An Original Study

Cost Savings of Hip Arthroplasty Patients on Specialized Orthopedic Surgery Units

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Abstract

We retrospectively compared resource use of 2 groups of patients who underwent total hip arthroplasty between 1996 and 2004: those cared for on specialized orthopedic surgery (SOS) units and those cared for on nonorthopedic nursing (NON) units. Of 5546 patients, 5275 (95.1%) were admitted to SOS units and 271 (4.9%) to NON units.

Mean overall adjusted cost saving for SOS patients was $622 (SD, $315; 95% CI, $3, $1241). Mean blood bank and room-and-board costs were lower on SOS units: $110 (SD, $36; 95% CI, $40, $181) and $298 (SD, $118; 95% CI, $66, $530), respectively. Difference in length of stay was not significant: mean, 0.19 day; SD, 0.11 day; 95% CI, –0.02 day, 0.40 day.

Our results suggest that SOS units, as one way of optimizing patient flow in the postoperative period, may reduce unnecessary inpatients costs.

Patient safety and cost containment measures have become priorities in hospital practices. Unique care models, such as use of hospitalists in caring for general medical[1,2] and orthopedic[3-6] populations and use of midlevel providers in the primary care setting,[7] have emerged in response to these needs. Geriatric evaluation and management units[8,9] and stroke units[10] have well-established records of reducing disability rates and improving survival rates while providing cost-effective care. Use of specialized orthopedic surgery (SOS) units may be a way to replicate these benefits in an orthopedic population.

The potential cost burden and increasing demand for arthroplasties in older populations are significant. Health care costs are 28% higher for patients with osteoarthritis than for patients without osteoarthritis.[11] Seventy-five percent of all total hip arthroplasties (THAs) are reimbursed by Medicare, which itself pays two thirds of all health care spending for the elderly.[12,13] With the increasing pressures of cost containment, hospitals are examining many aspects of their practices to ensure fiscal sustainability, safety, and efficiency.[14] Effective triage of the appropriate patient to the appropriate place at the appropriate time may have an impact on these outcomes. This is relevant, as hospitals are often filled to capacity, and patients may be admitted to any open bed rather than triaged to a specific location. Noticing an increase in the number of THA patients admitted to floors away from our SOS units, we set out to determine if patient triage to the nonorthopedic nursing (NON) units had any impact on outcomes.

Methods

A historical cohort study was conducted on all elective primary, unilateral THA patients admitted between January 1, 1996, and December 31, 2004. Our 794-bed, tertiary-care center is the primary site for elective nontraumatic orthopedic surgery. All surgical procedures were performed by 13 faculty orthopedic surgeons specializing in lower extremity joint procedures. This minimal-risk study was approved by our institutional review board waiving the requirement for informed consent. Only patients who provided prior authorization for use of their medical record for clinical research were eligible.

Patients were identified using a previously described joint registry with 5-year follow-up approaching 95%.[15] We identified all postoperative THA patients initially transferred from the postanesthesia care unit to a nonmonitored, general care nursing unit (N = 11,062). Patients excluded from analysis included those who underwent urgent, revision, or bilateral arthroplasties; inpatients referred or transferred from other institutions with a documented primary surgical indication of trauma or septic arthritis; patients directly transferred to the intensive care unit (ICU) after surgical intervention, including patients requiring immediate postoperative cardiac monitoring; and patients admitted to the hospital before the day of the procedure. All surgeries were performed during the week

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Table I. Characteristics of Specialized Orthopedic Surgery (SOS) and Nonorthopedic Nursing (NON) Units

Characteristic	SOS Units	NON Units
Unit type	General orthopedic	General surgical care
Patient type	Elective postoperative orthopedic patients only	Any medical or surgical patient
Determinants of physical location for orthopedic patient	Primary bed assignment for elective orthopedic patient	Admitted to these units only if SOS units have reached bed capacity
Orthopedic-trained nursing staff	Yes. Additional post-RN training in orthopedics a requirement; these RNs seldom float to nonorthopedic units	No. May have additional training or experience in an unrelated medical or surgical discipline; floating to other units may occur
Orthopedic-specific physical and occupational therapy	Provided by certified physical therapists trained in lower extremity joint procedures; site-based therapy on SOS units	Provided by certified physical therapists not necessarily with specialization in lower extremity joint procedures; site-based therapy on NON units
Social workers	Dedicated to SOS unit	Not dedicated to NON unit
Interdisciplinary team meetings	Three-times-a-week meetings of RN, physical therapist, occupational therapist, social worker, and physician	No team meetings
Postoperative orthopedic order sets	Available hospital-wide; nursing staff familiar with order sets	Available hospital-wide; nursing staff may not be entirely familiar with order sets
Rehabilitation protocols	Orthopedic-specific	Not orthopedic-specific
Patient care instructions and hospital dismissal summary	Readily available, cowritten by orthopedic team and orthopedic RN	Not readily available, must be obtained by staff from SOS units, cowritten by orthopedic team and nonorthopedic RN
Discharge protocol	Targeted to postarthroplasty patient	Generic hospital-wide

Abbreviation: RN, registered nurse.

(Monday–Friday). We identified 6009 patients eligible for the study.

Patient baseline clinical and demographic characteristics (surgical indication, age, sex, race, residence status, height and weight at time of surgery, cemented arthroplasty, and dates of admission, surgery, discharge, death, and last follow-up) were abstracted from the Total Joint Registry. Other demographics and details regarding each surgical episode were obtained from the Decision Support System (DSS) administrative database (Eclipsys, Boca Raton, FL). Charlson comorbidity scores were calculated using identified comorbid conditions.[16,17] Other variables obtained from the DSS database included location of nursing care units, time and date of admission, time and date of discharge, discharge disposition, and length of stay (LOS). From departmental databases, we abstracted type of anesthesia (general, regional, combined), American Society of Anesthesiologists (ASA) physical status, and dates and times of ICU admissions and discharges. In addition, we assessed unexpected ICU admissions and stays.

Our primary endpoints were LOS and overall, hospital, and physician costs after transfer from the postanesthesia care unit to the end of the patient's hospitalization. Overall, hospital, and physician costs were obtained from the DSS database, including details regarding resource use for the indexed surgical episode, including blood bank, ICU, laboratory, pharmacy, physical therapy, occupational therapy, respiratory therapy, radiology, and room-and-board costs. Blood bank costs were defined as the costs of storage, processing, and transfusion delivery. To examine only hospital flow and resource use between postoperative nursing units, we specifically excluded the costs associated with surgery, operating room, and anesthesia. Inflation-adjusted estimates using standardized 2005 costs of provider perspectives were used to calculate costs, obtained from the Mayo cost data warehouse.[5,18,19]

LOS was defined as number of days from time of admission for the indexed surgical episode to time of discharge from the hospital. Readmission was defined as a nonelective hospital admission within 30 days after discharge. Using both federal and state death registries, we identified patients who expired. Both in-hospital (during indexed

Table II. Characteristics of Patients Undergoing Unilateral Total Hip Arthroplasty (N = 5546)

Patient Characteristic	SOS Units (n = 5275) n	%	NON Units (n = 271) n	%	*P*
Mean age, y (SD)	62.8 (14.7)		63.7 (14.7)		.31
Sex					.92
Male	2553	48.4	132	48.7	
Female	2722	51.6	139	51.3	
Year of surgery					<.001
1996	493	98.6	7	1.4	
1997	561	99.1	5	1.9	
1998	538	98.2	10	1.8	
1999	579	98.6	8	1.4	
2000	558	97.9	12	2.1	
2001	570	92.5	46	7.5	
2002	593	90.3	64	9.7	
2003	652	91.6	60	8.4	
2004	731	92.5	59	7.5	
Uncemented arthroplasty	3454	65.4	190	70.1	.28
Anesthesia type					.02
General	2644	50.1	146	53.9	
Regional	2275	43.1	98	36.2	
Combined	356	6.8	27	10.0	
American Society of Anesthesiologists class					
I	382	7.3	13	4.8	
II	3124	59.3	153	56.5	
III	1742	33.1	101	37.3	
IV	23	0.4	4	1.5	
Mean (SD)	2.27 (0.59)		2.35 (0.60)		.02
Charlson comorbidity					
Acquired immunodeficiency syndrome	6	0.1	0	0	.58
Cancer	100	1.9	5	1.9	.95
Cerebrovascular disease	15	0.3	0	0	.38
Chronic pulmonary disease	291	5.5	16	5.9	.79
Congestive heart failure	60	1.1	7	2.6	.03
Dementia	4	0.1	0	0	.65
Diabetes	395	7.5	25	9.2	.29
Hemiplegia	2	0.04	0	0	.75
Metastatic solid tumor	40	0.8	2	0.7	.97
Myocardial infarction	28	0.5	2	0.7	.65
Peripheral vascular disease	40	0.8	4	1.5	.19
Renal disease	31	0.6	4	1.5	.07
Rheumatologic disease	19	0.4	2	0.7	.32
Ulcers	15	0.3	0	0	.38
Mean (SD)	0.20 (0.46)		0.25 (0.50)		.11

Abbreviations: SOS, specialized orthopedic surgery; NOS, nonorthopedic nursing.

surgical episode) and 30-day mortality were defined as all-cause death. Given the paucity of these events, we created an aggregate endpoint that included 30-day mortality, 30-day reoperations, and 30-day readmissions.

SOS units, the location for priority placement for all postoperative elective THA patients, are defined as general care nursing units having skilled nursing and allied health staff specifically trained to care for postoperative orthopedic patients. Table I lists the differences between SOS and NON units. The sole determinant of postoperative patient triage to a SOS unit is bed availability, which is dependent on staff availability and elective surgical volume. Number and severity of medical comorbidities, time of discharge from postanesthesia care unit, degree of postoperative medical complications, and patient's room preferences have no impact on where a patient is admitted; admission to either a SOS unit or a NON unit depends, instead, on the patient's location the evening of postoperative admission. As neither type of unit contains monitored beds, postoperative patients who require cardiovascular monitoring must be admitted to the ICU. The primary orthopedic team does rounds on all its patients every day, regardless of in-hospital location, and is responsible for consulting medical and pain services as necessary.

Data from the databases were combined into a single database. Excluded from the analysis were 463 patients—58 for missing cost data; 3 for multiple joint replacements during the specified episode; 210 for direct admission from operating room to ICU; 143 for day-before-surgery admission; and 49 for medical records not authorized for research purposes—leading to a final patient cohort of 5546 patients. Our study had 80% power to detect a SOS–NON difference as small as 0.22 day in LOS and $761 in hospital costs.

Table III. Unadjusted Costs Between Specialized Orthopedic Surgery (SOS) and Nonorthopedic Nursing (NON) Units[a]

	Unadjusted Cost				
	SOS Units		NON Units		
Service	Mean	SD	Mean	SD	P
Hospital	$11,076	$4921	$11,052	$6677	.94
Room and board	$4366	$1811	$4671	$3682	.18
Intensive care unit	$36	$445	$105	$1270	.37
Pharmacy	$811	$2331	$800	$674	.94
Laboratory	$419	$356	$425	$649	.80
Radiology	$165	$339	$155	$290	.61
Physical/occupational/respiratory therapy	$749	$494	$742	$474	.82
Transfusion-related	$217	$413	$337	$1857	.29
Physician	$219	$464	$295	$833	.14
Evaluation and management	$71	$183	$101	$275	.08
Physician, radiology	$89	$196	$97	$201	.55
Other	$23	$107	$49	$367	.26
Total	$11,294	$5203	$11,289	$7331	.99

[a]Mean costs are costs from time of discharge from postanesthesia care unit to time of hospital discharge.

Statistical Analysis

Chi-square tests were used to compare baseline characteristics, including sex, race, patient residence (local or referred), individual Charlson comorbid conditions, anesthesia type, cemented arthroplasty, admitting diagnosis, 30-day readmission rates, and discharge location; the Wilcoxon rank sum test was used to assess differences in LOS, costs, age, ICU days, reoperations, total Charlson score, and ASA class; and the Fisher exact test was used to test for unadjusted 30-day mortality rates between groups.

Our primary goal was to determine LOS differences and cost differences between SOS and NON units. Generalized linear regression models were used to adjust these analyses for baseline characteristics and surgical covariates. The effect of the nursing unit was based on a regression coefficient adjusted for age, sex, ASA class, anesthesia type, surgery year, and Charlson comorbidities. Age was divided into 5 categories (<55, 55–64, 65–69, 70–74, and >75 years) with 65–69 characterized as the reference group. Each comorbid condition was treated as an indicator variable. Indicator variables were also assigned for the calendar year in which the patient underwent surgery, with 2004 being the reference category.

ICU use, 30-day outcomes, and disposition at discharge were secondary outcomes. Logistic regression models adjusting for previously specified covariates were used to assess the effects of SOS-unit care on subsequent transfer to the ICU (yes or no) and on the combined endpoint of 30-day mortality, readmissions, or reoperations. $P<.05$ was considered statistically significant. All analyses were performed with statistical software (SAS, version 9.1; SAS Institute, Cary, NC).

Results

Table II lists patients' baseline characteristics. There were 5275 patients admitted to SOS units and 271 patients admitted to NON units. There were no differences in the proportion of local residents between groups (10.5% vs 9.2%, respectively; $P = .51$). Caucasians constituted 91% of the patient cohort in both groups ($P = .87$). Mean LOS was 4.9 days in both groups. After the prespecified covariates were incorporated, there was no LOS difference between the groups (0.19 day; $P = .08$; 95% CI, –0.02 day, 0.40 day). Unadjusted cost differences between groups are outlined in Table III (and adjusted costs in Table IV). Overall episode and hospital mean costs were significantly lower in the SOS group, representing a cost savings of 5.5% and 5.8%, respectively. Per-patient room and blood bank costs were $298 and $110 lower in the SOS group, respectively, representing 6.4% and 32.8% cost reductions.

Frequency of ICU admissions, total ICU days, and associated costs were similar between the groups. The unadjusted 30-day mortality rate was statistically lower on SOS units (0.09% vs 0.74%; $P = .04$). A priori, we accounted for the low prevalence of postoperative complications by creating a composite endpoint. There were no between-group differences in the composite endpoint from the regression analysis adjusted for these specific covariates or between any of the individual components (0.22 event; OR, 1.25; 95% CI, 0.72 event, 2.18 event). There were no differences in dismissal rate to nursing homes between SOS and NON groups (17.0% vs 14.4%; $P = .53$).

Discussion

Our study is the first to examine the impact of SOS units on resource use in the elective THA population. Overall and hospital costs for elective THA patients were lower for those admitted to SOS units (vs NON units) after surgery. Specifically, room-and-board costs and blood bank costs were reduced. ICU, LOS, and number of unexpected ICU transfers did not differ between groups, suggesting that the adjusted hospital cost savings are attributable to other factors, including specialized interdisciplinary units not ordinarily captured by administrative datasets. This environment provides a large volume of orthopedic surgical patients over time, with the same teams of nurses, surgeons, and allied health providers. A familiar environment, necessary for consistent application of clinical pathways

Table IV. Adjusted Differences in Costs Between Specialized Orthopedic Surgery Units and Nonorthopedic Nursing Units[a]

	Adjusted Cost			
Service	Difference	SD	*P*	95% CI
Hospital	$642	$296	.03	$62, $1222
Room and board	$298	$118	.01	$66, $530
Intensive care unit	$40	$31	.21	–$22, $101
Pharmacy	–$31	$143	.83	–$311, $249
Laboratory	$35	$22	.10	–$7, $78
Radiology	$10	$21	.64	–$31, $51
Physical/occupational/respiratory therapy	$17	$23	.45	–$28, $62
Transfusion-related	$110	$36	.002	$40, $181
Physician	$49	$30	.10	–$9, $106
Evaluation and management	$7	$7	.50	–$14, $28
Physician, radiology	$3	$12	.82	–$21, $27
Other	$25	$8	.002	$9, $40
Total	$622	$316	.04	$4, $1241

[a]Adjusted data represent differences between specialized orthopedic surgery unit and nonorthopedic nursing unit after adjusting for age, sex, anesthesia type, American Society of Anesthesiologists class, and Charlson comorbidity from time of discharge from postanesthesia care unit to time of hospital discharge. Positive adjusted dollar amount represents cost "savings" relative to nonorthopedic nursing unit. All values rounded to nearest dollar. Statistical significance at $P<.05$.

and order sets, is created in the multidisciplinary setting in which care providers routinely interact.[20]

Optimizing patient logistics through a care episode is a recognized way to contain costs.[21] Although some interventions concentrate on preoperative methods, our study excluded operative, surgical, and anesthesia costs and focused mainly on initiatives to improve postoperative patient flow from the postanesthesia care unit to discharge—much of which depends highly on nursing and allied health services.[22] Studies by Meyers and colleagues[23] and Healy and colleagues[24] suggest that cost reduction should focus not only on implant cost but also on anesthesia, operating room, and nursing or hospital room costs. Our study results suggest that SOS units, as a postoperative means to reduce costs, facilitate patient flow and, if all elective postoperative THA patients are ensured bed availability, reduce overall costs by 5.5%. With a current annual mean of 60 patients cared for on NON units, our institution could recoup an estimated $37,000 yearly simply by triaging THA patients only to SOS units. Further studies are required to determine the indirect and hidden costs of implementing and sustaining such units; these costs will affect the actual cost savings.[25]

Reducing LOS, the primary determinant of overall costs, is often the cornerstone in reducing hospital costs. Antoniou and colleagues[26] found mean LOS to be 4.2 days in US hospitals from 1997 to 2001. As estimated from the Nationwide Inpatient Sample database, LOS at high-volume centers, such as ours, was 5.78 days.[27] That study, however, included patients from an earlier period (1988–2000) with its older practices and systems, which may account for longer LOS. Our mean LOS was slightly higher than the 4.2 days reported by Antoniou and colleagues, possibly because of the high percentage of referred patients (89.6%).[26] Achieving incremental savings and improved outcomes by further reducing LOS in an environment with preexisting care pathways is often difficult, so alternative approaches and strategies are often necessary.[24] The clinical pathway found specifically that use of SOS units did not reduce LOS, suggesting that the clinical pathway alone may not be responsible for our data differences, as certain elements of this pathway are used throughout the hospital, regardless of postoperative nursing unit. Our data are contrary to other clinical pathways, using standardized protocols for patients undergoing other surgical interventions,[28-31] that have been shown to reduce LOS.[32] It is unknown whether patients discharged from SOS units were by matter of protocol discharged earlier in the day, or when they actually left the hospital.[5] More studies are needed to better address and prevent cost shifting.

Blood bank costs were significantly lower for patients on SOS units than for patients on NON units. Uncemented arthroplasty may have more transfusion requirements,[33] but we did not appreciate any between-group differences related to this variable. Although there are guidelines for using blood products,[34-37] transfusion decisions often come down to clinical judgment. As we used administrative databases, we could not determine transfusion indications or patient hemoglobin levels.

There were no differences in our combined 30-day endpoint, but there was a slightly higher unadjusted rate of deaths in NON patients at 30 days. In patients who undergo elective THA, mortality has ranged from 0.29% to 0.41%[38-40] (30 days), 0.8%[41] (60 days), and 1%[39] (90 days). The mortality rate was low (0.13%) for patients on SOS units.

A recent Cochrane review[42] outlines the uncertainties of outcomes in patients who undergo discharge planning from hospital, but whether our patients may have inadvertently been discharged from hospital to an inappropriate environment is unknown. Bozic and colleagues[43] determined that predictors of discharge to an extended-care facility after elective THA included older age, higher ASA class, Medicare insurance, and female sex. The 1 posthospitalization death in the NON group had all these predictors, which may suggest that NON nursing staff underestimated the postdischarge nursing care this patient required. However, we have no information on the course of events that followed this patient's discharge, making any causative statements regarding this death unknown. As advocated by other authors, a 30-day endpoint was used, as a longer period may have led to inclusion of deaths not directly attributable to the surgery.[44] If a 90-day period were used, as is used for payment periods, relevant clinical data (reason for readmission or reoperation) would not be routinely captured in our registry because of our predominantly referral-based practice. However, our results should be interpreted with caution because of the paucity of events in these groups.

Given our large referral surgery practice, it may be difficult to generalize our results to community settings. However, we believe these results can be applied to both tertiary-care referral and community settings. Nurses with expertise in caring for postoperative orthopedic patients can be found in both hospital settings. Our results lend credence to theories of microsystems and advanced teamwork as mechanisms for improving patient outcomes, in which physicians, nurses, and allied health workers frequently interact in the same health care environment. When interdisciplinary health providers work as a team on a daily basis, habits and patterns inevitably develop, are often unplanned, and may be difficult to quantify. We also focused our study on unilateral primary THA to minimize confounding, as revisions and bilateral procedures are known to be associated with significantly higher costs, LOS, and complication rates.[45,46]

Our study had all the inherent limitations of a historical cohort study, and only a prospective, randomized trial could properly address our aims. The validity of the data from the various databases depended on collection and entry of the data by trained personnel who may not be familiar with medical aspects or terminology of patient care. We noted differences in patient characteristics at baseline and, despite the sample sizes being proportionally larger in the SOS group, accounted for these in our analysis by using both linear and logistic regression models. Using administrative databases, we could not abstract times and dates of discharge for which all hospital staff agreed that the patient was ready for discharge, as compared with when they actually left; we also could not determine specific inpatient complications. Actual time of discharge often depends on skilled nursing facility bed availability. Our study period was 1996 to 2004, and, though practice differences may be considered a limitation (as changes may occur), not only did we adjust for surgery year in our analysis, but we neither expected nor encountered any significant practice issues during this study period. This allowed us to provide sufficient study power to detect small differences in costs. However, we caution that our study was not intended as a formal cost-effectiveness analysis, and so we could not explore the effect of startup costs for such a nursing unit. Whether patient satisfaction was improved on such units is also unknown. Prospective evaluation of practice-related interventions and patient satisfaction in improving cost-effectiveness is needed. Practitioners and institutions are increasingly being required, by internal and external quality and regulatory bodies, to improve the quality of their practices to ensure safe, evidence-based, and efficient health care. In this regard, consideration should be given to performing such elective procedures only if the appropriate nursing unit is available for the postoperative patient.

Conclusions

Costs for postoperative THA patients are lower for those cared for on SOS units than for those cared for on NON units. Research should focus on addressing specific questions related to different care processes, as both health care institutions and practitioners alike are under increased scrutiny to minimize costs. We argue that, for elective THA patients, the surgical procedures should be linked to bed availability in nursing units that specialize in THA care. Our study results show that paying deliberate attention to postoperative logistics and patient flow may be one more step toward optimizing resource use.

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