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Femoral–Sciatic Nerve Blocks for Complex Outpatient Knee Surgery Are Associated with Less Postoperative Pain Before Same-day Discharge

A Review of 1,200 Consecutive Cases from the Period 1996–1999

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Background: **Outpatient knee surgery has come to involve increasingly complex procedures. The authors present observational data from a nerve block algorithm designed for the care of outpatients undergoing knee surgery. The aim of this report is to demonstrate differences in pain and unplanned hospital admission associated with surgical complexity and nerve blocks used.**

Methods: **Day-of-surgery outcomes were studied for 1,200 consecutive outpatients undergoing routine arthroscopy or one of six complex outpatient knee procedures. Nerve blocks were administered on the basis of anticipated pain from open incisions in the femoral and sciatic nerve distributions. Regression analysis was used to determine factors associated with postoperative pain and unplanned hospital admissions, and patients were categorized as having received femoral and sciatic nerve blocks (FSB), femoral nerve block only (FNB), or no nerve blocks.**

Results: **Patients undergoing more complex (*vs.* less invasive) knee surgery were at greater risk for pain ($P \leq 0.004$), whereas the use of FSB (*vs.* FNB or no block) was associated with less pain ($P < 0.01$). When no nerve blocks were used, more complex (*vs.* less invasive) knee surgery was associated with a 10-fold greater risk of hospital admission ($P = 0.001$). In the regression analyses, more complex surgery ($P < 0.001$) was associated with increased risk of admission, and the use of FNB or FSB (*vs.* no block) was associated with a 2.5-fold reduction in unplanned admissions ($P = 0.009$).**

Conclusions: **For complex knee surgery, the use of FSB was associated with less pain; the use of FNB or FSB (*vs.* no block) was associated with fewer hospital admissions.**

OUTPATIENTS with sprains or dislocations of the knee account for over 3 million physician office visits per year.[1] In 1997, 52,000 hospitalizations and 115,000 patient-days in the hospital (2.2 days per patient stay) were attributed to this same admitting diagnosis.[1] Dislocations and sprains are annually responsible for 225 million days of restricted activity, 61 million days of bed-disability, and 65 million lost days of work.[1] It follows that a pain management strategy for patients undergoing complex knee surgery would have the potential to reduce the number of days of restricted activity and lost work.

Knee surgery can generate significant postoperative pain. Pain is one of the most common symptoms requiring hospital admissions after outpatient surgery.[2,3] The use of multimodal analgesia combined with peripheral nerve blocks tends to minimize pain, rendering patients less likely to require hospital admission.

Edkin *et al.*[4,5] have reported that the femoral nerve block (FNB) increases the likelihood of a pain-free postoperative course, allowing discharge within 23 h after arthroscopic reconstruction of the anterior cruciate ligament (ACL) with patellar tendon autograft. Beginning in July 1996, on the basis of the 1995 report by Edkin *et al.*,[4] our group recommended and provided FNB analgesia to facilitate same-day discharge for patients undergoing ACL reconstruction with allograft, patellar tendon autograft, and hamstring autograft.

During the succeeding years, we extended the use of nerve block analgesia to the care of patients undergoing more complex knee surgeries (high tibial osteotomy, multiple ligament reconstruction, and meniscal reconstruction). In these more complex procedures, we provided both femoral and sciatic nerve blocks (FSBs) because open incisions and significant surgical trespass were noted in the distribution of the sciatic nerve.

In 2000, it was reported that FNB alone (*vs.* controls) was not adequate for ACL reconstruction with hamstring autograft.[6] Frost *et al.*[6] commented that the graft harvest, graft fixation, or both appeared to contribute to significant postoperative pain in the sciatic nerve distribution, rendering FNB analgesia alone insufficient. The report by Frost *et al.*[6] not only forced our group to reconsider how we categorize pain after ACL reconstruction with hamstring autograft but also prompted an institutional review of the value of FNB alone for complex outpatient knee surgery.

The current observational study was designed to determine the association between the use of nerve blocks (FNB or FSB) and the requirement for postoperative parenteral analgesic nursing interventions for pain in

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Table 1. Categories of Outpatient Knee Surgery

Less Invasive Category	More Complex Category
Evaluation during anesthesia/manipulation	High tibial osteotomy
Knee arthroscopy with	Knee arthroscopy with
•Debridement	•ACL with patellar tendon or hamstring autograft
•Lateral retinacular release	•ACL and/or other ligament reconstruction (LCL, PCL, MCL)
•Meniscal surgery/meniscectomy	•Posterior oblique ligament and/or posterolateral corner reconstruction
•Meniscal repair	•Meniscal reconstruction
•Removal of superficial hardware	—
•Drop-out cast application	—
•Allograft ACL reconstruction	—

ACL = anterior cruciate ligament; LCL = lateral collateral ligament; MCL = medial collateral ligament; PCL = posterior cruciate ligament.

two types of outpatient knee surgery (less invasive and more complex). We also studied the association between nerve blocks used and unplanned admissions in same categories of knee surgery. We tested the following hypothesis: when surgical pain in the femoral and sciatic nerve distributions is predicted to be sufficient to require at least one postoperative analgesic nursing intervention, administering FSB (*vs.* FNB or no block) is associated with a lower incidence of parenteral analgesic nursing interventions and unplanned hospital admissions.

Materials and Methods

The study was conducted at a teaching hospital–integrated outpatient surgery center. The Institutional Review Board for the Health Sciences at our facility approved retrospective review of hospital charts and databases.

Categories of Surgical Invasiveness

We categorized seven discrete surgical procedures in two complexity categories for this analysis. The first surgical complexity category, "less invasive," comprised minimally invasive diagnostic arthroscopic procedures, procedures with meniscal debridement, and ACL reconstruction with (cadaver donor) allograft. Patients in the other category of knee surgery ("more complex" [table 1]), comprising ACL reconstruction with or without patellar tendon or hamstring autograft, high tibial osteotomy, multiligament reconstruction, or meniscal reconstruction, underwent therapeutic arthroscopic and/or open procedures, from which postoperative pain was attributed to the distributions of both femoral and sciatic nerves.

Chart Review

The study population was a consecutive sample of outpatients undergoing knee surgery by three surgeons within a 3-yr period (July 1996 through June 1999; n = 1,200). All charts were reviewed within 2–4 weeks after the day of surgery as part of a continuous quality improvement program.

Anesthesia Techniques Used to Provide Surgical Conditions

A detailed overview of the anesthesia techniques used is listed in the Appendix.

Definition of General Anesthesia

If the airway was secured and volatile agents were used, then the patient was deemed to have undergone general anesthesia (GA) (table 2). Total intravenous GA techniques were not used during the period of observational study. Otherwise, the patient was categorized as "no GA." "No GA" patients underwent nerve block anesthesia, spinal anesthesia, or epidural anesthesia (Appendix).

Nerve Block Category Summary for Analysis

Three nerve block categories were delineated: no nerve blocks, FNB, and FSB. Both femoral and lumbar plexus blocks were included in the FNB and FSB categories. Because both intermediate (*e.g.*, mepivacaine) and long-acting (*e.g.*, ropivacaine) local anesthetics provided analgesia through the duration of the same-day hospitalization (which was the endpoint of the retrospective chart review), the local anesthetic used for respective nerve blocks did not influence the nerve block category designation.

Intraarticular Analgesia

Throughout the study period described, the intraarticular dosing regimen for all categories of surgical complexity was the administration of bupivacaine 0.5% (20–30 ml) with epinephrine (5 μg/mL) and morphine (10 mg), with or without neostigmine (0.5 mg).

Recovery Outcome Data

Parenteral analgesic nursing interventions in the postanesthesia care unit (PACU) and step-down recovery unit (SDRU) were individually categorized as dichotomous (yes/no) variables (table 3). If patients received at least one dose of a parenteral analgesic (opioid or ketorolac), then the patient was deemed to have had postoperative pain requiring an analgesic nursing intervention.

Table 2. Demographics of Five Subcategories of Outpatient Knee Surgery

Variables	Less Invasive*	ACL Allograft	ACL PTA	ACL HA	HTO, MER, MUR	Total
N	380	163	318	235	104	1200
Age, mean (95% CI), median	36 (35, 38), 35	33 (32, 35), 34	24 (23, 25), 21	25 (23, 26), 20	35 (33, 38), 36	30 (29, 31), 27
ASA/PS, n (% within categories)*	—	—	—	—	—	—
I	238 (63%)	116 (72%)	262 (83%)	196 (84%)	60 (58%)	872 (73%)
II	125 (33%)	41 (25%)	52 (17%)	37 (16%)	40 (39%)	295 (25%)
>II	17 (4%)	5 (3%)	0	1 (<1%)	3 (3%)	26 (2%)
Gender, n (% within categories)						
Male	234 (62%)	100 (61%)	257 (81%)	80 (34%)	69 (66%)	740 (62%)
Female	146 (38%)	63 (39%)	61 (19%)	155 (66%)	35 (34%)	460 (38%)
GA used (secured airway, volatile agent)	131 (35%)	50 (31%)	99 (31%)	99 (22%)	23 (42%)	402 (34%)
NB, n (% within categories)						
None	271 (71%)	37 (23%)	74 (23%)	47 (20%)	9 (9%)	438 (36%)
FNB	51 (13%)	79 (48%)	172 (54%)	134 (57%)	19 (18%)	455 (38%)
FNB and SNB	58 (15%)	47 (29%)	72 (23%)	54 (23%)	76 (73%)	307 (26%)
PACU bypass rate	84% (320/380)	73% (119/163)	79% (252/318)	79% (186/235)	73% (76/104)	79% (953/1200)
PACU†	27% (16/60)	32% (14/44)	21% (14/66)	31% (15/49)	32% (9/28)	28% (68/247)
SDRU‡	6% (21/380)	7% (12/163)	14% (43/318)	17% (40/235)	10% (10/104)	11% (126/1200)
UHA	4/379 (1%)	4/142 (3%)	8/302 (3%)	14/226 (6%)	7/102 (7%)	37/1151 (3%)

The Less Invasive category in this table excludes ACL Allograft (detailed in the next column). All subsequent listings of the Less Invasive category include the ACL allograft subset.

* ASA/PS was not recorded for 7 patients. † Nursing interventions required for pain for patients routed to PACU. ‡ Nursing interventions in the step-down recovery unit required for pain.

ACL = anterior cruciate ligament; Recon = reconstruction; ASA/PS = American Society of Anesthesiologists physical status classification; FNB = femoral nerve block; HA = hamstring autograft; HTO = high tibial osteotomy; MER = meniscal reconstruction; MUR = multiligament reconstruction; NB = nerve block; PTA = patellar tendon autograft; SDRU = step-down recovery unit; SNB = sciatic nerve block; UHA = unplanned hospital admission.

Unplanned Admission

Unplanned admission associated with an anesthesia-related issue (pain management, postoperative nausea/vomiting, somnolence, urinary retention, etc.) was a dichotomous (yes/no) variable. Patients who were admitted to the hospital only because the third-party payer preapproved the admission were not included in this analysis. Details regarding the reasons for unplanned admissions (on the day of surgery) and readmissions (after same-day discharge) are presented.

Table 3. Pain Requiring Nursing Interventions and Unplanned Hospital Admissions

Variable	Less Invasive	More Invasive
Pain in PACU, n	—	—
(% within categories)		
No NB	20/65(31%)	13/41(32%)
FNB	10/34(29%)	19/74(26%)
FNB and SNB	0/5	6/28(21%)
Pain in SDRU, n	—	—
(% within categories)		
No NB§	22/308 (7%)	28/130(22%)
FNB‖	8/130 (6%)	53/325(16%)
FSB	3/105 (3%)	12/202 (6%)*
UHA, n	—	—
(% within categories)		
No NB#	4/299 (1%)	14/120(12%)
FNB	3/119 (3%)	9/310(3%)†
FSB	1/103 (1%)	6/200(2%)‡

* $P < 0.001$ (FSB *vs.* FNB [odds ratio = 0.3; 95% CI 0.2, 0.6], and FSB *vs.* no NB [odds ratio = 0.2; 95% CI 0.1, 0.5]). † $P < 0.001$ (FNB *vs.* No blocks, odds ratio = 0.2; 95% CI: 0.1, 0.5). ‡ $P = 0.002$ (FSB *vs.* No blocks, odds ratio = 0.2; 95% CI: 0.1, 0.6). § $P < 0.001$ (more invasive *vs.* less invasive, odds ratio = 3.6; 95% CI: 2.0, 6.5). ‖ $P = 0.004$ (more invasive *vs.* less invasive, odds ratio = 3.0; 95% CI 1.4, 6.4). # $P = 0.001$ (more invasive *vs.* less invasive, odds ratio = 9.7; 95% CI 3.1, 30).

FNB = femoral nerve block; FSB = femoral and sciatic nerve block; NB = nerve block; SDRU = step-down recovery unit; SNB = sciatic nerve block; UHA = unplanned hospital admission.

Statistical Methods

Cross-tabulations and χ^2 tests were used for nursing interventions and unplanned admissions. The surgical categories "less invasive" and "more complex" were compared with respect to the need for nursing interventions for pain and unplanned hospital admissions. Nursing interventions for pain were subdivided as PACU and SDRU interventions.

Logistic Regression Models for Nursing Interventions and Unplanned Admissions

We used binomial logistic regression to determine which covariates (age, gender, ASA physical status, GA *vs.* no GA, nerve block categories, and surgical invasiveness category) were associated with the requirement for nursing intervention and unplanned hospital admission. "Dummy variables" were constructed for the three nerve block categories and the two surgical complexity categories. Sequential regression models were run with use of step-down nursing interventions and unplanned admissions as the dependent variables. Univariate regressions were run first, with use of one covariate at a time. Next, covariates that were significant predictors ($P < 0.2$) were considered together in the multivariate regression model.

Number-needed-to-treat Analysis

We calculated the number needed to treat for more complex knee surgery according to the anesthesia-related covariates in the multivariate regression models. To do so, the incidences of analgesic nursing interventions and unplanned hospital admission for the category "GA with volatile agent and no nerve blocks" was compared with the same incidences for the category "no GA with nerve block(s)." The lower-incidence findings were subtracted from the higher-incidence findings to determine the absolute risk reduction, and then the reciprocal of the absolute risk reduction was computed to determine the number needed to treat.

For all tests, a P value of less than 0.05 was considered significant.

Results

Demographics

Of the 1,200 knee surgery outpatients in the sample, 543 underwent less invasive and the remainder underwent more complex surgery (table 2). GA was used in 34% of patients (n = 402); 36% (n = 438) received no blocks, 38% (n = 455) received FNB, and 26% (n = 307) received FSB. The overall PACU bypass rate was 79%, and the unplanned admission rate was 3%. There were no differences in SDRU interventions for pain on the basis of whether patients bypassed PACU or not.

Cross-Tabular Analyses of Surgical Invasiveness and Nerve Block Categories

Pain in PACU. A total of 247 patients required a PACU stay. No statistically significant differences were found in relation to surgical complexity and nerve block categories (table 3).

Pain in SDRU. Among patients who did not receive nerve blocks, those who underwent more complex surgery were significantly more likely to require SDRU parenteral interventions for pain than were those who underwent less invasive surgery (22% *vs.* 7%; $P < 0.001$). More complex surgery patients receiving FSB were significantly less likely to require SDRU parenteral nursing interventions for pain than were more complex surgery patients receiving FNB only (6% *vs.* 16%; $P < 0.001$).

Unplanned Hospital Admission

Among patients who did not receive nerve blocks, more complex surgery patients were significantly more likely to have been admitted to the hospital than were less invasive surgery patients ($P = 0.001$). More complex surgery patients receiving FNB or FSB were significantly less likely to require hospital admission than were more complex surgery patients receiving no nerve blocks ($P \leq 0.002$).

Regression Analyses

Regression models were run comparing more complex surgery patients to the referent less invasive surgery patients. Univariate regression showed that the covariates age, ASA physical status, and gender did not predict either SDRU interventions for pain or unplanned hospital admissions.

Predictors of SDRU Nursing Interventions for Pain with Multivariate Regression Analysis

One model was fitted with three covariates (table 4). In this model, more complex surgery ($P < 0.001$) and

Table 4. Logistic Regression Models Testing Odds Ratio of Step-Down Nursing Interventions Required for Parenteral Analgesics and Unplanned Hospital Admissions

	SDRU Pain Requiring PNI		Unplanned Hospital Admission	
Univariate	OR	*P*	OR	*P*
Referent	1.0	—	1.0	—
More complex	2.5 (1.7,3.9)	**<0.001**	3.1 (1.4,6.8)	**0.005**
No GA	1.0	—	1.0	—
GA	2.6 (1.8,3.8)	**<0.001**	3.7 (1.9,7.2)	**<0.001**
Male	1.0	—	1.0	—
Female	1.3 (0.8,1.9)	**0.195**	1.1	0.714
No or FNB only	1.0	—	1.0	—
FSB	0.4 (0.2,0.6)	**<0.001**	0.6	0.303
No Block	1.0	—	1.0	—
FNB or FSB	0.9	0.433	0.6 (0.3,1.1)	**0.120**
Multivariate	—	—	—	—
More complex	2.8 (1.8,4.3)	**<0.001**	4.7 (2.0, 11)	**<0.001**
GA	2.1 (1.4,3.1)	**<0.001**	3.3 (1.7,6.6)	**0.001**
Female	—	—	—	—
FSB	0.4 (0.2,0.8)	**0.004**	—	—
FNB or FSB	—	—	0.4 (0.2,0.8)	0.009

Items with boldfaced *P* values in the univariate LR results were included in the multivariate LR equation.

FNB = femoral nerve block; FSB = femoral and sciatic nerve blocks; GA = general anesthesia; LR = logistic regression; OR = odds ratio; PNI = parenteral nursing interventions; SDRU = step-down recovery unit.

Table 5. Number-needed-to-treat Analysis for Pain Requiring Nursing Interventions, and Unplanned Hospital Admissions, Based on Patients Undergoing More Complex Knee Surgery with 'GAVA and No Blocks' *versus* 'No GA with Blocks'

Parameter	GAVA with No Blocks	No GA with Blocks	*P*	Absolute Risk Reduction	Needed to Treat, n†
Pain in SDRU*	30/187 (16%)	43/592 (7.3%)	<0.001	8.7% (0.087)	11.5
UHA	13/176 (7.4%)	11/585 (1.9%)	<0.001	5.5% (0.055)	18

* Requiring at least one nursing intervention. † Interpreted as follows: 11.5 patients need to be treated with "No GA with blocks" to avoid one patient requiring at least one step-down nursing intervention for analgesia after "GAVA with no blocks." Eighteen patients need to be treated with "No GA with blocks" to avoid one patient requiring an unplanned hospital admission after "GAVA with no blocks."

GAVA = general anesthesia with volatile agents and opioid analgesia; SDRU = step-down recovery unit; UHA = unplanned hospital admission

GA with a volatile agent predicted an association with a requirement for SDRU analgesic nursing interventions ($P < 0.001$), whereas FSB (*vs.* FNB or no block) predicted a lesser requirement for these nursing interventions ($P = 0.004$).

Predictors of Unplanned Hospital Admissions with Multivariate Regression Analysis

One model was fitted, again with three covariates (table 4). In this model, other than more complex surgery ($P < 0.001$), GA predicted an association with unplanned hospital admission ($P = 0.001$), whereas FNB or FSB predicted a lesser requirement for unplanned admissions ($P = 0.009$).

Number-needed-to-treat Analysis

For more complex knee surgery, the number of patients needed to treat with "no GA and nerve block(s)" to avoid the requirement of analgesic nursing interventions for one patient after "GA with volatile agents and no blocks" was 11.5. For unplanned admissions, the number needed to treat was 18 (table 5).

Characteristics of Patients Requiring Unplanned Hospital Admissions

Thirty-seven patients in our sample required an unplanned hospital admission. One less invasive surgery patient was admitted for excessive somnolence after GA. Another less invasive surgery patient had a history of chronic knee pain (requiring per-oral opioids), agreed to a femoral nerve block for analgesia, and underwent debridement. This patient's nonoperative knee buckled while standing (during voiding) before discharge, and the small toe on the nonoperative leg was fractured.

One patient (less invasive category) underwent allograft ACL reconstruction with epidural anesthesia and was admitted for urinary retention. Two patients in the more complex category had hypotension from epidural spread of the lumbar plexus block and were admitted for observation. Another three patients were admitted for pain or postoperative nausea and vomiting after SDRU nursing staff did not completely follow the clinical pathway standardized orders; it is not possible to determine which of these three patients (if any) could have avoided admission.

The remaining 29 patients were admitted for refractory postoperative nausea and vomiting (15), pain (5), or both (9). Eleven of the 14 patients admitted for pain underwent more complex surgery, and none had FSB. Sixteen of the 24 patients with postoperative nausea and vomiting had GA, and 4 had lumbar plexus–sciatic blocks for surgical anesthesia.

Characteristics of Patients Requiring Unplanned Hospital Readmissions (after Same-day Discharge)

Thirty-six of 1,200 patients were readmitted after same-day discharge to the emergency department or hospital floor; 6 of these 36 were also admitted immediately after surgery. Fifteen patients had infection of the surgical site, and 9 were readmitted for vascular or wound complications (including bleeding, hematoma, effusion, or evaluation for deep vein thrombosis). Of the remaining 12 (not returning for surgical complications), 7 had surgical site pain, 1 had postoperative nausea and vomiting, 3 had headache or backache, and one had residual numbness.

Of the seven patients with pain, three were in the less invasive surgery category. Three patients readmitted with pain were in the more complex surgery category, and two of them had FNB (*vs.* one with FSB) on the day of surgery. The patient reporting postoperative nausea and vomiting had lumbar plexus and sciatic nerve blocks for more complex surgery. All three patients with headache or back pain had neuraxial anesthesia (spinal for one with back pain and one with headache; epidural for one with back pain). The patient with residual numbness had GA with femoral and sciatic nerve blocks and presented to the emergency department on the second postoperative day.

Of the 12 patients not returning for surgical complications, 7 were discharged from the emergency department and 5 were admitted to the orthopedic service. All 5 admitted patients were discharged the next day. Ten of the 12 patients presented within 3 days of their surgery; the other 2 presented on postoperative day 6.

Discussion

In our review of 1,200 consecutive outpatients presenting for knee surgery, we demonstrated that among

patients who received FSB for more complex knee surgery there was a lower incidence of nursing interventions for pain in the step-down unit. In addition, patients who received FNB or FSB had fewer associated unplanned hospital admissions than patients undergoing similar procedures without the same nerve blocks.

We have delineated two discrete categories of outpatient knee surgery complexity (table 1), and these categories are substantiated in this observational study by the data in tables 3 and 4. Table 3 illustrates that more complex knee surgery patients with no blocks required more analgesic nursing interventions in the step-down unit than patients in the less invasive surgery category. Table 4 illustrates that more complex knee surgery was associated with both a greater likelihood of parenteral analgesic nursing interventions in the step-down unit and unplanned hospital admissions.

These findings validate our observations that there appear to be at least two categories of outpatient knee surgery complexity, with respect to pain management and unplanned hospital admission. In this report, we demonstrate the importance of determining the planned extent of arthroscopic *versus* open knee procedures in order to provide analgesia specific to the relevant nerve distributions.

The results of this observational study also reemphasize the conclusions of our earlier report on a smaller data set,[7] that GA with volatile agents, in our institution, is associated with potential barriers for achieving a symptom-free same-day hospital course and discharge; 17% of ACL patients receiving only GA with volatile agents (and no blocks) required unplanned hospital admission in our earlier study.[7] In our regression models for the current study, GA with a volatile agent was consistently associated with a 200% increase in SDRU nursing interventions for pain and a >300% increase in unplanned hospital admissions.

After more complex outpatient knee surgery, FSB was associated with a lower incidence of analgesic nursing interventions in the SDRU (lower by 60%, on the basis of the odds ratio in table 4). This finding confirms our first hypothesis statement, that when surgical pain in the femoral and sciatic nerve distributions is predicted to be significant, administering FSB (*vs.* no block or FNB only) is associated with a lower incidence of parenteral analgesic nursing interventions. Meanwhile, FNB or FSB was associated with fewer unplanned admissions (reduced by 60%, on the basis of the odds ratio in table 4). Our second hypothesis statement was not exactly confirmed, however; the use of FNB or FSB (not FSB alone) was associated with less risk of unplanned hospital admission than was use of no blocks.

In contrast to implications from previous reports, we found no gender differences in postoperative pain interventions and unplanned admissions. Taenzer *et al.*[8] reported significantly greater pain and less functional capacity during the first 2 days after ACL reconstruction in women than in men. In that study, GA techniques were standardized throughout their observational study, but nerve block analgesia was not used. Whether nerve block analgesia offsets gender differences in immediate postoperative pain is unclear and will require definitive prospective study.

Nerve Block Analgesia, Reflex Neuromuscular Inhibition, and Outcomes

Nerve blocks are commonly performed for patients undergoing peripheral orthopedic surgery to optimize both surgical conditions and postoperative analgesia. The use of nerve blocks with avoidance of GA has been associated with less postoperative pain, nausea, vomiting, and unplanned hospital admissions after outpatient ACL reconstruction.[7,9,10] New nerve block techniques with indwelling nerve sheath catheters now allow for continuous nerve block analgesia for several days postoperatively.[11,12] Applied together, these care strategies (nerve blocks, continuous catheters for sensory-specific nerve block, and the avoidance of GA with volatile agents) promise to minimize postoperative symptoms throughout the first 2–4 days after complex outpatient knee procedures.

Several randomized studies of anesthesia and analgesia for patients undergoing total knee replacement have provided useful information and introduced new controversies. In one study, patients receiving GA did not gain additional analgesic benefit from a femoral nerve sheath infusion in comparison with a single-injection FNB, although both groups required less postoperative opioid analgesia than did nonblocked controls.[13] Another study showed that patients undergoing spinal anesthesia and single-injection FNB had better short-term pain outcomes than did patients not receiving the FNB.[14] Neither of these studies addressed range of motion in extension or patient-reported health outcome indicators during the first week after surgery; range of motion on extension is an important early milestone in rehabilitation after ACL reconstruction.

Another view in the controversy addressing physical function outcomes after nerve block analgesia has gained momentum recently. It is postulated that continuous FNB analgesia (*vs.* patient-controlled intravenous opioid analgesia) leads to not only better pain relief but also significantly better knee flexion, faster achievement of ambulation goals, and overall faster convalescence.[15,16] These studies showed that total knee replacement patients undergoing GA with either continuous epidural analgesia or continuous FNB analgesia made faster progress toward rehabilitation objectives[15,16] and were discharged from the inpatient rehabilitation unit sooner than were patients receiving traditional patient-controlled intravenous opioid analgesia.[16]

These two studies were limited by the precision of the

outcomes measured (neither assessed knee extension but rather angles of passive flexion)[16] *versus* active flexion,[15] and neither addressed patient-reported physical outcomes (neither generic nor condition-specific survey instruments). Although these studies of patients undergoing total knee replacement showed favorable effects of continuous (for 1 day[15] and 2 days[16] after surgery) FNB analgesia, comparative range-of-motion benefits (with *vs.* without continuous FNB analgesia) were reduced 3 months after surgery.

Intraarticular analgesia for knee surgery of all complexity levels is an analgesic opportunity that should not be overlooked, but its value for more invasive knee surgery should not be overestimated. Our data indicate that intraarticular analgesia was not sufficient in the more complex knee surgery categories to promote reliable same-day discharge (*i.e.*, there was a 12% unplanned admission rate after more complex knee surgery when intraarticular injection was used but nerve blocks were not used [table 3]). Myriad studies examining local anesthetics,[17] opioids,[18–21] ketorolac,[17,19] and neostigmine[22] have all demonstrated multiple mechanisms of effective intraarticular analgesia.

At our institution, we currently use bupivacaine 0.25% with epinephrine, 5 μg/ml (10 ml); neostigmine, 0.5 mg; and meperidine, 50 mg. Intraarticular morphine in doses >2 mg is associated with an antianalgesic effect related to histamine release; the local anesthetic properties of meperidine offset any similar histamine-release antianalgesic effect.

Limitations

Our primary endpoints were pain and unplanned admission. For this study, pain was defined by the surrogate outcome of whether any parenteral analgesic nursing interventions were administered in the SDRU. During the observational period, there were no specific nursing guidelines or protocols for treatment of pain, other than that all orders for alleviation of pain were given by the anesthesiologist. In addition, the SDRU nurses did not routinely record verbal pain scores throughout the observation period, a circumstance requiring us to use a surrogate measure. With respect to unplanned admission, all potential admissions were to be cleared (per unit policy) with the lead authors (B.A.W., M.L.K.) or the anesthesiologist-of-record (who was a member of the outpatient regional anesthesia service) before the surgical house staff was called for admission orders. Multiple analgesic and antiemetic interventions were routinely attempted before patients were considered refractory and in need of admission.

One potential criticism is the lack of generalizability of these findings because of, *e.g.*, differences in anesthesia techniques or discharge criteria in teaching-hospital outpatient surgery centers *versus* free-standing centers. We have found that using modern anesthetic agents and minimizing the use of volatile agents allow for faster emergence and recovery. We frequently used spinal anesthesia (see Appendix); it has regained popularity as a reasonable option for same-day surgery[23–25] as the incidence of spinal headache and transient radicular irritation have decreased, and discharge times have been shortened by the use of ipsilateral dosing and/or smaller total doses. We believe these recent reports regarding outpatient spinal anesthesia, in combination with FSB (for more complex surgery), offer viable options for both teaching hospitals and free-standing surgery centers.

Another criticism is that this study is a retrospective analysis of consecutive patients in a nonrandomized fashion. We posit that the large sample used and our findings provide meaningful associations with important outcome indicators (nursing interventions, unplanned admissions). Our report serves to encourage the use of nerve block analgesia in routine clinical care for complex knee surgery in order to facilitate PACU bypass, reduce the number of nursing interventions, and minimize unplanned admissions, pending future studies with strict controls and participant randomization.

Another weakness of this observational study is that PACU bypass is achieved in 79% of patients, rendering only 21% of patient data available to compare nursing interventions for pain in the PACU. Future prospective studies may logically determine PACU bypass eligibility upon PACU arrival but have more direct recording of PACU nursing interventions for pain (including total opioid doses and verbal pain scores before and after dosing).

In summary, outpatients undergoing more complex surgery had a significantly lower incidence of parenteral analgesic nursing interventions in the step-down recovery unit when FSB was used and when GA with volatile agents was not used. The use of FNB or FSB, as well as nonuse of GA with volatile agents, predicted a lower risk for unplanned hospital admission. A prospective randomized study is needed to confirm these findings.

Appendix

Anesthesia Techniques Used to Provide Surgical Conditions

All patients underwent general anesthesia (GA) or regional anesthesia (RA) to provide surgical conditions.

General Anesthesia Techniques

GA consisted of induction with propofol and maintenance with nitrous oxide and a volatile agent (isoflurane, sevoflurane, or desflurane). Total intravenous anesthesia techniques were not used during the period of observational study. The airway was secured with a laryngeal mask device or an endotracheal tube.

Neuraxial Anesthesia Techniques to Provide Surgical Conditions

Neuraxial anesthesia included epidural and spinal techniques. Epidural patients (dosed with lidocaine, mepivacaine, or bupivacaine) did not receive analgesic nerve blocks. Spinal patients were dosed with procaine for short-duration arthroscopy or with mepivacaine or bupivacaine for longer-duration and complex procedures. Spinal patients commonly received analgesic nerve blocks if their surgical procedures were in the more complex category.

Nerve Block Techniques to Provide Surgical Conditions.

Lumbar Plexus or Femoral Nerve. When lumbar plexus or femoral nerve blocks were used for surgical anesthesia, one of the following agents was used: ropivacaine (0.6–0.75%) or bupivacaine 0.375% with mepivacaine 1%. The volume used for the lumbar plexus was 30 ml (or 0.5 ml/kg for patients weighing <60 kg); 35–40 ml was the dose for the femoral nerve.

Sciatic Nerve. When sciatic nerve blocks were used for surgical anesthesia, the volume used was 20–30 ml. One of the following agents was used: ropivacaine (0.6–0.75%), bupivacaine 0.375% with mepivacaine 1%, or mepivacaine (1.2–2.0%). Mepivacaine was routinely used for surgery in the less invasive category, as well as for ACL reconstruction procedures in the more complex category. Ropivacaine or the mepivacaine–bupivacaine mixture was used for the remainder of the more complex knee surgery category.

Sedation and Nerve Block Analgesic Techniques

RA techniques to produce surgical conditions (*e.g.*, spinal anesthesia, epidural anesthesia, or nerve block anesthesia) included sedation with midazolam and fentanyl (administered before nerve block procedures and/or intraoperatively) and a continuous intraoperative infusion of propofol.

Analgesic nerve blocks (coupled with GA or spinal anesthesia) consisted of bupivacaine (0.25–0.375%) with epinephrine (5 μg/mL). The dosing volume was 30–40 ml for FNB and 20–30 ml for sciatic nerve blocks (when used).

Specific nerve block agents, concentrations, and volumes within the choices listed above were used at the discretion of the attending anesthesiologist.

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