The Economic Implications of a Multimodal Analgesic Regimen for Patients Undergoing Major Orthopedic Surgery

A Comparative Study of Direct Costs

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Background and Objectives: Total knee and total hip arthoplasty (THA) are 2 of the most common surgical procedures performed in the United States and represent the greatest single Medicare procedural expenditure. This study was designed to evaluate the economic impact of implementing a multimodal analgesic regimen (Total Joint Regional Anesthesia [TJRA] Clinical Pathway) on the estimated direct medical costs of patients undergoing lower extremity joint replacement surgery.

Methods: An economic cost comparison was performed on Mayo Clinic patients (n = 100) undergoing traditional total knee or total hip arthroplasty using the TJRA Clinical Pathway. Study patients were matched 1:1 with historical controls undergoing similar procedures using traditional anesthetic (non-TJRA) techniques. Matching criteria included age, sex, surgeon, type of procedure, and American Society of Anesthesiologists (ASA) physical status (PS) classification. Hospital-based direct costs were collected for each patient and analyzed in standardized inflation-adjusted constant dollars using cost-to-charge ratios, wage indexes, and physician services valued using Medicare reimbursement rates. The estimated mean direct hospital costs were compared between groups, and a subgroup analysis was performed based on ASA PS classification.

Results: The estimated mean direct hospital costs were significantly reduced among TJRA patients when compared with controls (cost difference, \$1999; 95% confidence interval, \$584–\$3231; P = 0.0004). A significant reduction in hospital-based (Medicare Part A) costs accounted for the majority of the total cost savings.

Conclusions: Use of a comprehensive, multimodal analgesic regimen (TJRA Clinical Pathway) in patients undergoing lower extremity joint replacement surgery provides a significant reduction in the estimated total direct medical costs. The reduction in mean cost is primarily associated with lower hospital-based (Medicare Part A) costs, with the greatest overall cost difference appearing among patients with significant comorbidities (ASA PS III–IV patients).

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Health care costs have risen dramatically during the past decade in the United States, with expenditures now exceeding \$2.2 trillion dollars annually.[1] Total knee and total hip arthroplasties are 2 of the most common surgical procedures performed in the United States and represent the greatest single Medicare procedural expenditure.[2,3] Recent data from the US Healthcare Cost and Utilization Project show that total knee and total hip replacement surgeries accounted for nearly \$30 billion dollars in 2004—an increase of more than \$9 billion dollars from 2003.[4] This cost increase is a direct reflection of the increased number of procedures being performed. In 2003, more than 600,000 primary and revision total knee and total hip arthroplasties were performed.[5] In 2004, this number increased to more than 830,000 procedures.[4] Although these numbers are staggering, the rate of increase is not unexpected. The American Academy of Orthopaedic Surgeons estimates that the number of total hip arthroplasties will continue to increase by as much as 50% per year, and the number of total knee arthroplasties by 300% per year through 2030. This tremendous growth in surgical volume is largely attributed to the aging "baby boomer" population.[6] Although national health care expenditures are dependent on multiple factors, the increased rate of total knee and total hip arthroplasties being performed will likely contribute to an associated escalation in national health care costs. Therefore, changes in surgical or anesthesia practice that are designed to decrease or contain the costs associated with these surgeries could have a significant impact on US health care expenditures.

The use of a comprehensive, preemptive multimodal analgesic regimen has been shown to lower opioid requirements, minimize opioid-related adverse side effects and complications, and reduce hospital length of stay after total knee and total hip replacement surgeries.[7] Changes in patient management and perioperative outcomes could potentially reduce the associated total direct medical costs for lower extremity joint replacement surgeries by reducing hospital stays and the services needed during hospitalization. However, it is unknown if these potential direct cost savings offset the increased costs associated with implementing a multimodal analgesic regimen.[7] Therefore, the primary aim of this investigation was to evaluate the economic impact of implementing the Mayo Clinic Total Joint Regional Anesthesia (TJRA) Clinical Pathway on estimated mean direct medical costs (primary outcome) in patients undergoing joint replacement surgery. We hypothesize that the cost savings achieved from using the TJRA Clinical Pathway (eg, decreased hospital length of stay and reduction in required inpatient services) offset the increased cost of implementing the process and will result in an overall reduction in direct medical episode of care costs.

METHODS

Approval for the study was granted by the Mayo Foundation institutional review board. Patients who did not grant access to their medical or administrative records for research purposes were excluded as per Minnesota statute. This was an observational, retrospective cohort study using a convenience

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sample of patients from a previous outcome study performed within the institution.[7]

Study Population

An economic analysis was performed on Mayo Clinic patients (n = 100) undergoing traditional (non–minimally invasive) total hip or total knee arthroplasty using the TJRA Clinical Pathway (TJRA cohort) who were retrospectively reviewed for a previous clinical investigation.[7] Participant eligibility was restricted to those patients receiving the TJRA Clinical Pathway (Table 1). Study patients were then matched 1:1 with historical controls (control cohort) undergoing total knee or total hip arthroplasty within 5 years of the matched TJRA patients using traditional surgical and anesthetic (non-TJRA) techniques. Traditional (non-TJRA) anesthetic techniques were defined as no preoperative administration of analgesic adjuvants (opioids, nonsteroidal anti-inflammatory agents, cyclooxygenase 2 inhibitors), intraoperative general or neuraxial anesthesia without peripheral nerve blockade, and intravenous opioids during the intraoperative and postoperative (patient-controlled analgesia) periods with conversion to oral opioid analgesics after 48 hrs. Patients were matched on (1) type of procedure, (2) age, (3) sex, (4) surgeon, and (5) American Society of Anesthesiologists (ASA) physical status (PS) classification. We selected this convenience sample of patients for economic evaluation because our previous investigation demonstrated a benefit in clinical outcomes. Clinical outcomes are important considerations when evaluating the economic impact of health care alternatives. Proposed changes in clinical practice should meet—or exceed—the documented clinical benefit of traditional practice models.[8]

Economic Data Collection and Outcomes

The economic analysis was performed from the perspective of the health care system. Health care utilization and associated billed charges were collected from the Olmsted County Healthcare Expenditure and Utilization Database (OCHEUD). The OCHEUD is an administrative database that provides a standardized inflation-adjusted estimate of the costs of each service or procedure provided since 1987 at Mayo Clinic and affiliated hospitals in constant dollars. Data from administrative sources were used to evaluate and compare the direct medical costs between the TJRA and control cohorts for the surgical episodes of interest. Billed charges were grouped into the Medicare Parts A and B classification system (Fig. 1).[9] However, this methodology was used for classification purposes only and does not imply that only Medicare patients were evaluated. Patients from several payer types were used within the study. Costs associated with Medicare Part A hospital services were estimated by adjusting billed charges using cost-to-charge ratios at the department level and wage indexes. Costs associated with Medicare Part B physician services were acquired using Medicare reimbursement rates. All costs were adjusted to reflect 2004 constant dollars.

The primary study outcome was the estimated mean direct medical cost for each surgical episode of interest. The economic analysis takes into account differences in the variable equipment and medications costs (Medicare Part A) as well as estimated physician costs (Medicare Part B).[8,10–12] Medicare Part A data were further subgrouped by revenue codes for detailed hospital cost analyses. Medicare Part A subgroups included hospital room and board costs, operating room costs, medical and surgical supply costs, pharmacy costs, and anesthesia supply costs.

TABLE 1. Mayo Clinic Total Joint Regional Anesthesia Clinical Pathway

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	Mayo Clinic Total Joint Regional Anesthesia Clinical Pathway
Preoperative holding area	(1) Oxycodone (extended release) 20 mg PO upon arrival to patient waiting area
	(2) Rofecoxib 50 mg PO upon arrival to patient waiting area
Anesthesia procedure room	(1) Lumbar plexus continuous peripheral nerve catheter
	(*a*) Total knee arthroplasty: posterior lumbar plexus (psoas) or femoral continuous nerve catheter
	(*b*) Total hip arthroplasty: posterior lumbar plexus (psoas) continuous nerve catheter
	(2) Sciatic nerve blockade (total hip and total knee arthroplasty patients)
PACU	(1) Acetaminophen 1000 mg + oxycodone 10 mg PO in PACU PRN VAS pain score ≥4
	(2) Lumbar plexus continuous peripheral nerve catheter
	(*a*) Bolus 10 mL 0.2% bupivacaine upon arrival in PACU
	(*b*) Begin continuous infusion bupivacaine 0.2% at 10 mL/hr
Patient care unit	(1) Ketorolac 15 mg IV every 6 hrs × 4 doses
	(2) Acetaminophen 1000 mg PO TID (8 AM, noon, 4 pm)
	(3) Oxycodone (extended release) 20 mg PO BID if <70 y old (10 mg PO BID if >70 y old)
	(4) Oxycodone 5 mg PO every 4 hrs PRN VAS pain score ≤4 (10 mg PO every 4 hrs PRN VAS pain score >4)
	(5) Lumbar plexus continuous peripheral nerve catheter: change infusion on POD 1 (6 AM) to bupivacaine 0.1% at 12 mL/hr for 24 hrs
	(6) Hep-Lock IV PRN
	(7) Do not discontinue Hep-Lock until peripheral nerve catheter is removed

The Clinical Pathway described above was used for the current investigation. However, subsequent modifications have been made and incorporated into our current practice. These include (1) celecoxib 400 mg PO upon arrival to patient waiting area as a replacement for rofecoxib, (2) the addition of gabapentin 600 mg PO upon arrival to the patient waiting area, (3) sciatic nerve blockade for total knee arthroplasty patients only, and (4) the discontinuation of oxycodone (extended release) after 4 doses.

PO indicates per os; PACU, postanesthesia care unit; VAS, verbal analog pain score; POD, postoperative day; IV, intravenous; BID, twice a day; TID, three times a day; PRN, pro re nata (as necessary).

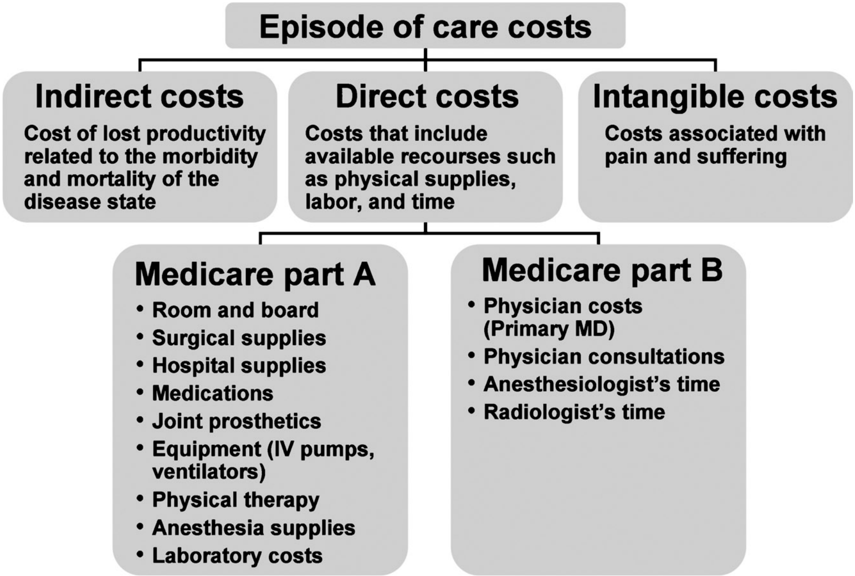

FIGURE 1. Classification of episode of care costs.[9]

Operating room cost is reflective of operating room time. It is calculated from patient entry and exit times from the operating room and includes the time to perform the regional anesthetic technique (single-injection and continuous peripheral nerve blockade), to induce anesthesia for the procedure, and for patient emergence and immediate anesthesia recovery. Operating room time is also used to calculate direct anesthesia physician costs in a unit-per-time basis.

Data Validation

Extensive data validation at the line-item level was performed to ensure that each surgical episode of interest was correctly billed and identified within administrative data sources to account for potential errors in billing. For example, it was confirmed that all patients had charges for hospital room and board, surgical supplies, operating room time, anesthesia services, and physician fees. The medical records of all cost outliers were examined in detail to assess whether high (or low) costs could be explained by patient or procedural characteristics documented within the medical record. During the validation process, 1 patient was found to have cost data for 2 anesthetic procedures (Medicare Part B physician charges) on the day of surgery. After review of the medical record, the 2 separate physician charges could not be explained. This was corrected by estimating the costs associated with the procedure as noted within the medical record (CPT4 code). The correction was based on the average time unit for that procedure and the Medicare payment rates for the year in which it was performed. In addition, 1 patient had missing cost data for anesthesia supplies. In this case, the cost was imputed by using the median cost of the patients in the study that had the same anesthesia procedure performed.

Statistical Analysis

The most appropriate statistical analysis from an economic and budgetary perspective is to derive the mean costs per patient.[13–15] Although median values may provide important descriptive information, all unadjusted costs are reported as means to account for patient outliers that represent actual costs to the institution. This methodology provides insight into the overall provider-based cost for an institution. However, both mean and median values have been reported for comparison

TABLE 2. Hospital and Physician Costs of Total Joint Replacement Surgery*

	TJRA Cohort, $ (n = 96)†	Control Cohort, $ (n = 96)†	Cost Difference, $ (95% CI)‡	*P*
Hospital costs (Medicare Part A)	12,505 (11,640) ± 4584	14,415 (13,126) ± 4532	1911 (578 to 3111)	0.0002
Room and board	4346 (3899) ± 1176	4647 (4252) ± 1513	300 (−84 to 718)	0.14
Medical/surgical supply	2544 (2036) ± 1572	3388 (2784) ± 1733	844 (378 to 1277)	<0.0001
Operating room	2641 (2620) ± 389	3014 (2969) ± 486	373 (246 to 489)	<0.0001
Pharmacy	746 (693) ± 192	1152 (786) ± 2161	406 (101 to 876)	0.07
Anesthesia supply	129 (177) ± 63	164 (212) ± 88	36 (14 to 56)	0.002
Physician costs (Medicare Part B)	2486 (2262) ± 683	2574 (2526) ± 410	88 (−77 to 239)	0.30
Anesthesia	368 (359) ± 61	444 (444) ± 78	76 (57 to 95)	<0.0001
Total costs	14,990 (14,226) ± 4773	16,989 (15,697) ± 4786	1999 (584 to 3231)	0.0004

*Estimated costs per patient are reported in 2004 constant dollars.

†Values are presented as mean (median) ± SD.

‡Intrapair differences are calculated as control minus TJRA. Bootstrap 95% CI using the percentile method.

TABLE 3. Hospital and Physician Costs of Total Joint Replacement Surgery and ASA PS*

ASA I–II Patients	TJRA Cohort† $ (n = 55)	Control Cohort† $ (n = 55)	Cost Difference‡ $ (95% CI)	*P*
Hospital costs (Medicare Part A)	11,716 (11,375) ± 2107	13,454 (12,536) ± 3583	1738 (712 to 2876)	0.003
Physician costs (Medicare Part B)	2572 (2274) ± 809	2555 (2526) ± 401	–16 (–271 to 223)	0.89
Anesthesia	354 (351) ± 45	446 (444) ± 85	91 (67 to 115)	<0.0001
Total costs	14,288 (14,083) ± 2395	16,010 (15,172) ± 3848	1722 (594 to 2954)	0.006
ASA III–IV Patients	**TJRA Cohort† $ (n = 38)**	**Control Cohort† $ (n = 38)**	**Cost Difference‡ $ (95% CI)**	***P***
Hospital costs (Medicare Part A)	13,746 (12,767) ± 6695	15,631 (13,935) ± 5232	1885 (–1130 to 4376)	0.18
Physician costs (Medicare Part B)	2360 (2253) ± 419	2595 (2566) ± 428	235 (47 to 430)	0.02
Anesthesia	388 (361) ± 77	444 (446) ± 68	55 (22 to 86)	0.001
Total costs	16,106 (14,774) ± 6925	18,226 (16,515) ± 5480	2120 (–996 to 4702)	0.14

*Estimated costs per patient are reported in 2004 constant dollars.

†Values are presented as mean (median) ± SD.

‡Intrapair differences are calculated as control minus TJRA. Bootstrap 95% CI using the percentile method.

purposes (Table 2). Intrapair mean differences in total direct costs, hospital costs, and physician costs were compared using paired *t* tests and nonparametric bootstrapping methods.[16,17] The analysis used techniques for matched pair analysis using a paired *t* test for comparing mean costs and deriving *P* values. Further data analysis was performed using nonparametric bootstrap methods to compare the mean costs between groups and to derive the 95% confidence intervals (CIs).

One factor that may influence the intensity of services, and thus costs, is patient comorbidity. Therefore, ancillary subgroup analyses were performed of costs by treatment group (TJRA vs control cohort) within ASA PS classification. American Society of Anesthesiologists PS I and II patients were collectively analyzed as group ASA PS I–II, whereas ASA PS III and IV patients were collectively analyzed as group ASA PS III–IV patients—the latter group indicating patients with more severe systemic comorbidity.

The sample size for the current study was fixed at 192 patients (n = 96 per cohort) based on a previous clinical investigation within the institution.[7] There are no similar studies within the literature from which to extract the expected mean, SD, variance, or distribution of costs. Because preliminary information on the mean and SD was unknown, a calculated 90% power would provide a minimum detectible effect size of 0.324.

RESULTS

Of the 100 patients who underwent traditional total hip or total knee arthroplasty using the TJRA Clinical Pathway (TJRA cohort),[7] consent for research review of the medical record was withdrawn by 4 subjects. Therefore, a final convenience sample of 96 matched case-control pairs were available for economic analyses.

Economic Outcomes

The estimated hospital (Medicare Part A), physician (Medicare Part B), and total costs for each cohort are listed in Table 2. Overall, total direct medical costs of hospitalization were $1999 lower for TJRA patients when compared with controls ($14,990 vs $16,989; 95% CI, $584–$3231). Component analysis of hospital (Medicare Part A) and physician (Medicare Part B) costs found that hospital-based costs were significantly reduced within the TJRA cohort and accounted for the majority of the total cost savings (Table 2). The observed difference in hospital costs was attributed primarily to significant reductions in medical and surgical supply costs, operating room costs, and anesthesia supply costs (Table 2). Although room and board and pharmacy costs were also reduced within the TJRA cohort, these component costs were not found to be statistically significant. Overall, physician costs (Medicare Part B) were not found to be significantly different between groups.

ASA PS Subgroup Analyses

The estimated hospital (Medicare Part A), physician (Medicare Part B), and total costs for ASA PS I–II and ASA PS III–IV patients are listed in Table 3. Three patients could not be matched on ASA physical status. Therefore, ASA subgroup ancillary analyses were limited to 93 matched pairs. Among ASA PS I–II patients, the TJRA cohort had significantly lower hospital (Medicare Part A) and overall total costs when compared with control patients (Fig. 2 and Table 3). Anesthesia physician costs were also significantly lower among TJRA patients. In contrast,

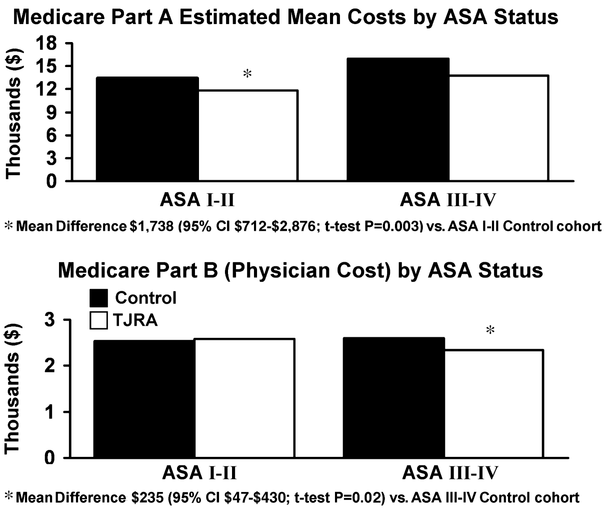

FIGURE 2. Medicare Parts A and B estimated mean costs by ASA PS.

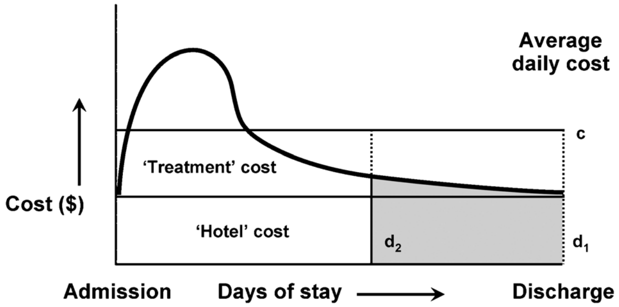

FIGURE 3. Estimating the cost savings associated with reductions in hospital length of stay. Hospital stays include a daily fixed cost called the "hotel" cost. In addition, a "treatment" cost is added to each hospital day. During hospitalization, the treatment costs are often greatest during the initial portion of the hospital stay reflecting greater care demands during the patient's initial illness (represented above). The result is that decreasing the length of stay from d_1 to d_2 at the end of hospitalization will likely not result in the same amount of savings as the daily average cost (line c) would estimate.[10] Reprinted with permission from Oxford University Press, Inc.

ASA PS III–IV patients within the TJRA cohort had significantly lower physician costs (Medicare Part B) when compared with ASA PS III–IV controls (Fig. 2). Although total costs were also lower among ASA PS III–IV patients within the TJRA Clinical Pathway, this difference did not reach statistical significance because of greater variability among these patients (Table 3).

DISCUSSION

The primary objective of the current investigation was to evaluate the economic impact of implementing a multimodal analgesic regimen (TJRA Clinical Pathway) on estimated mean direct medical costs in patients undergoing joint replacement surgery. The findings suggest that the introduction of the TJRA Clinical Pathway for lower extremity arthroplasty resulted in an estimated total direct medical cost reduction of $1999 per surgical episode. The majority of the cost savings occurred in hospital-based (Medicare Part A) costs, including significant savings in medical and surgical supply costs as well as operating room costs. Although not statistically significant, the remaining Medicare Part A component costs (room and board, pharmacy costs) also demonstrated an absolute cost reduction favoring the TJRA cohort. Patients with greater disease burden (ASA PS III–IV patients) seemed to benefit most from the TJRA Clinical Pathway—demonstrating a greater cost savings when compared with healthier patients (ASA PS I–II patients).

Several factors may have contributed to the economic savings observed among patients within the TJRA cohort. However, 2 synergistic factors may have been particularly important. First, our previous investigation demonstrated that patients receiving the TJRA Clinical Pathway had improved analgesia with lower opioid requirements and a significant reduction in the number of opioid-related adverse side effects and complications.[7] We speculate that these beneficial outcomes may have resulted in fewer interventions (eg, venous blood draws, laboratory analysis, medication administration, intravenous fluids, nasogastric tube or urinary catheter placement, ambulation assistance) among TJRA patients and lower overall medical supply costs. Second, TJRA patients had a significant reduction in their hospital length of stay (1.2 days) when compared with controls.[7] Patients spending less time in the hospital will naturally accrue fewer hospital supply costs. Although the reduction in medical and surgical supply costs is likely due, in part, to this reduction in hospital length of stay, the overall cost reduction is tempered by the fact that hospital supply costs decrease during the final days of a patient's hospitalization. This is particularly true when compared with the initial days of their hospital encounter.[10] This phenomenon contributes to a nonlinear reduction in hospital costs—above the baseline constant "hotel cost"—as a patient's hospital length of stay moves toward discharge (Fig. 3). As a result, the length of stay reduction of the last day of hospitalization will have a reduced effect on the overall room and board costs. Although we showed an absolute reduction of $300 favoring the TJRA cohort in room and board costs, the study may have been underpowered to determine if a statistically significant reduction in room and board costs actually exists.

The reduction in operating room costs reflects a decrease in the amount of time spent in the operating room. Although there is increased anesthesia time associated with regional block placement,[18] peripheral nerve blockade may reduce intraoperative opioid administration, sedation requirements, and the need for general anesthesia. We speculate that a reduction in opioid administration, deep sedation, or general anesthesia may decrease operating room time secondary to abbreviated emergence intervals and the time required to exit the surgical suite.

The TJRA Clinical Pathway reduced the estimated mean direct medical cost in both healthy patients (ASA PS I–II) and in those with more significant comorbidities (ASA PS III–IV). The observed cost reduction in ASA PS I–II patients was statistically significant. However, the cost reduction among ASA III–IV patients—although nominally greater—did not reach statistical significance because of greater variability. Our previous investigation demonstrated improved analgesia, earlier ambulation, and a reduction in opioid-related adverse effects and complications.[7] These beneficial perioperative outcomes may minimize the risk of exacerbating preexisting comorbidities that are common among ASA PS III and IV patients, resulting in a reduction in direct medical costs. However, the current investigation was likely underpowered to detect a significant difference among ASA III–IV patients due to high cost variability. Further investigation is needed to identify whether a comprehensive multimodal analgesic pathway preferentially benefits surgical patients with significant comorbidities.

The estimated mean direct medical cost reductions found in patients undergoing the TJRA Clinical Pathway may not reliably translate into an overall net savings for the institution. For example, many of the costs associated with maintaining a surgical practice within a hospital setting are fixed.[19–23] Nursing, physical therapy, housekeeping, food service, and maintenance staff are salaried employees in most major institutions. Therefore, a reduction in hospital length of stay for any given patient does not directly reduce the personnel costs of the institution. Furthermore, the reduction in per-patient mean direct medical cost does not take into consideration the opportunity costs associated with vacant operating rooms or hospital beds. However, if the associated reduction in hospital length of stay allows an increase in surgical volume for elective joint replacement surgery, the institution may benefit from an increased revenue stream. Finally, US health care financing is further complicated by providers and health care institutions having a variety of contracts with third-party payers for procedural payment. In cases of fixed payments—regardless of the patient's postoperative hospital course—the institutional cost savings realized from a reduced length of stay may have an even greater impact on the profit margin for an institution. Conversely, some payer compensation programs increase hospital payments based on duration of hospitalization and could therefore provide an economic disincentive for accelerated hospital discharge times.

An important strength of the current investigation was the ability to use the OCHEUD.[24] This unique administrative database provides a standardized inflation-adjusted estimate of the costs of each service or procedure provided since 1987 at Mayo Clinic and affiliated hospitals in constant dollars. The value of each unit of service is adjusted to national cost norms by the use of widely accepted valuation techniques. This process minimizes discrepancies between billed charges and true resource use. The database is also able to provide an estimated economic cost for each line item in the billing record and is able to aggregate these costs into categories. Use of the database allowed us to describe and compare the estimated mean costs between study subjects and their matched controls with a degree of economic resolution that would have otherwise been very difficult or impossible. In addition, the database provides standardized dollar values for surgical procedures that may have occurred during different periods.

The study also has important limitations. First, the study design used a retrospective convenience sample from a prior clinical investigation, resulting in a nonrandomized assignment of patients to either the TJRA or control cohort. Sample-size determinations were based on the assessment of clinical—not financial—outcomes. Because of this, the study may have had limited power to detect differences in some cost end points of interest given the high variability in costs of care. However, determining sample size based solely on economic outcomes may lead to ethical concerns regarding the appropriateness of enrolling additional subjects for cost analysis despite identifying the clinical superiority of a particular treatment modality.[13] Second, data acquisition occurred at a single, high-volume referral medical center. Patients and results may differ at other institutions or within alternative practice settings. Although financial data may be highly dependent on an institution's practice patterns, cost standardization was ensured using cost-to-charge ratios, wage indexes, Medicare reimbursement rates for physician services, and costs standardized to US dollars (2004). Third, the current investigation was limited to the evaluation of direct medical costs. It did not take into consideration indirect costs such as a patient's time away from work, the potential cost to family members to help care for the patient (loss time and wages), or indirect costs associated with morbidity. Evaluating indirect costs such as these would be necessary to further assess the societal cost impact of the TJRA Clinical Pathway or other changes in clinical care. Finally, the potential effect of even a single outlier on economic data can be a significant limitation in the performance of economic studies. For example, 1 patient in the TJRA cohort had hemophilia A. Although this patient underwent the TJRA Clinical Pathway and had minimal pain and no opioid-related complications from surgery, the patient received multiple blood draws, laboratory evaluations, and transfusions secondary to their preexisting condition. These interventions significantly increased the patient's hospital-based costs during their episode of care. If we would have excluded this patient outlier from consideration, the estimated mean direct hospital costs within the TJRA cohort would have decreased further from \$14,990 ± \$4773 to \$14,591 ± \$2746—resulting in a reduction in mean costs by an additional \$400 as well as an associated reduction in the variance of the cohort.

In summary, the TJRA Clinical Pathway provided a significant reduction in the estimated total direct medical costs associated with total hip or total knee replacement surgery. The reduction in mean cost is primarily associated with lower hospital-based (Medicare Part A) costs, with the greatest overall cost difference appearing among patients with significant comorbidities (ASA PS III–IV patients). These results suggest that changes in anesthetic practice alone can have a significant economic impact on health care economics within a single institution. However, additional prospective clinical and economic studies are needed to evaluate the cost-effectiveness of changes in clinical practice and their impact on local, regional, or national health care expenditures.

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