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SYMPOSIUM: VALUE BASED HEALTHCARE

# Does Age or Bilateral Disease Influence the Value of Hip Arthroplasty?

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**Abstract**

*Background* Measuring value in medicine is an increasingly important issue as healthcare spending continues to rise and cost containment becomes even more important. However, value assessments can be affected by patient factors and comorbidities.

*Questions/purposes* We therefore quantified the approximate value of total hip arthroplasty and determined if patient age and Charnley classification affected the EuroQol5D (EQ5D) after hip arthroplasty.

*Methods* Using charge data and an institutional joint registry, we evaluated 1442 patients after hip arthroplasty. Using the Charnley case-mix index to define bilateral disease and age of 65 years to distinguish between elderly and young patients, statistical comparisons were made among all groups. We obtained subspecialty physician charges and hospital charges.

*Results* Patients with both unilateral and bilateral disease in both age groups had improved EQ5D scores after total hip arthroplasty, and the average change in scores was 0.27. There was no difference in the change in utility scores when patients older than 65 years of age were compared with patients younger than 65 years or when patients with unilateral disease were compared with those with bilateral disease. The average cost per quality-adjusted life-year (QALY) gained was $9773/QALY.

*Conclusions* Our data suggest the value of total hip arthroplasty compares favorably with other medical and surgical interventions for other patient groups. No adjustments for patient age or disease status of the contralateral limb are necessary when reporting the value of total hip arthroplasty.

*Level of Evidence* Level IV, economic and decision analyses study. See Guidelines for Authors for a complete description of levels of evidence.

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## Introduction

The United States spends $1.6 trillion for health care annually [26]. It is estimated that 20% to 30% of medical interventions fall into the "overuse" or "misuse" categories [4]. These estimates would lead one to conclude that $300 billion is wasted annually. Based partly on these figures, many experts in healthcare delivery are calling for a change to a value-based system [4, 23, 26]. Value in health care can be defined as the health outcomes achieved per dollar spent. Increasing value by increasing quality, rather than simply decreasing cost, should be the goal. Currently, the quality movement is focused on process compliance (for example, appropriate timing and dosing of perioperative antibiotics) rather than patient-based outcomes. Measuring patient results is mandatory in showing improvements in value.

As the population ages, orthopaedic interventions, specifically TKA and THA, are becoming increasingly more common procedures in the United States [17]. Kurtz et al. displayed that the demand for primary THAs will increase 172% by 2030 to 572,000 surgeries per year nationwide [17]. Thus, orthopaedic care will represent a large part of medical expenditure and orthopaedic specialists will be under pressure to display value for the interventions that they provide. The common measurement parameters currently used such as infection rates, mortality rates, and revision rates fail to account for patient-based outcomes such as improvement in pain, function, and quality of life [22]. Identifying an appropriate tool for measuring these outcomes and using it to evaluate interventions and treatments over time is essential to defining quality and thereby calculating value. Several studies using cost data suggest that, in appropriately selected patients, hip arthroplasty is cost-effective [15, 18, 21]. These studies estimate cost ($)/quality-adjusted life-year (QALY) between $1863.55 and $27,139.

However, the EuroQol5D does not account for case complexities and patient comorbidities, which can influence patient outcome. When present, such factors must be appropriately adjusted for to appropriately determine outcomes. When determining value, all comorbidities and patient factors need to be assessed to determine if adjustments are necessary to normalize outcomes. In addition, quantifying the magnitude of these adjustments will make it possible to incentivize surgeons to care for higher-risk patients under the value-based system. Although our hospital registry does not currently capture medical comorbidities, it does capture Charnley classification [10] and age, both of which we consider surrogates for comorbidities.

Worse outcomes, both functional and perceived, have been noted in patients with bilateral disease [2, 7]. This suggests the results of outcome measures in patients with bilateral disease may not be comparable to those with unilateral disease. Other studies have described older age groups achieving better pain scores at the same time as attaining lower functional scores when compared with their younger counterparts [5, 8, 14, 25]. Similarly, it has been suggested that some outcome measures are not appropriate for patients older than 65 years as a result of poor response rates [16].

We therefore asked (1) whether patients with bilateral hip disease and (2) patients older than 65 years would have less improvement in their EQ5D scores after THA and thus require adjustments in postoperative outcome measures. (3) We also sought to determine cost-effectiveness of hip arthroplasty in these patient groups by using hospital charges as a surrogate for cost.

## Patients and Methods

From our prospective database we identified 1946 patients who completed EQ5D questionnaires [3, 6, 28] and underwent hip arthroplasty. The collection of these data spanned from 1972 through 2010. Not all surgeons in our institution required that EQ5D questionnaires be completed in the pre- and postoperative setting. We included patients with a primary THA and an age older than 18 years. Five hundred four patients who had undergone a revision THA were excluded from the study. Patients lacking partial but not complete pre- and postoperative data were not excluded and values were determined using mixed model repeated-measures analysis of variance. The exclusions left 1442 patients. We evaluated patients younger than 65 years separately from those 65 years and older. To account for bilateral disease, patients were classified into Charnley Groups A, B, or C. The Charnley A category accounts for unilateral disease, the B category for bilateral disease, and the C category for unilateral or bilateral disease with other comorbidities that would affect outcome measures [10]. These classifications were given at the time of presentation and were confirmed by the operative surgeon at the time of surgery.

There were 878 patients younger than 65 years old who underwent THA (Table 1). Their average age was

**Table 1.** Demographic data

| | Patients undergoing THA younger than 65 years | | | Patients undergoing THA 65 years of age and older | | |
|---|---|---|---|---|---|---|
| Charnley class | A | B | C | A | B | C |
| Count (hips) | 560 | 284 | 34 | 323 | 211 | 30 |
| Female gender (%) | 240 (43) | 129 (45) | 18 (53) | 170 (53) | 98 (46) | 21 (70) |
| Mean age (years; range) | 53.1 (15.8–64.9) | 53.8 (19.3–64.8) | 53.4 (29.0–64.7) | 72.6 (65.0–91.1) | 73.6 (65.0–90.3) | 75.2 (65.3–88.7) |
| Mean body mass index ± SD | 28.2 ± 5.9 | 27.7 ± 5.7 | 31.4 ± 7.1 | 26.8 ± 4.6 | 27.8 ± 5.8 | 25.9 ± 7.2 |
| Mean followup ± SD (years) | 8.7 ± 7.0 | 5.7 ± 6.7 | 2.5 ± 1.5 | 6.5 ± 4.1 | 4.1 ± 4.1 | 2.0 ± 1.0 |
| Hips with preoperative EQ-5D (%) | 119 (21) | 115 (40) | 18 (53) | 52 (16) | 88 (42) | 18 (60) |

53 years. Within this group, we classified 560 as Charnley A, 284 Charnley B, and 34 Charnley C. In the older than 65-year-old group, we classified 323 as Charnley A, 211 Charnley B, and 30 Charnley C. Their average age was 73 years. Patients in the Charnley A group younger than 65 years of age had a minimum followup of 3 months (average, 9 years; range, 0.23–36 years). Patients older than 65 years of age in Charnley Classes A through C had an average followup of 7, 4, and 2 years, respectively. No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records and radiographs.

Six surgeons evaluated and treated patients with EQ5D scores. THA was performed through a posterior approach or through a modified Hardinge approach depending on surgeon preference.

Patients were seen routinely after their arthroplasty procedure for clinical and radiographic examination at the 6-week, 3-month, 6-month, and 1-year marks. Patients completed questionnaires in the preoperative setting, at the 6-month followup, and yearly thereafter.

The patient-based outcome measure used was the EQ5D, a generic instrument for assessing quality of life, which identifies 243 possible health states. It is based on five questions about mobility, self-care, usual activity, pain/discomfort, and anxiety/depression. There are three possible levels of response for each item [3, 6, 28]. These levels of severity are: no problems, some/moderate problems, or extreme problems. Patients were instructed to select the description that best fit their current limitations. A dedicated technician was available to answer any patient questions. The EQ5D gives a weighted utility score and the index is calculated from the five domains. Perfect health and death have utility values of one and zero, respectively, and states worse than death (less than 0) are possible. Any increase in the patient's baseline represents an increase in QALYs. The minimally important difference (MID) is the smallest change in value for any clinical measure presumed important from the patient's or the physician's perspective. According to Walters and Brazier, the MID for the EQ5D is 0.074 [32].

Information regarding patient charges was obtained through the accounting department at Massachusetts General Hospital (MGH). Data were obtained by searching the diagnosis-related group for THA in the fiscal years 2008–2009, giving the most recent data available. This information included Medicare and Medicaid patients only. Each patient had a total hospital charge for their procedure. This included the preoperative workup, the operating room charges, and the postoperative in-house care. Physician data were also recorded for each procedure that had been billed if it was related to the THA. Each patient had a physician charge from the orthopaedic surgeon, the anesthesiologist, and the radiology department. A majority of patients had charges from the pathologist and the cardiologist. A smaller proportion of patients had charges from primary care physicians and urologists. The total physician charge was calculated for each patient and added to each patient's hospital charges. An average was obtained and used as the charge total to calculate value. Using the initial cost and the utility values obtained, the value of THA was calculated, where value was computed as total cost divided by total utilities gained. The initial cost was amortized over a 10-year timeframe and the change in utilities observed from preoperative to postoperative measurement was assumed to persist over the 10-year timeframe. For this analysis we assumed no additional costs were incurred over the first 10 years and that there were no revisions. Costs and utilities were discounted at a rate of 3% over the 10-year period.

Statistical analysis was performed on changes in pre- and postoperative EQ5D scores and was determined using mixed model repeated-measures analysis of variance. This was specifically chosen to handle the common problem of missing data by using a modern statistical technique in clinical research and fits a correlation structure (compound symmetry) to account for patients not having both preoperative and postoperative scores.

## Results

All patients had an improvement in EQ5D scores regardless of age and Charnley classification (Table 2). However, we found no difference in EQ5D scores between Charnley classification groups ($p = 0.272$ for younger than 65 years and $p = 0.805$ for older than 65 years). Similarly, there was no difference ($p = 0.353$) in EQ5D scores between age groups.

The average cost for caring for patients undergoing THA at MGH during the fiscal years 2008–2009, including hospital and physician charges, was $22,900.00 with a standard deviation of $14,265.09. With this, we were able to calculate value for all groups. Overall, the value of a THA was $9773/QALY. Charnley A patients younger than 65 years showed costs of $8671/QALY, whereas Type B and C patients in the same age category showed costs of $11,200/QALY and $9269/QALY, respectively. Patients aged 65 years and older showed slightly increased costs when compared with younger patients in Charnley Classes A through C at $10,752/QALY, $9955/QALY, and $11,200/QALY, respectively (Table 3).

## Discussion

The determination of the value of a procedure or intervention should be based on patient outcome measures.

**Table 2.** Assessment of change in health index for each implant subdivided by age and Charnley Classes A through C*

| Charnley class | Preoperative | Postoperative | Δ (95% CI) | p value |
|---|---|---|---|---|
| THA < 65 years | 0.46 ± 0.30 | 0.75 ± 0.28 | 0.29 (0.25–0.33) | < 0.001 |
| A | 0.44 ± 0.30 | 0.75 ± 0.29 | 0.32 (0.26–0.37) | < 0.001 |
| B | 0.51 ± 0.28 | 0.75 ± 0.29 | 0.24 (0.18–0.31) | < 0.001 |
| C | 0.28 ± 0.26 | 0.53 ± 0.35 | 0.25 (0.03–0.47) | 0.027 |
| THA ≥ 65 years | 0.49 ± 0.30 | 0.75 ± 0.24 | 0.26 (0.21–0.31) | < 0.001 |
| A | 0.49 ± 0.28 | 0.74 ± 0.25 | 0.25 (0.17–0.32) | < 0.001 |
| B | 0.49 ± 0.30 | 0.77 ± 0.21 | 0.27 (0.21–0.34 | < 0.001 |
| C | 0.45 ± 0.34 | 0.67 ± 0.27 | 0.22 (0.01–0.43) | 0.039 |

* Average pre- and postoperative EQ5D scores of each patient group with p values to determine statistically significant change. Data are represented as a mean ± SD. Changes were determined using mixed model repeated-measures analysis of variance and represented with 95% confidence intervals (CIs).

**Table 3.** Value for THA separated for age and bilateral disease*

| | |
|---|---|
| Age younger than 65 years | |
| Charnley A | $8671/QALY |
| Charnley B | $11,200/QALY |
| Charnley C | $9269/QALY |
| Age older than 65 years | |
| Charnley A | $10,752/QALY |
| Charnley B | $9955/QALY |
| Charnley C | $11,200/QALY |

* Calculations performed assuming: 10-year survival, utility values are maintained at steady state over the 10 years, and future costs and utilities are discounted at rate of 3%; QALY = quality-adjusted life-years.

The EQ5D is a tool that has been used to determine patient-based outcomes for multiple medical interventions, including hip arthroplasty. This information can be combined with the cost of the intervention to determine value. However, patient outcome can be affected by factors other than the intervention such as comorbidities, age, and the extent of disease. These factors should be identified and corrected for. We determined if bilateral hip disease and patient age are factors that affect patient-based outcome measures and, ultimately, value after THA.

Our study is limited by a number of factors. First, we had limited followup times. We have extended our database to include more EQ5D data on patients and will be able to provide more robust followup in the future. Second, we calculated health values for only one time (the most recent followup). Longitudinal measurement of health utility values will allow for more precise determinations of the value of THA. Third, we used only one measure of health quality. However, the EQ5D is useful in that it measures the patient's value of their health condition and has high response rates. This response rate would indicate the ease with which patients are able to complete it. It also corresponds well to hip-specific questionnaires such as the WOMAC, demonstrating that patient value is correlated with function and pain relief, although the correlation is not direct [9]. Fourth, we assumed the same revision rate for all patients. This may slightly underestimate total cost because younger patients may have more revisions than older patients. Fifth, the hospital charges we give are the most accurate charge data that the hospital records. However, these charges are only from the Medicare and Medicaid population and may not represent those of patients covered by private insurance. Also, the hospital from which the data were obtained does not practice a formal demand matching program. However, this is a retrospective study and surgeons may have used some of the principles of demand matching in making implant choices. This is a potential limitation. Sixth, compared with the Charnley A and B patients, our population of Charnley C patients is relatively small. Larger numbers would allow for more accurate assessment of differences between the groups.

All patient groups in this study had improvements in quality of life as measured by the EQ5D. We found no difference in patients who had one arthritic hip or bilateral arthritic hips regardless of age group. It would follow that no correction for bilateral hip disease is necessary in displaying value when caring for patients with bilateral hip disease. In contrast to our study, Rolfson et al. demonstrated Charnley Class A and B patients had greater improvement than Charnley Class C patients [24]. This "comorbid" group encompasses a large variety of medical ailments and diseases that can have an effect on outcome. More specific data on this group need to be obtained to determine which comorbidities have the greatest negative effect on outcome. Both studies demonstrated that Class A and B patients had similar improvements.

We found no difference in EQ5D when controlling for age. Thus, our data suggest patient age should not be taken into consideration when formulating outcome adjustments for determining value. Nilsdotter and Lohmander evaluated preoperative waiting time as well as patient age as factors influencing postoperative, patient-based outcomes. The authors used the SF-36 and WOMAC as their functional outcome measures. They found patients younger than 72 years of age reached higher scores for pain and function than did the older group despite having similar preoperative scores [20]. In this respect, our study stands in contrast to that of Nilsdotter et al. We used 65 years for the cutoff between young and old patients. For our study, this seemed appropriate given the large number of patients undergoing surgery in their 50 s. Nilsdotter et al. also point out that pain relief is often obtained early in the postoperative course. This is in contrast to physical function, which continues to improve up to 1 year [20]. This would suggest that when determining value, results at a minimum of 1-year followup would be necessary to give a true measure of final outcome. More importantly, it highlights the difference between functional gains such as pain relief and walking ability and value, as measured by utility instruments such as the EQ5D, which are more universally applicable for determining resource allocation across an entire medical care delivery system. Similar conclusions can be drawn when evaluating other studies that have noted age as a risk for worse functional outcomes, decreased walking scores, yet less pain [5, 8, 14, 25]. These studies combined visual analog pain scores with non-EQ5D outcome measures such as the WOMAC and Harris hip score. If our findings are viewed in light of these previous studies, it would seem logical that lower functional outcomes after hip arthroplasty in older patients do not translate into worse patient satisfaction.

Our study reinforces the utility of EQ5D data in determining patient functional and symptomatic improvement after THA. All groups, regardless of age and Charnley classification, realized improvements in EQ5D scores that were greater than the previously defined MID after their surgical intervention. In addition, by accurately recording cost associated with hip arthroplasty (or any other procedure), value can be clearly defined when combined with the patient outcome data. By determining value with universal utility measures, rather than functional outcome scores or other procedure-specific parameters such as ROM, orthopaedic procedures can be compared with interventions across other subspecialties (Table 4). Value for THA compares favorably with interventions such as discectomy for a herniated disc ($34,355/QALY) [29] and digital screening mammography ($26,500/QALY) [30]. One must also keep in mind that nonoperative treatment for osteoarthritis incurs a yearly cost to the medical system. Gupta et al. have estimated this cost to be $9900 [11]. We did not use the costs of nonoperative treatment of the arthritic hip, which may have slightly underestimated cost/QALY benefit.

**Table 4.** Comparison of cost ($)/QALY for multiple surgical and medical interventions, across subspecialties, and cost ($)/QALY of THA from our study

| Procedure | Cost ($)/QALY |
|---|---|
| THA | 10,561 |
| Screening colonoscopy | 9000–22,000 [27] |
| Screening mammography | 26,500 [30] |
| Discectomy | 34,355 [29] |
| Cataract surgery | 22,000 [1] |
| THA (low risk) | 9700 [19] |
| CABG | 4300 [13] |
| Dialysis | 28,800 [12] |
| Rotator cuff repair | 3091.90 [31] |

QALY = quality-adjusted life-years; CABG = coronary artery bypass grafting.

In conclusion, our data demonstrate high value for hip arthroplasty in all patient groups regardless of age and the status of the nonoperative hip with costs per QALY well below cost-effectiveness thresholds. In addition, the data do not support using age or bilateral disease as patient outcome modifiers. Once identified, appropriate adjustments to final patient outcomes need to be made to appropriately compare value. Further longitudinal collection of health utility and cost data to assess the value of THA will allow for more precise determinations of the value of the intervention. This will be crucial for obtaining appropriate funds to ensure access to this procedure for the growing population of patients with degenerative diseases of the hip. If accurate, easily obtained, reliable patient data can be presented to surgeons, and they are able to follow postoperative outcomes in their population and display the value of their care in a health system increasingly concerned with cost and allocation of funds, these data will allow for appropriate allocation of national resources to valuable health interventions, including hip arthroplasties, which are frequent targets for attempts at reduced spending.

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