Patient-Related Risk Factors That Predict Poor Outcome after Total Hip Replacement

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Objective. To identify factors associated with poor outcome after total hip replacement (THR) surgery.

Data Sources. This article is the first to present results from the American Medical Group Association (AMGA) THR consortium.

Study Design. The outcomes evaluated were pain and physical function. Eight patient risk factors were evaluated. These included the age, sex, race, marital status, and education of the patient; whether the patient had polyarticular disease or other comorbid conditions; and the patient's preoperative pain and physical function score.

Data Collection. Data were collected from patients using AMGA-approved, self-administered questionnaires preoperatively and at six weeks, three months, six months, one year, and two years postoperatively.

Principal Findings. Of the patient risk factors studied, race, education, number of comorbid conditions, and preoperative Health Status Questionnaire (HSQ) score were found to be associated with poor outcome. These risk factors were found to have an effect on both pain and physical function at six months postoperatively. Patients with higher preoperative scores were found to have higher postoperative scores, but substantially fewer of these patients received any benefit from their surgery. For each 10-point increase in preoperative score, patients could expect at least a 6-point decrease in postoperative improvement.

Conclusions. Our study indicates that preoperative status is an important predictor of outcome for THR.

Key Words. Total hip replacement, functional status, outcomes research, risk factors

Total hip replacement (THR) is one of the most common adult orthopedic procedures performed in the United States (Harris and Sledge 1990; Sharkness et al. 1993). With the aging of the U.S. population, utilization of this procedure is likely to increase (Friedman and Elixhauser 1993). Therefore, a clear understanding of factors associated with poor outcome for THR is

imperative. In the five decades since THRs were first performed, numerous studies have illustrated the overall success of the procedure (Gogia, Christensen, and Schmidt 1994; Kirwan, Currey, Freeman, et al. 1994; Malchau et al. 1993; Harris and Sledge 1990). The majority of these studies measured only intermediate physiologic outcomes such as range of motion and dislocation rate. Only a few studies have measured the ultimate outcomes experienced by patients, such as patient health status, function, pain, well-being, and satisfaction (Wright, Rudicel, and Feinstein 1994; Gartland 1988). Recently, attempts have been made to address this deficiency through multicenter outcomes measurement efforts designed to collect and pool information on patient outcomes. This article is the first to present results from one such effort, organized under the auspices of the American Medical Group Association (AMGA, formerly AGPA) (Sanderson-Austin, Swyers, and Johnson 1993).

The AMGA Total Hip Replacement Consortium is an association of clinics performing and collecting data on THR. The AMGA began collecting data from hip replacement recipients and their physicians in 1991. In the five years since its inception, the consortium has collected and pooled data on over 1,500 patients from 14 different clinics across the United States.[1] The purpose of this study is to conduct a preliminary analysis of the AMGA THR database to identify factors associated with poor outcome after total hip replacement surgery. The specific risk factors chosen for these analyses were divided into three categories: demographic risk factors, medical history risk factors, and preoperative functional status. Demographic risk factors considered include the patient's age at surgery, female gender, African American race, marital status, low education, and low income. Medical history risk factors considered include polyarticular arthritis, number of comorbid conditions, and obesity.

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Preoperative functional status measures evaluated include pain and physical function.

Through identifying risk factors, the authors hope to move closer to developing a model that can be used to predict patient outcome based on the existence of specific risk factors known prior to the procedure. This model would provide better information to guide shared decision making by physicians and patients regarding the appropriateness of THR.

METHODS

DATA COLLECTION

Data were analyzed from the AMGA THR database. Collection of AMGA THR data follows a predefined protocol. Data are collected from patients and physicians using AMGA-approved, self-administered questionnaires preoperatively and at six weeks, three months, six months, one year, and two years postoperatively. In addition, physicians complete a day-of-surgery and a day-of-discharge form for each patient. Only patient-reported data were used in these analyses. The questionnaires either were completed in the clinic or mailed to the patient's home with a stamped, addressed envelope. Patient perceptions regarding hip replacement were assessed using the Hip TyPE (Technology of Patient Experience) condition-specific questions (Liang 1990). The Hip TyPE questions ask the patients to rate their ability to walk, the extent to which they limp, and their ability to dress themselves, among other functional capacities. The Hip TyPE is part of the Outcomes Management System (OMS), a series of questionnaires and data collection forms developed by Interstudy (Ellwood 1988). Patient perceptions regarding general health status, pain, physical function, role function, social function, energy level, and mental health were assessed using the Health Status Questionnaire (HSQ) version 2.0 (Ware et al. 1993). Patient demographic information and expectations for the surgery were also collected.

To be referred into the AMGA THR database, patients must have been 21 years or older, must have received THR surgery at one of the AMGA THR Consortium sites, and must have agreed to participate in the study after invitation by staff within the clinic. For these preliminary analyses, clinics were required to submit their data to the AMGA THR database as of October 1, 1994, and patients were required to have complete preoperative data and to have had enough time, post-surgery, to complete a six-month-postoperative

questionnaire. Data were transmitted to Henry Ford Health System without patient, clinic, and physician identifiers for the purposes of analysis.

STATISTICAL ANALYSIS

ANALYSES OF OUTCOMES

The outcomes evaluated in these analyses were HSQ pain and physical function (Ware et al. 1993). Throughout this article, the term *function* refers to both HSQ pain and physical function unless physical function is specifically mentioned. HSQ pain scores were tallied from two questions, one containing five response levels and the other six response levels. HSQ physical function scores were tallied from ten questions, each containing five response levels. Patient-reported mean HSQ pain and physical function scores were examined over time. Four patient-reported outcomes were then analyzed in depth: change in HSQ pain score that occurred from baseline to six months and one year postoperatively, and change in HSQ physical function score that occurred from baseline to six months and one year postoperatively.

ANALYSIS OF RISK FACTORS

Ten patient risk factors were evaluated. Risk factors were divided into three categories: demographic, medical history, and preoperative HSQ score. Within this study, low education was defined as less than a high school education, and low income was defined as an annual household income of less than $20,000. An estimate of the overall burden of comorbid disease was determined by the total number of individual comorbid diseases for each patient. Comorbid conditions considered included congestive heart failure, chronic lung disease, blindness or trouble seeing, deafness or trouble hearing, diabetes mellitus, asthma, ulcer or gastrointestinal bleeding, and sciatica or chronic back problem.

Statistical analyses were completed using SAS statistical software (SAS Institute Inc. 1990). Univariate results are presented as the difference in means from baseline to follow-up, with the confidence interval around this difference, as well as corresponding p-values. Univariate analyses were completed for all risk factors and outcomes, with the exception of comorbid conditions and preoperative function, using the student's t-test. Univariate analyses for the number of comorbid conditions and preoperative function were completed using a linear regression model.

A multiple linear regression model was fitted to obtain estimates for each risk factor in the presence of all of the others.[2] Multivariate results are

presented as the adjusted difference in means from baseline to follow-up, with the confidence interval around this difference, as well as corresponding *p*-values.

RESULTS

Excluded from these analyses were patients with a diagnosis of tumor ($n = 9$), arthritis due to old infection ($n = 1$), metabolic deposition ($n = 4$), acute fracture ($n = 45$), and old fracture ($n = 30$). After these exclusions, the AMGA THR outcomes database contained complete preoperative HSQ pain and physical function observations for 848 patients who had at least eight months of follow-up. Eight months of follow-up was chosen because this is the time period allowed by the AMGA THR protocol for patients to complete the six-month questionnaire. Of these patients, 442 (52 percent) had complete HSQ data for the six-month-postoperative time period. A subset of 172 patients had complete data for the one-year-postoperative time period. Due to the large number of missing values for the obesity and low-income variables, these risk factors were eliminated from the analyses. The prevalence of the risk factors within the sample are presented in Table 1.

HSQ scores are reported on a scale from 0 to 100, with a 0 score indicating extremely compromised function and a score of 100 indicating no impairment of function. Figure 1 shows the change in mean HSQ bodily pain score over time. Rapid change is found during the immediate postoperative period with a leveling off in change by six months post-surgery. Figure 2 shows the change in mean HSQ physical function score over time. Change

Table 1: Prevalence of Risk Factors within the Study Population ($n = 442$)

	Patients with Risk Factor	*Missing Values*	*% of Study Population (Excluding Patients with Missing Values)*
Demographic risk factors			
Age ≥65	251	0	57
Female gender	264	0	60
African American	54	20	13
Nonmarried	151	9	35
Low education	98	3	22
Medical history risk factors			
Polyarticular arthritis	298	0	67
Comorbid condition present	189	0	43

is more gradual during the immediate postoperative period, with a leveling off in change by six months.

Distributions of the change in HSQ pain scores and in HSQ physical function scores from baseline to six months and one year were plotted but, for brevity, are not presented. These figures showed that change scores approximate a normal distribution and that these distributions at six months and one year are very similar. In addition, these distributions indicated that approximately 16 percent of patients report no change in pain or increased pain at six months, and approximately 24 percent of patients report no change in physical function or decreased physical function at six months.

Results of the univariate and multivariate analyses for pain change and physical function change at six months are presented in Tables 2 and 3. Results of the univariate and multivariate analyses at one year are not presented because of small numbers and because these results did not affect any of our conclusions. Of the demographic risk factors studied, only African American race and low education were found to have an effect on outcome. After adjustment for all other risk factors, African American race was associated with a decrease of 9.5 points in pain score change (95% C.I. −18.3, −3.5) at six months. After adjustment for all other risk factors, low education was associated with a decrease of 6.2 points in pain score change (95% C.I. −16.9, −2.1) and a decrease of 10.9 points in physical function score change (95% C.I. −12.3, −0.1) and a decrease of 7.7 points in physical function score change (95% C.I. −13.8, −1.6).

Preoperative function was found to be associated with change in bodily pain and physical function scores. Patients with low preoperative scores were found to have lower scores postoperatively as compared to patients with high preoperative scores. However, each 1.0-point increase in preoperative score was associated with a corresponding decrease of 0.6 points in physical function score change and a decrease of 0.7 points in pain score change. In Figures 3 and 4, the relationship between preoperative score and improvement (defined as a positive change in score from preoperative to six months postoperative) is illustrated. In these figures, the percentage of patients who reported improvement by six months after surgery is plotted according to their preoperative score category. A much higher percentage of patients with low (0–19) preoperative scores were found to report pain and physical function improvement as compared to patients with high (80–100) preoperative scores.

After adjustment for other risk factors, the number of comorbid conditions was found to have an effect on both pain and physical function improvement at six months postoperatively. With each additional comorbid condition

Figure 1: Change in Mean HSQ Bodily Pain Score over Time

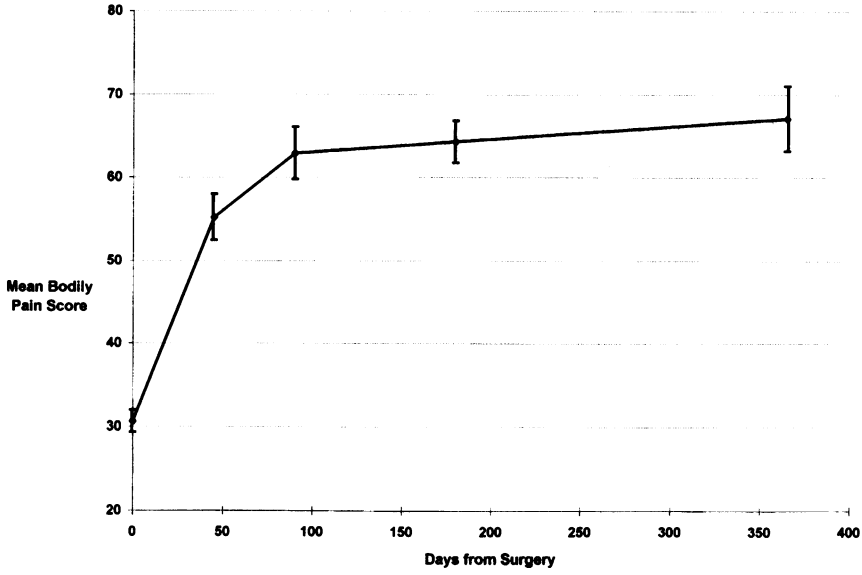


Figure 2: Change in Mean HSQ Physical Function Score over Time

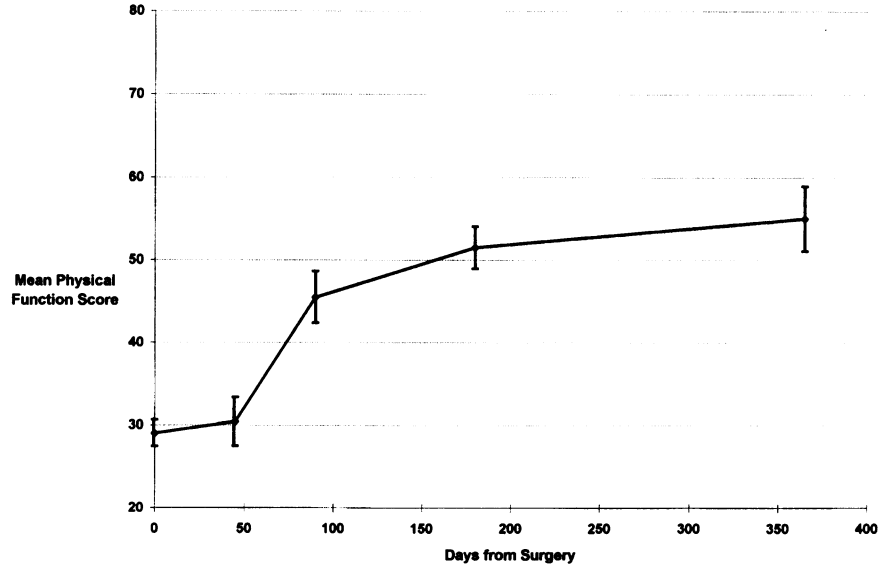


Table 2: Difference in Pain Score Change from Baseline to Six Months ($n = 442$)

	n	*Difference in Means*	*Confidence Interval*	p	*Difference in Means Adjusted*	*Confidence Interval*	p
Demographic risk factors							
Age ≥65	442	2.7	(−2.6, 8.0)	.31	4.4	(−0.7, 9.5)	.09
Female gender	442	4.3	(−1.0, 9.6)	.11	−0.9	(−6.2, 4.4)	.72
African American	422	−9.2	(−17.2, −1.2)	.02	−9.5	(−16.9,−2.1)	.01
Nonmarried	433	2.7	(−2.9, 8.3)	.35	1.6	(−3.7, 6.9)	.55
Low education	439	−4.4	(−10.7, 1.9)	.17	−6.2	(−12.3,−0.1)	.04
Medical history risk factors							
Polyarticular arthritis	441	−1.9	(−7.5, 3.7)	.93	−2.8	(−8.1, 2.5)	.30
Number of comorbid conditions	442	−2.7	(−5.6, 0.3)	.08	−4.6	(−7.5,−1.7)	<.01
Preoperative function risk factors							
Preop HSQ bodily pain score	442	−0.6	(−0.8,−0.5)	<.01	−0.7*	(−0.5,−0.9)	<.01

* For a difference of ten points in the preoperative score, improvement declines by seven points.

Table 3: Difference in Physical Function Score Change from Baseline to Six Months Postoperative ($n = 439$)

	n	*Difference in Means*	*Confidence Interval*	p	*Difference in Means Adjusted*	*Confidence Interval*	p
Demographic risk factors							
Age ≥65	439	−1.3	(−6.9, 4.3)	.66	−0.5	(−5.8, 4.8)	.85
Female gender	439	−0.1	(−5.8, 5.6)	.96	−4.2	(−9.5, 1.1)	.31
African American	418	−12.4	(−20.6, −4.2)	<.01	−10.9	(−18.3,−3.5)	<.01
Nonmarried	428	−0.4	(−6.3, 5.5)	.89	−0.2	(−5.5, 5.1)	.94
Low education	436	−7.8	(−14.5,−1.1)	.04	−7.7	(−13.8,−1.6)	.02
Medical history risk factors							
Polyarticular arthritis	439	1.2	(−4.7, 7.1)	.70	−0.8	(−6.3, 4.7)	.78
Number of comorbid conditions	439	−5.2	(−8.3,−2.1)	<.01	−4.7	(−7.6,−1.8)	<.01
Preoperative function risk factors							
Preop HSQ physical function score	439*	−0.6	(−0.7,−0.5)	<.01	−0.6**	(−0.4,−0.8)	<.01

* Three patients missing preoperative physical function observations.

** For a difference of ten points in the preoperative score, improvement declines by six points.

Figure 3: Frequency of Patients Reporting Improvement in Pain Score at Six Months Postoperative by Preoperative Score Category ($n = 442$)

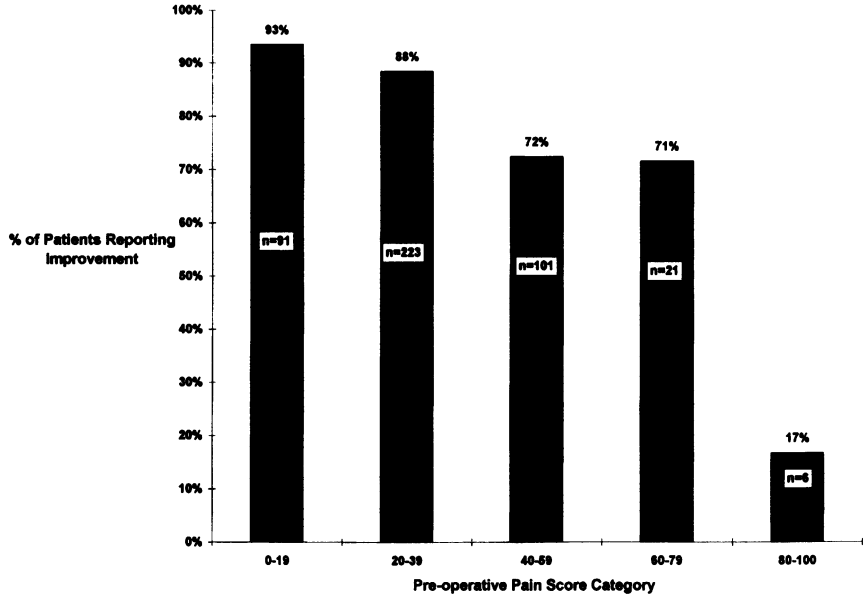
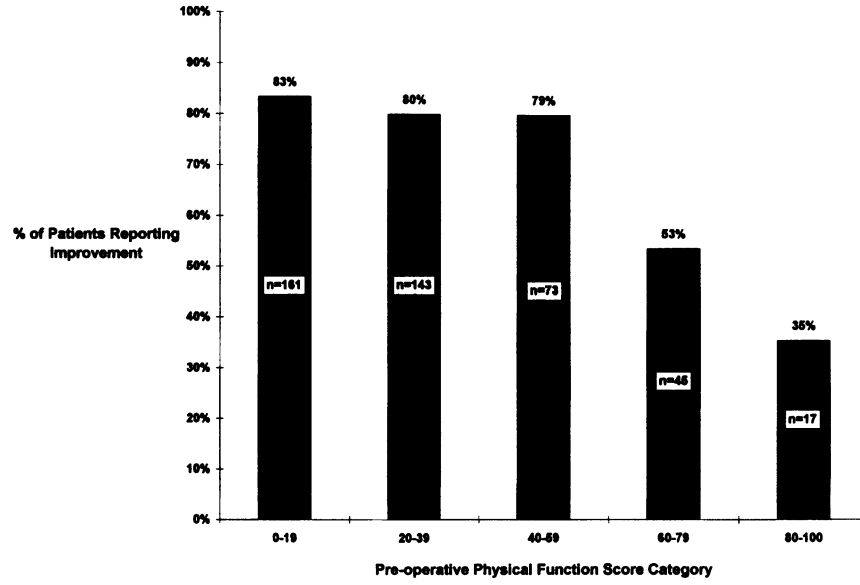


Figure 4: Frequency of Patients Reporting Improvement in Physical Function Score at Six Months Postoperative by Preoperative Score Category ($n = 442$)



there was a corresponding decrease of 4.6 points in pain score change (95% C.I. −7.5, −1.7) and a decrease of 4.7 points in physical function score change (95% C.I. −7.6, −1.8). The effect of each individual comorbid condition on pain and physical function improvement at six months, after adjustment for other risk factors, are presented in Table 4. The effect of sciatica or a chronic back problem on pain improvement and the effect of vision difficulties on physical function improvement are of particular interest.

DISCUSSION

The primary indications for THR are pain and restriction of mobility (Wiklund and Romanus 1991; Friedman and Elixhauser 1993). As in numerous other studies, this study found that THR resulted in rapid and marked improvement in pain and physical function for a majority of patients. Most of this improvement occurred during the first six months following surgery. Gains in pain improvement were found to be faster than gains in physical function improvement. This outcome is consistent with that of other studies and supports a widely accepted practice philosophy among surgeons that

Table 4: Difference in Pain Score Change and Physical Function Score Change from Baseline to Six Months for each Comorbid Condition

		Difference in Pain Score Change (n = 442)			*Difference in Physical Function Score Change (n = 439)*		
Comorbid Condition	n	*Difference in Means Adjusted*	*Confidence Interval*	p	*Difference in Means Adjusted*	*Confidence Interval*	p
Congestive heart failure	39	−6.3	(−14.9, 2.3)	.15	−2.2	(−10.8, 6.4)	.63
Chronic lung disease	26	−3.5	(−14.3, 7.3)	.52	−5.3	(−16.3, 5.7)	.34
Blindness or trouble seeing (even with glasses)	25	−5.2	(−16.0, 5.6)	.35	−15.0	(−26.2,−3.8)	.01
Deafness or trouble hearing	61	1.1	(−3.9, 6.1)	.77	−3.3	(−8.3, 1.7)	.39
Diabetes mellitus	31	−5.3	(−9.4,−1.2)	.30	−0.7	(−4.8, 3.4)	.90
Asthma	18	0.3	(−12.8, 13.4)	.96	0.6	(−12.9, 14.1)	.93
Ulcer or gastrointestinal bleeding	19	−11.2	(−23.4, 1.0)	.07	−5.0	(−17.7, 7.7)	.44
Sciatica or chronic back problem	62	−9.6	(−17.0,−2.2)	.01	−6.9	(−14.5, 0.7)	.08

the primary role of THR is to provide relief of pain, with physical function improvement as a secondary objective for many patients (Gogia, Christensen, and Schmidt 1994; Harris and Sledge 1990).

The results of this analysis indicate that approximately 84 percent of patients report improvement in pain and 76 percent report improvement in physical function by six months postoperatively. Although these results are very good when compared to the results of many other surgical procedures, it is interesting to note that many previous studies on THR have reported success rates exceeding 90 percent (Malchau et al. 1993; Kirwan, Currey, Freeman, et al. 1994; Harris and Sledge 1990). Because a majority of these studies made use of physician-reported outcome measures and not patient-reported outcome data, the difference in the success rate found in our study may well represent the variation that has been found to exist between a patient's perception and his or her physician's explicit criteria for success (Black, Petticrew, Ginzler, et al. 1991).

The factors chosen for study in this preliminary analysis were those that we believed would have a negative effect on outcome after THR. Age at surgery was included as a risk factor due to poorer healing, poorer toleration of complications, and worse baseline disease in the elderly (Thorsen, McKenna, and Gottschalck 1993; Perersen, Solgaard, and Simonsen 1989). Female gender was included as a risk factor due to the higher risk of osteoporosis in women and the effect this higher risk can have on THR outcome (Farmer et al. 1987; Felson, Zhang, Hannan, et al. 1993). Marital status was considered to be a risk factor due to the increased probability of complications from injury or stress for patients without social supports (Cummings, Phillips, Wheat, et al. 1988). We considered nonmarried status as a possible proxy for lack of social supports.

African American race was included as a risk factor in this study because of the higher prevalence of low socioeconomic status within the African American population (Osborne and Feit 1992). Some previous studies on THR, however, have indicated that African American race may confer benefits due to physiologic factors such as a slower rate of bone loss and greater bone remodeling (Bell, Greene, Epstein, et al. 1985; Liel, Edwards, Shary, et al. 1988; Farmer et al. 1987). Therefore, the specific effect of African American race on THR outcome is somewhat unclear. In our study, African American race was found to decrease improvement in both bodily pain and physical function scores at six months postoperatively.

Low education has been shown to be an important risk factor in other medical conditions such as cardiovascular disease and obesity and, therefore, was included in these analyses (Haan, Kaplan, and Camacho 1987; Matthews,

Kelsey, Meilahn, et al. 1989; Winkleby et al. 1992). Patients with minimal education are hypothesized to have a reduced knowledge of disease and related factors such as promotion of healing, avoidance of complications, and the need to seek prompt medical care when necessary. In our study, low education was found to be a predictor of poor outcome following THR surgery. These results should be interpreted with caution, however, due to the lack of sufficient data for the low-income variable.

We considered certain medical history variables as candidate risk factors for poor THR outcomes. Polyarticular arthritis or the presence of a comorbid condition were believed to indicate dysfunction from other joints or medical conditions that would hinder functional gains from THR. Further, these conditions might be a proxy for more severe arthritis of the hip joint or for poor overall health (Greenfield et al. 1993; Cleary, Reilly, Greenfield, et al. 1993). In these analyses only comorbidity was found to be associated with poor outcome after THR. These results suggest that the presence and number of comorbid conditions, representing compromised ability in other organ systems and poor overall health, may diminish the gains possible from THR surgery. In these analyses, comorbid conditions were considered individually and as a simple additive index. Charlson et al. (1987) developed a method for the weighting of comorbid conditions, and the results of their study indicated that none of the comorbid conditions considered in this article were of a severity sufficient to warrant a weighting of greater than 1. Thus, a simple additive index was utilized. This approach, however, does not take into consideration the physical impairment due to the disease (Greenfield et al. 1993).

The association of preoperative function and outcome is the most interesting result of these analyses. Good preoperative (baseline) function was hypothesized to be a risk factor for poor outcome in this study because individuals who already have high preoperative scores may have a smaller opportunity to benefit from THR. We found few studies that included preoperative function as a potential risk factor for poor outcome and determined that, depending on the ways in which outcome is calculated, different conclusions about the effect of preoperative function on postoperative outcome can be made. In one study, Cleary, Reilly, Greenfield, et al. (1993) used post-procedure quality of life as their outcome measure rather than the change between pre- and post-surgical scores. These authors found a positive association between preoperative function and postoperative outcome. Liang, Cullen, Larson, et al. (1986) used change (pre-surgery versus post-surgery) as their outcome measure and determined that total joint arthroplasty was

more cost-effective in those patients with the most to gain. Liang's results indicated that a negative association existed between preoperative function and postoperative outcome.

In our study, we chose to look at outcome in two ways, as mean postoperative score and as change in score from the preoperative to postoperative time period. Our results indicate that patients with lower preoperative function will have lower postoperative function, but that substantially more of the patients will have received benefit from their surgery (Figures 3 and 4). Patients with a high preoperative function score may be less likely to improve after total hip replacement surgery. For each 10-point increase in preoperative score, patients can expect at least 6 points less postoperative improvement. Indeed, patients with very high preoperative function scores (80 or above) were actually found to have a mean postoperative score lower than their mean preoperative score. One implication of these results is that surgeons should carefully consider all alternatives before operating on patients with high preoperative function because these patients will improve only slightly. A second implication of these results is that improvement, not just the final score, is an important outcome measure for patients receiving THR.

Our study has potential limitations. Missing data are a substantial problem. Due to the large number of missing observations for the obesity and low-income variables, multivariate results are presented without these factors. The number of patients with complete observations for our outcome measures at six months and one year was also low. Many patients enrolled in the study did not complete the required forms. Based on previous experience at our institution (Robens-Paradise and Clipper 1994), the length of the data collection forms may have been a barrier to high completion rates. In addition, the AMGA consortium has been trying to collect data as a part of clinical practice. Comparisons were made of demographic and medical history factors between responders and nonresponders, and no substantial differences were found. Further, sensitivity analyses were completed for the preoperative function variable in which missing outcomes were assumed to be either extremely poor (0) or extremely good (100). Even with these adjustments, the association between preoperative function and improvement remained.

Despite these limitations, the results of this preliminary study indicate that preoperative HSQ bodily pain and HSQ physical function scores may provide an important source of information to clinicians and their patients contemplating total hip replacement surgery. As indicated in the introduction to this article, we intend to use these results in developing a model that can be used to predict patient outcome following THR. A predictive model can

be used to provide patients with a realistic estimation of their probability of success, and it can give physicians information that may be used to determine whether or not a patient should even be offered the procedure. Methods for developing a predictive model and the value of such a model have been clearly delineated in other studies (Stoskopf and Dadakis Horn 1992; Selker, Griffith, and D'Agostino 1994). The results from this article represent the first steps toward this goal.

NOTES

1. Participating clinics include: Arnett Managed Health, Lafayette, IN; Camino Clinic, Sunnyvale, CA; Carle Clinic Association, Urbana, IL; Dreyer Health Plans, Aurora, IL; Guthrie Healthcare, Sayre, PA; Henry Ford Health System, Detroit, MI; Kaiser Permanente, Fresno, CA: Lewis-Gale Clinic, Salem, VA; Lovelace Clinic, Albuquerque, NM; Midelfort Clinic, Eau Claire, WI; Scott & White, Temple, TX; Straub Clinic & Hospital, Honolulu, HI; Virginia Mason Clinic, Seattle, WA; and Welborn Clinic, Evansville, IN.
2. The form of the equation was as follows:

$$\text{change in score} = y\text{-intercept} + \beta_1 * (\text{age} \geq 65) + \beta_2 * (\text{female gender}) + \beta_3 * (\text{African American}) + \beta_4 * (\text{nonmarried}) + \beta_5 * (\text{low education}) + \beta_6 * (\text{polyarticular arthritis}) + \beta_7 * (\text{number of comorbid conditions}) + \beta_8 * (\text{preoperative score}).$$

   Here change in score and preoperative score are continuous variables. Age $\geq$ 65, female gender, African American race, nonmarried status, low education, and polyarticular diseases are dichotomous variables. Number of comorbid conditions is a categorical variable.

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