Comparison of Outcomes of Using Spinal Versus General Anesthesia in Total Hip Arthroplasty

Stephen G. Maurer, MD, Andrew L. Chen, MD, Rudi Hiebert, MSc, Gavin C. Pereira, FRCS, and Paul E. Di Cesare, MD

Abstract

Blood loss, operative time, and rate of complications were compared in 606 patients undergoing primary unilateral total hip arthroplasty with either spinal anesthesia (SA) or general anesthesia (GA). Patients were followed for 2 years after surgery. Compared with GA, SA resulted in mean reductions of 12% in operative time, 25% in estimated intraoperative blood loss, 38% in rate of operative blood loss, and 50% in intraoperative transfusion requirements. Compared with patients receiving GA, patients receiving SA had higher hemoglobin levels on postoperative days 1 and 2 and a 20% lower total transfusion requirement. SA appears superior to GA for this procedure.

Patients undergoing unilateral total hip arthroplasty (THA) may be offered either regional or general anesthesia (GA). In the study reported here, we wanted to clarify 2 issues by comparing surgical outcomes associated with use of regional intrathecal anesthesia, specifically spinal anesthesia (SA), versus use of GA. First, regional intrathecal anesthesia (SA or epidurals) can lower overall perioperative blood pressure,[1] which has important implications for surgical management, as lowered blood pressure can reduce the amount of intraoperative blood loss, reducing the need for postoperative transfusion and thereby limiting the risk for infection from contaminated blood. This consideration is important for patients at risk for significant levels of blood loss during surgery and for patients unwilling or unable to safely predonate blood. Second, though intrathecal anesthesia procedures are routinely performed, they are associated with certain risks, including postoperative nausea and vomiting,[2] itching,[3] cardiac anomalies,[4] and subdural hygroma.[5]

Dr. Maurer and Dr. Chen were Residents and Mr. Hiebert is Epidemiologist, Department of Orthopaedic Surgery, New York University–Hospital for Joint Diseases, New York, New York.
Dr. Pereira is Consultant in Orthopaedics and Trauma, University Hospital Coventry and Warwickshire, Coventry, United Kingdom.
Dr. Di Cesare is Chairman, Department of Orthopaedic Surgery, University of California at Davis Medical Center, Sacramento, California.

Requests for reprints: Paul E. Di Cesare, MD, 4860 Y Street, Suite 3800, Sacramento, CA 95817 (tel, 212-598-6567; fax, 212-598-6096; e-mail, pedicesare@aol.com).

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Studies comparing epidural regional versus GA in patients undergoing THA have reported a correlation between regional anesthesia and shorter operative time, decreased intraoperative and postoperative blood loss, reduced blood replacement, and fewer thromboembolic complications.[6-15] A search of the literature revealed no reports of clinical outcomes in unilateral THA related to use of SA. Differences in type, dosage, and placement of anesthesia and consequent differences in benefits and risks between epidurals and SA merit a separate study. The purpose of this study was to determine whether SA is superior to GA for primary unilateral THA.

Materials and Methods

The study population consisted of all cases of primary unilateral THA at the Hospital for Joint Diseases between January 1995 and January 1998. Patient characteristics (age, sex, diagnosis, comorbid conditions, body mass index [BMI], preoperative health status), surgical characteristics (procedure, surgery duration, anesthesia type, intraoperative complications, intraoperative hemoglobin (Hb) level, transfusion requirement, intraoperative blood loss), and postoperative course until discharge (thromboembolic prophylaxis, postoperative complications, transfusion requirement) were recorded. Approval for the investigation was obtained from the institutional review board and the ethics committee.

Which anesthesia to use (GA or SA) was left to the anesthesiologist's discretion, based on patient age, comorbidities, past medical history, and operative risk stratification per American Society of Anesthesiology (ASA) classification.[16] The study was conducted when the anesthesiologists at our hospital were changing their total joint replacement practice of mostly administering GA to mostly administering SA. In some cases (eg, aortic stenosis), GA was preferred over SA. SA was not administered to patients with a history of neurologic disorder or to most patients with previous lumbosacral spine surgery. Older patients with higher ASA grades were more likely to receive SA.

For patients in the SA group, 3 mL of 0.5% bupivacaine was injected into the subarachnoid space at the L4–L5 interspace. Intravenous sedation was given during the procedure, as indicated. Propofol was used for induction in all patients undergoing GA. After intubation, GA was maintained with nitrous oxide in combination with oxygen, desflurane, and fentanyl. Rocuronium bromide was used as a muscle relaxant.

Table I. Patient Demographics*

	General Anesthesia		Spinal Anesthesia *n*	
Total	234		372	
Male	107	(45.7%)	169	(45.4%)
Female	127	(54.3%)	203	(54.6%)
Mean (SD)				
Age, years	54.7	(16.0)†	63.3	(13.7)
Height, inches	65.9	(4.4)	65.6	(4.1)
Weight, pounds	180.6	(47.4)	177.2	(40.3)
BMI, kg/m^2	29.1	(6.4)	28.9	(6.0)
ASA operative risk	2.3	(0.9)	2.5	(0.9)

*BMI indicates body mass index; ASA, American Society of Anesthesiology.
†P<.001 (vs spinal).

Table II. Operative Data, n (%)

	General Anesthesia (n = 234)		Spinal Anesthesia (n = 372)	
Surgical approach				
Posterior	215	(91.9%)	342	(91.9%)
Lateral	19	(8.1%)	30	(8.1%)
Operative side				
Left	97	(40.9%)	173	(46.5%)
Right	137	(59.1%)	199	(53.5%)
Fixation method				
Cemented	11	(4.7%)	26	(7.0%)
Hybrid	108	(46.2%)	239	(64.2 %)
Uncemented	115	(49.1%)	107	(28.8%)

Table III. Operative Indications, n (%)

Condition	General Anesthesia		Spinal Anesthesia	
Osteoarthritis	157	(67.1%)	287	(77.1%)
Avascular necrosis	32	(13.7%)	31	(8.3%)
Rheumatoid arthritis (RA)	11	(4.7%)	21	(5.6%)
Inflammatory arthritis (excluding RA)	7	(2.9%)	13	(3.5%)
Posttraumatic arthritis	15	(6.4%)	11	(2.9%)
Developmental dysplasia	8	(3.4%)	6	(1.6%)
S/P arthrodesis	2	(<1%)	2	(<1%)
Tumor	2	(<1%)	1	(<1%)

All THAs were performed with the patient in the lateral decubitus position. Operative time was defined as the period between skin incision and skin closure. Procedures involving uncemented acetabular and femoral components were categorized as "uncemented"; procedures with uncemented acetabular components and cemented femoral components were categorized as "hybrid"; and procedures in which both the acetabular and femoral components were placed with cement were categorized as "cemented." Intraoperative Hb measurements were obtained at the discretion of the anesthesiologist; if hematocrit was low and if the patient was hypotensive, intraoperative blood transfusions were given after adequate fluid replacement with crystalloid. Consideration for postoperative transfusion was made on an individual basis, according to patient age and comorbid conditions; in general, the decision to transfuse was made if the Hb level was lower than 9.0 g/dL and the patient had symptomatic anemia.

Wound drains were placed intraoperatively and removed on postoperative day 1 or 2, with perioperative antibiotics continued until drain removal. Wound drainage was recorded on a daily basis. All patients were placed on postoperative thromboembolic prophylaxis with low-molecular-weight heparin (LMWH). Physical therapy was initiated on postoperative day 1. Immediate postoperative and serial postoperative daily Hb levels, postoperative transfusion requirements, and incidence of complications were recorded for all patients.

When patients demonstrated signs or symptoms consistent with either deep venous thrombosis or pulmo-

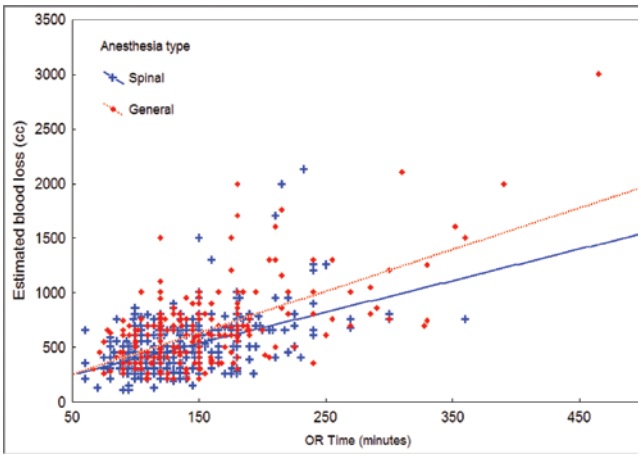

Figure. Scatterplot, with best-fit curves, of estimated blood loss vs. operative time

nary embolism, venous duplex scans, ventilation-perfusion scans, and pulmonary angiograms were obtained to evaluate the presence of possible thromboembolic phenomena.

Patient and treatment characteristics of those receiving SA and those receiving GA were compared using Student *t* test, χ^2 analysis, or nonparametric methods as appropriate. Linear regression was used to test for factors associated with differences in estimated intraoperative blood loss. Both continuous variables (operating room time, BMI, age) and categorical variables (ASA rating, anesthesia type, surgical approach, cement use, sex, associated conditions, presence of systemic conditions) were entered into the statistical model. Indicator variables were used to represent categorical variables with more than 2 levels. All factors were entered simultaneously. The regression model was fit setting the intercept to 0. The criterion for statistical significance was set at $P<.05$.

Results

From January 1995 to January 1998, 606 patients enrolled in the study. Tables I, II, and III summarize, respectively, the demographic composition, operative data, and operative indications of the study sample.

Endotracheal GA was administered to 234 of these patients (mean age, 54.7 years; range, 16-94 years): 107 males (45.7%) and 127 females (54.3%). Mean BMI was 29.1 kg/m^2 (range, 16.8-53.7 kg/m^2); 149 patients (63.7%) were classified as nonobese (BMI, <30 kg/m^2), 72 (30.8%) were classified as obese (BMI, 30-40 kg/m^2), and 13 (5.5%) were classified as morbidly obese (BMI, >40 kg/m^2). Operative risk stratification as per ASA yielded a mean score of 2.3 (SD, 0.9). The surgical approach was posterior in 215 patients (91.9%) and lateral in 19 (8.1%), using 11 cemented (4.7%), 108 hybrid (46.2%), and 115 uncemented (49.1%) components.

SA was administered to the remaining 372 patients (mean age, 63.3 years; range, 20-90 years): 169 males (45.4%) and 203 females (54.6%). Mean BMI was 28.9 kg/m^2 (range, 16.7-58.6 kg/m^2); 231 patients (62.1%) were classified as nonobese, 119 as obese, and 22 as morbidly obese, as per BMI. Operative risk stratification as per ASA yielded a mean score of 2.5 (SD, 0.9). The surgical approach was posterior in 342 patients (91.9%) and lateral in 30 (8.1%), using 26 cemented (7.0%), 239 hybrid (64.2%), and 107 uncemented (28.8%) components.

No statistical differences were found between the 2 groups with respect to operative indications, sex, BMI, surgical side, surgical approach, incidence of systemic disorders, or rate of intraoperative or postoperative complications. GA patients were a mean of 8.6 years younger than SA patients ($P<.001$).

Mean operative time was 156 minutes (SD, 60 minutes) for GA patients and 137 minutes (SD, 41 minutes) for SA patients ($P<.001$). Mean estimated blood loss was 647 mL (SD, 360 mL) for GA patients and 495 mL (SD, 246 mL) for SA patients ($P<.001$). Table IV shows the results of the stepwise linear regression of factors associated with intraoperative blood loss rate. Overall, patients bled at a rate of approximately 2.6 mL/min ($\beta = 2.618$, $P<.001$). Of the factors retained in the model, sex, use of hybrid prostheses, and anesthesia demonstrated clinically meaningful relationships with blood loss rates. On average, males bled 0.45 mL/min faster than women ($\beta = .450$, $P<.01$). Patients with a hybrid prosthetic (a cemented femur prosthetic and an uncemented acetabular prosthetic) bled 0.33 mL/min faster than patients with uncemented prostheses ($\beta = .333$, $P<.05$). GA patients bled 0.6 mL/min faster than SA patients ($\beta = .624$, $P<.001$). The Figure illustrates the relative rates of blood loss (unadjusted) between GA and SA patients.

TABLE IV. Estimated Rate of Blood Lossas a Function of Factors Identified from Forward Stepwise Regression*

Factor†	Relative Risk	Standard Error	t	P	95% CI Lower	95% CI Upper
Operative time	*2.62*	*0.32*	*8.16*	*.001*	*1.99*	*3.25*
BMI	*3.47*	*0.89*	*3.90*	*.001*	*1.72*	*5.22*
Male	*0.45*	*0.13*	*3.49*	*.001*	*0.20*	*0.70*
Cemented femur + acetabular prostheses	*-0.02*	*0.27*	*-0.08*	*.936*	*-0.56*	*0.51*
Cemented femur + uncemented acetabular prostheses	*0.33*	*0.14*	*2.39*	*.017*	*0.06*	*0.61*
General anesthesia	*0.62*	*0.13*	*4.69*	*.000*	*0.36*	*0.89*

*BMI indicates body mass index; CI, confidence interval.
†Reference group: spinal anesthesia, female, uncemented femoral and acetabular prostheses.

Table V. Hemoglobin Data, Mean (SD) g/dL

	General Anesthesia		Spinal Anesthesia	
Preoperative	*12.5*	*(1.6)*	*12.6*	*(1.6)*
Immediate postoperative	*11.2*	*(1.4)*	*11.1*	*(1.5)*
Postoperative day				
1	*9.5*	*(1.2)**	*9.8*	*(1.2)*
2	*9.3*	*(1.1)***	*9.7*	*(1.2)*
3	*9.4*	*(1.1)**	*9.7*	*(1.1)*
4	*9.5*	*(1.0)*	*9.7*	*(1.1)*
5	*9.6*	*(1.1)*	*9.8*	*(1.1)*

**P<.01. **P<.001 (vs spinal).*

Uncemented components were used in a larger ($P<.01$) proportion of GA patients (115, 49.1%) than SA patients (107, 28.8%); hybrid components were used in a larger ($P<.01$) proportion of SA patients (239, 64.2%) than GA patients (108, 46.2%); and cemented components were used in a larger ($P>.05$) proportion of SA patients (26, 7.0%) than GA patients (11, 4.7%).

The GA group had 16 intraoperative complications (6.7%): 1 acetabular wall fracture (0.4%), 3 acetabular rim fractures (1.3%), 10 femur fractures (4.2%), 1 acetabular rim fracture in conjunction with a femur fracture (0.4%), and 1 femoral perforation (0.4%). The SA group had 17 intraoperative complications (4.6%): 4 acetabular medial wall perforations (1.1%), 2 acetabular wall fractures (0.5%), 2 acetabular rim fractures (0.5%), 8 femur fractures (2.2%), and 1 femoral perforation (0.3%). Differences between the groups' complication rates were not statistically significant.

Table V displays preoperative, immediate postoperative, and serial postoperative daily Hb levels. GA patients' mean preoperative Hb level, 12.5 g/dL (SD, 1.6 g/dL), dropped to a mean immediate postoperative Hb level of 11.2g/dL (SD, 1.3 g/dL). SA patients' mean preoperative Hb level, 12.6 g/dL (SD, 1.6 g/dL), dropped to a mean immediate postoperative Hb level of 11.1 g/dL (SD, 1.5 g/dL). There were no statistical differences between the groups' preoperative or immediate postoperative Hb levels. Mean postoperative Hb levels, however, were significantly lower in patients who received GA on postoperative day 1 (9.5 ± 1.2 g/dL vs 9.8 ± 1.2 g/dL; $P<.01$), on postoperative day 2 (9.3 ± 1.1 g/dL vs 9.7 ± 1.2 g/dL; $P<.001$), and on postoperative day 3 (9.4 ± 1.1 g/dL vs 9.7 ± 1.1 g/dL; $P<.01$).

Table VI summarizes the groups' transfusion data. GA patients (vs SA patients) received twice as many intraoperative transfusions (0.16 ± 0.45 U vs 0.08 ± 0.33 U; $P<.05$) and more total transfusions (1.06 ± 1.07 U vs 0.85 ± 0.98 U; $P<.05$). In addition, there were more postoperative transfusions in the GA group (0.90 ± 0.89 U) than in the SA group (0.77 ± 0.92 U).

Thromboembolic complications (deep venous thrombosis or pulmonary embolism) occurred in 4 GA patients (1.7%) and 6 SA patients (1.6%). The difference was not statistically significant. All patients were successfully managed with intravenous heparin anticoagulation and long-term oral anticoagulation with warfarin therapy.

Discussion

The principal finding of this study is that patients receiving SA had lower intraoperative blood loss than patients receiving GA. Although epidurals have been associated with lower intraoperative and postoperative blood loss,[17-24] to our knowledge no previous study has examined the clinical outcomes associated with use of SA in THA. The decision to implement an observational study design (vs an experimental design) was based on the best principles of clinical research practice, which require that, before a randomized clinical trial is conducted, an observational (and/or pilot) study first be performed to evaluate for effect size, possible confounders and covariates, and possible risks to patients.[25]

Observational designs are weaker than experimental designs for assessing causality because overall characteristics usually differ between the groups being compared.[26] In our study, SA patients were older on average and more likely to receive a cemented implant. These differences can be attributed to the preferences of the anesthesiologist and the orthopedic surgeon. The anesthesiologist at our hospital usually recommends regional anesthesia for older patients. The surgeons tend to use cemented femoral components for older patients, who have wider femoral canals and reduced ability for bony growth onto uncemented stems. These differences, however, do not invalidate the finding that SA was associated with reduced intraoperative blood loss. Multivariate regression, which was used to analyze the

Table VI. Transfusion Data, Mean (SD), U

Transfusion	General Anesthesia		Spinal Anesthesia	
Intraoperative	*0.16*	*(0.45)**	*0.08*	*(0.33)*
Postoperative	*0.90*	*(0.89)*	*0.77*	*(0.92)*
Total	*1.06*	*(1.07)**	*0.85*	*(0.98)*

**P<.05 (vs spinal).*

data for this study, produces coefficients that express the relationship between the risk factor of interest and outcome statistically adjusted for differences in all other factors between the comparison groups. Conceptually, multivariate regression is similar to the usual procedure of stratifying and computing weighted measures of association.[27]

This study collected data that other authors have considered important potential covariates or confounders for surgical outcomes of THA—patient characteristics (age, sex, diagnosis, comorbid conditions, BMI, preoperative health status), surgical characteristics (procedure, surgery duration, anesthesia type, intraoperative complications, intraoperative Hb levels, transfusion requirement, intraoperative blood loss), and postoperative course until discharge (thromboembolic prophylaxis, postoperative complications, transfusion requirement). Another potentially important variable—data for it were captured and included in the statistical analysis—is Hb level during hospitalization. It has been established that bleeding rates and complications can be influenced by type of deep venous thrombosis prophylaxis used; in this study, there was only one standard form, so it was eliminated as a possible confounding variable.[28,29]

The association between decreased intraoperative blood loss and use of SA can be explained physiologically. SA results in a preganglionic sympathetic blockade that has several hemodynamically beneficial effects: redistribution of blood flow away from muscle and bone to skin and subcutaneous tissues; lower mean arterial blood pressure, right atrial pressure, pulmonary arterial pressure, and peripheral venous pressure; and peripheral dilation of the arteries, arterioles, and veins of the lower extremity resulting in less arterial and venous bleeding and easier attainment of hemostasis.[11,30]

In our study, mean Hb level dropped from 12.6 (preoperative) to 11.1 (immediate postoperative) in the SA group and from 12.5 to 11.2 in the GA group. Although the between-groups difference was not significant, we believe that the lower immediate postoperative Hb level in the SA group might be explained by hemodilution and the redistribution of fluid compartments that occurs in SA.

The present study demonstrated no statistical significance in the rate of clinically important thromboembolic complications between the GA group (1.7%) and the SA group (1.6%) with the thromboembolic prophylaxis protocol used (LMWH). However, we documented and investigated symptomatic thromboembolic complications only. Multiple investigations have clinically and experimentally demonstrated decreased rates of deep venous thrombosis and pulmonary embolus with regional anesthesia—citing increased lower extremity blood flow, decreased coagulation tendency, and stimulation of the fibrinolytic system as possible reasons for observed effects.[8-15,31-33] Use of SA may therefore confer protection with respect to thromboembolic phenomena, depending on the thromboembolic prophylaxis used; it may also therefore decrease the clinical incidence of such complications.[6,34,35]

Use of regional anesthesia, though common in orthopedic applications, is not without its concerns. Lessire and colleagues,[36] examining the hemodynamic effects of GA alone versus GA with epidural augmentation in geriatric patients, concluded that the latter may result in significant cardiac depression and cardiovascular instability and should therefore be used with caution in high-risk patients. In a longitudinal observational study of 741 hip fracture patients receiving GA versus SA during operative fixation, Gilbert and colleagues[35] concluded that the GA patients did as well as, if not better than, the SA patients; they speculated that direct neurotoxicity, compressive neuropathy, or local ischemia may have accounted for the observed effects. Several studies have examined the safety of regional anesthesia in THA. Retrospectively reviewing 195 cases of primary unilateral THA, Brinker and colleagues[6] found no statistical differences between general and epidural anesthesia with respect to length of hospitalization, nonsurgical operating room time, intraoperative femur fractures, thromboembolic phenomena, deep infections, or death; the authors concluded that epidural anesthesia is safe for patients undergoing primary unilateral THA. Similarly, Dauphin and colleagues[34] demonstrated no significant differences in the 2 groups in incidence of deep venous thrombosis, cardiac dysrhythmia, or cardiac ischemia.

In the present study, SA patients generally did better than GA patients on several different measures. Selection of anesthesia for surgical candidates is complex and multifactorial and must account for factors such as age, comorbid conditions, and patient preference. In this investigation, use of SA had statistically significantly decreased operative time, rate of intraoperative and postoperative blood loss, and transfusion requirement. These findings have significant implications for maximization of cost-effectiveness of THA as well as for quality of patient care and safety. We conclude that SA is superior to GA for primary unilateral THA, especially in older patients or patients with significant comorbidities that may preclude use of endotracheal GA.

Authors' Disclosure Statement

The authors report no actual or potential conflict of interest in relation to this article.

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