for inflation but not including physician fees). The primary predictor was preoperative comorbidity status defined by the Deyo index. The Deyo index assigns scores of 1 to 6 for 17 diagnostic categories (myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, rheumatologic disease, peptic ulcer disease, mild liver disease, severe liver disease, diabetes, diabetes with chronic complications, hemiplegia or paraplegia, renal disease, any malignancy including leukaemia and lymphoma, metastatic solid tumour, and acquired immunodeficiency syndrome). The sum of each score was the overall comorbidity status (the Deyo score). A Deyo score of 0 (referent group) indicates no comorbidity; 1 to 4, moderate; and 5 to 36, substantial. The number of patients in the referent group was larger than in the other 2 groups and therefore chosen as the cut-off.

The covariates were age, race, gender, surgeon volume, and hospital volume. Surgeon volume was defined as the total number of shoulder arthroplasties...
(total and hemiarthroplasty) performed by each surgeon per year. It was divided into low (≤2), medium (3–4), and high (>4). Hospital volume was based on the number of shoulder arthroplastic procedures performed at each hospital per year. It was divided into low (≤6), medium (7–13), and high (>13). The cut-offs for both surgeon and hospital volumes were at 0, 33rd, and 66th percentiles to ensure similar distributions in each group to have clinically meaningful differences.

Overall mean hospital mortality and postoperative complication rates, and length of hospital stay and hospital costs stratified by the Deyo score were compared using the Pearson Chi squared test and the F-test, respectively. The effects of the Deyo score on hospital mortality and postoperative complications were estimated using multiple logistic regression.

The length of hospital stay and hospital costs were estimated using multiple linear regression. The magnitude of the estimated effects of the Deyo score on the 4 outcomes were expressed as crude odds ratios (ORs) and adjusted ORs for age, race, gender, surgeon volume, and hospital volume. Incremental ORs were compared to measure the dose-response relationship of the Deyo score on hospital mortality and postoperative complications.\textsuperscript{32}

**RESULTS**

Of the 28 434 procedures, 67% were for patients aged >65 years, 66% of patients were Caucasian, and 67%
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were females. 71 had died. The mean length of hospital stay was 3.4 (standard deviation [SD], 1.9) days. The mean hospital costs was US$16 468 (SD, 1630). There were 360 postoperative complications (Table 1).

A Deyo score of 0 was used as the referent group. A Deyo score of 5 to 36 had the highest proportion of hospital mortality (1.0%), postoperative complications (1.6%), length of hospital stay (mean, 4.3 days; SD, 2.0 days) and hospital costs (mean, US$18 840; SD, $1660). The referent group had the lowest proportion of hospital mortality (0.1%), length of hospital stay (mean, 3.2 days; SD, 1.9 days), and hospital costs (mean, US$15 792; SD, $1620). The Deyo score of 1 to 4 had the lowest proportion of postoperative complications (0.9%) [Table 2]. This is likely due to the small number of patients in this stratum or ineffectiveness for the Deyo score to predict postoperative complications in patients with low comorbidity.

Higher Deyo scores tended to be associated with higher hospital mortality, postoperative complications, length of hospital stay, and hospital costs (Table 3). Compared to the referent group, patients with the highest Deyo scores (5–36) exhibited adjusted ORs of 11.8 (95% confidence interval [CI], 4.8–29.3; p=0.011) for hospital mortality and 1.1 (95% CI, 0.8–1.6; p=0.098) for developing postoperative complications. They also had the highest adjusted length of hospital stay (mean, 4.1; 95% CI, 4.0–4.2 days) and the highest adjusted hospital costs (mean, US$18 549; 95% CI, $18 174–18 932); these were $2893 greater than those for the referent group and $2372 greater than those for all patients.

**DISCUSSION**

The Deyo index has been used as a means of adjustment for confounding by baseline comorbidity status.\(^\text{18–21}\) Despite being a technically challenging procedure, shoulder arthroplasty was relatively safe for healthy individuals. In our study, the risk of hospital mortality, postoperative complications, length of hospital stay, and hospital costs increased as the Deyo score increased. Our study further

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Deyo score</th>
<th>p Value</th>
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<tbody>
<tr>
<td>Hospital mortality (95% CI)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crude OR</strong></td>
<td>1</td>
<td>1.9 (0.8–4.5)</td>
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<tr>
<td><strong>Adjusted OR</strong></td>
<td>1</td>
<td>2.9 (0.8–10.4)</td>
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<tr>
<td>Postoperative complications (95% CI)</td>
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<tr>
<td><strong>Crude OR</strong></td>
<td>1</td>
<td>0.7 (0.5–0.9)</td>
</tr>
<tr>
<td><strong>Adjusted OR</strong></td>
<td>1</td>
<td>0.7 (0.4–1.1)</td>
</tr>
<tr>
<td>Mean length of hospital stay (95% CI) [days]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crude OR</strong></td>
<td>3.2 (3.2–3.2)</td>
<td>3.5 (3.4–3.6)</td>
</tr>
<tr>
<td><strong>Adjusted OR</strong></td>
<td>3.1 (3.0–3.1)</td>
<td>3.3 (3.2–3.3)</td>
</tr>
<tr>
<td>Mean hospital costs (95% CI) [US$]</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crude OR</strong></td>
<td>15 792 (15 683–15 903)</td>
<td>17 153 (16 912–17 398)</td>
</tr>
<tr>
<td><strong>Adjusted OR</strong></td>
<td>15 656 (15 496–15 818)</td>
<td>16 716 (16 372–17 068)</td>
</tr>
</tbody>
</table>

* Adjusted ORs reflect adjustment for age, race, gender, surgeon volume, and hospital volume. Missing values were not included in calculation of adjusted values.*

**Table 2**

Outcomes stratified by Deyo score

**Table 3**

Crude and adjusted odds ratios (ORs) of outcomes stratified by Deyo score*
characterised the shoulder arthroplasty population and confirmed that baseline comorbidity status (the Deyo score) was a predictor of outcomes and costs in the shoulder arthroplasty population. These findings can be applied to decrease morbidity, mortality, and unnecessary use of resources on unsuitable surgical candidates.

Our study had limitations. The numbers of hospital mortality and postoperative complications were small. This affected the precision for estimating the Deyo score pertaining to these parameters, which was reflected by the wide confidence intervals. The use of a secondary database also introduced the possibility of errors in coding of the diagnoses and procedures. The NIS database only enabled ascertainment of morbidity and mortality in hospital; events that occur subsequent to patient discharge were not considered. Costs in the NIS database did not take into account physician fees.

Further studies are needed to identify specific predictors of outcomes in the shoulder arthroplasty population, to assess trends within the 17 categories that define the Deyo score, and to examine whether any of these parameters are amenable to interventions. Some comorbidities are more correlated with worse outcomes and increased costs than others. By identifying factors relevant to outcomes and costs, health care providers can better determine who should be referred for shoulder arthroplasty and what should be considered, given a certain clinical presentation, age, socioeconomic status, and gender. This can provide insight on ways to decrease hospital mortality, postoperative complications, length of hospital stay, and hospital costs, which are all pertinent to health care costs incurred by hospitals, patients, and insurance companies.

REFERENCES