▼ Original Article

A Pre-Emptive Multimodal Pathway Featuring Peripheral Nerve Block Improves Perioperative Outcomes After Major Orthopedic Surgery

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Background and Objectives: Patients undergoing major orthopedic surgery experience significant postoperative pain. Failure to provide adequate analgesia may impede early physical therapy and rehabilitation, which are important factors for maintaining joint range of motion and facilitating hospital dismissal. We examined the effect of a pre-emptive, multimodal, perioperative analgesic regimen emphasizing peripheral nerve block in patients undergoing total hip (THA) and total knee (TKA) arthroplasty. Perioperative outcomes and major postoperative complications were evaluated.

Methods: One hundred consecutive patients undergoing primary or revision THA or TKA using the Mayo Clinic Total Joint Regional Anesthesia (TJRA) protocol were retrospectively reviewed. The TJRA protocol is a pre-emptive, multimodal, perioperative analgesic regimen emphasizing peripheral nerve block that was jointly developed by the Departments of Anesthesiology and Orthopedic Surgery. Identified patients were matched 1:1 with historical controls undergoing identical surgical procedures with traditional anesthetic techniques. Matching criteria included patient age, gender, surgeon, date of surgery, and American Society of Anesthesiologists physical status. Patient demographics, preoperative joint range of motion, and anesthetic management were recorded for each patient. The primary study outcome was hospital length of stay. Secondary outcome variables included time to ambulation, joint range of motion, and discharge eligibility. Postoperative verbal analog pain scores (VAS), opioid requirements, side effects, and perioperative complications were also documented.

Results: One hundred patients underwent THA or TKA using the newly implemented Mayo Clinic TJRA protocol. Matched controls (n = 100) received intravenous patient-controlled analgesia with subsequent conversion to oral analgesics for postoperative pain management. TJRA patients had significantly shorter hospital lengths of stay (3.8 days *v* 5.0 days; $P < .001$), achieved discharge eligibility significantly sooner (1.7 ± 1.9 days earlier; $P < .0001$), and had improved joint range of motion (90° *v* 85°; $P = .008$) when compared with matched controls. TJRA patients had significantly improved postoperative analgesia, including lower VAS pain scores (postoperative day 0 through postoperative day 3; $P < .001$), and lower opioid requirements (postoperative day 0 to postoperative day 2; $P = .04$). Adverse outcomes such as postoperative urinary retention (50% *v* 31%; $P < .001$), and ileus formation (7% *v* 1%; $P = .01$) occurred more frequently among control patients.

Conclusions: Patients undergoing THA or TKA using a comprehensive, pre-emptive, multimodal analgesic regimen emphasizing peripheral nerve block may have significantly improved perioperative outcomes, and fewer adverse events, when compared with patients receiving traditional intravenous opioids during the initial postoperative period. Improved perioperative outcomes include a shortened hospital length of stay, and a significant reduction in postoperative urinary retention and ileus formation. *Reg Anesth Pain Med 2008;33:510-517.*

Key Words: Peripheral nerve block, Multimodal analgesia, Perioperative outcomes, Total joint arthroplasty.

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Patients undergoing total hip and knee replacement surgery experience significant postoperative pain.[1] Severe pain occurs in 60% and moderate pain in up to 30% of patients undergoing total knee arthroplasty.[2] Failure to provide adequate analgesia may impede early physical therapy and rapid rehabilitation, which are both important factors for maintaining joint range of motion and facilitating hospital dismissal.[3,4] Many treatment regimens for managing severe postoperative orthopedic pain include significant doses of parenteral opioids. These treatment regimens are commonly associated with significant opioid-related side effects (sedation, nausea, vomiting, pruritus, ileus, urinary retention) that can adversely affect patient outcomes and prolong hospital length of stay.[5]

In an effort to avoid many of the side effects commonly associated with opioid-induced analgesia, clinicians have begun adopting multimodal therapeutic regimens. Multimodal analgesia has become an important concept in the field of modern pain management.[3,6-9] The concept is designed to combat pain perception along several pathways of signal transmission, including the surgical site and surrounding tissues, local sensory nerves, and central nervous system. Advantages include superior analgesia secondary to the synergistic effects of multiple agents acting via different pain pathways, the ability to limit parenteral opioid administration, and minimizing opioid-related side effects. Although previous investigators have examined the beneficial effects of multimodal anesthesia,[6,8,10-12] very few have examined its role in patients undergoing major orthopedic joint replacement surgery.[6,13]

Peripheral nerve block is another modality of pain management that has received recognition because of its ability to provide superior analgesia with fewer side effects, when compared with traditional intravenous opioids.[14] However, many of the outcome studies documenting the beneficial effects of peripheral block have examined these techniques in isolation, or in combination with traditional intravenous opioids.[4,14-19] Investigations avoiding intravenous opioids, and incorporating peripheral nerve block into a comprehensive, pre-emptive, multimodal analgesic regimen are lacking for patients undergoing total hip or knee replacement surgery. Therefore, the goal of this investigation was to examine the effect of a pre-emptive, multimodal, perioperative analgesic regimen, using peripheral nerve block in patients undergoing major orthopedic surgery. Perioperative outcomes including hospital length of stay, discharge eligibility, time to ambulation, joint range of motion, and major postoperative complications were evaluated.

Methods

After institutional review board approval, the medical records of 100 consecutive patients undergoing primary or revision total hip (THA) or total knee (TKA) replacement surgery using a pre-emptive, multimodal, perioperative analgesic regimen (Table 1) were retrospectively reviewed. The Mayo Clinic Total Joint Regional Anesthesia Protocol (TJRA) is a comprehensive clinical pathway for patients undergoing major joint replacement surgery. Peripheral nerve block and the use of perineural catheters are a major component of the clinical pathway. The TJRA protocol was developed from the collective experience of Mayo Clinic anesthesiologists and orthopedic surgeons, based upon previous experience and exposure to physicians and practice models outside the institution.[20] Patients with a history of opioid dependence (opioid use within the last 4 weeks), coagulation abnormalities, suspected bacteremia or septicemia, pre-existing neurologic deficits, or allergies to study medications were excluded from participation.

All study patients were managed during the preoperative, intraoperative, and postoperative periods as outlined in Table 1. Briefly, patients undergoing total knee arthroplasty received a preinduction lumbar plexus (psoas compartment or femoral) perineural catheter bolused with bupivacaine 0.5% (20 mL) with 1:200,000 epinephrine. Total hip arthroplasty patients received a posterior lumbar plexus (psoas compartment) perineural catheter bolused with bupivacaine 0.5% (20 mL) and 1:200,000 epinephrine. All study patients received a single injection sciatic nerve block (30 mL bupivacaine 0.5% with 1:200,000 epinephrine) in addition to their lumbar plexus perineural catheter. Pre- and postoperative oral adjuvants, and perioperative local anesthetic infusion regimens are described in Table 1. Intraoperative opioid administration was at the discretion of the attending anesthesiologist. No *intravenous* opioids were administered during the postoperative period. Breakthrough pain was managed with oral oxycodone as outlined in Table 1. All perineural catheters remained in situ a minimum of 36 hours postoperatively, and were discontinued on the morning of the second postoperative day.

Patient demographics including age, gender, height, and weight were collected for all patients. Preoperative joint range of motion (total knee arthroplasty patients), procedure type (primary total knee arthroplasty, revision total knee arthroplasty, primary total hip arthroplasty, or revision total hip arthroplasty), and surgical duration (incision to closure) were recorded as documented in the dictated surgical note. Intraoperative anesthetic manage-

Table 1. Mayo Clinic Total Joint Regional Anesthesia Protocol*

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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 block (total hip and total knee arthroplasty patients)
Post-Anesthesia Care Unit (PACU)	1. Acetaminophen 1,000 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 hours × 4 doses 2. Acetaminophen 1,000 mg PO TID (08:00, 12:00, 16:00 hours) 3. Oxycodone (extended release) 20 mg PO BID if <70 years old (10 mg PO BID if >70 years 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 (6:00 AM) to bupivacaine 0.1% at 12 mL/hr for 24 hours 6. Heplock IV PRN 7. Do not discontinue Heplock until peripheral nerve catheter removed

Abbreviations: BID, twice a day; IV, intravenous; PO, per os; POD, postoperative day; PRN, pro re nata (as necessary); TID, 3 times a day; VAS, verbal analog pain score.

*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 block for total knee arthroplasty patients only; and (4) the discontinuation of oxycodone (extended release) after 4 doses.

ment was categorized as: (1) general anesthesia; (2) neuraxial anesthesia; or (3) peripheral nerve block only. All perioperative sedative and opioid administration was recorded as documented within the electronic medical record. Pre- and intraoperative opioid and sedative administration was collected from the electronic anesthetic record. Postoperative medications were documented from the electronic pharmacy and therapeutic medication profile. No patients received pre- or intraoperative antiemetic therapy.

Postoperative verbal analog pain scores (VAS; 0, no pain to 10, worst pain imaginable), opioid requirements to maintain a verbal analog pain score of ≤3, and side effects such as nausea (absent, present/not treated, or present/treated), vomiting (absent, present/not treated, or present/treated), pruritus (absent, present/not treated, or present/treated), and urinary retention (absent, or present and requiring urinary catheterization), occurring within the postanesthesia care unit were documented.

Upon admission to the hospital ward, verbal analog pain scores (at rest and with activity), total opioid requirements, the presence and type of postoperative anticoagulation (if applicable), and observations regarding nausea, vomiting, pruritus, and urinary retention were documented as described above. Rest VAS pain scores were defined as those pain assessments documented within the daily nursing notes. A minimum of 1 rest VAS pain score is recorded during each nursing shift (8 hours). However, all pain scores were collected if more than 1 assessment was documented during a given nursing shift. Median pain scores were reported. VAS pain scores with activity were defined as those scores documented during each physical therapy session.

The time required to achieve 4 major postoperative milestones was also recorded. Postoperative milestones included: (1) the ability to transfer from bed to chair; (2) ambulation (the ability to walk >10 steps with the use of a walker or crutches with the assistance of a physical therapist); (3) discharge eligibility; and (4) hospital length of stay. Discharge eligibility was defined as: (1) satisfactory analgesia (consistent VAS ≤3) with oral medications; (2) satisfactory oral intake without nausea or vomiting; (3) unassisted crutch-walking and the ability to perform activities of daily living; and (4) the ability to stair-climb if steps were present within the patient's home.

Joint range of motion (total knee arthroplasty patients) and perioperative complications were recorded at the time of hospital dismissal, and at the patient's 6 to 8 week surgical follow-up visit. Perioperative complications included: (1) perineural catheter complications (catheter kinking or leaking, catheter dislodgement); (2) local anesthetic toxicity (tinnitus, perioral numbness, seizure) or high spinal

block; (3) neurologic injury or dysfunction; (4) renal dysfunction (serum creatine elevation ≥0.5 g/dL from preoperative baseline); (5) myocardial infarction (elevated serum troponin levels); (6) postoperative ileus (delayed return of bowel sounds >48 hours postoperatively requiring nasogastric tube placement); (7) radiographically confirmed deep venous thrombosis or pulmonary embolism; (8) localized bleeding complications; (9) wound infection (positive joint aspirate cultures); and (10) cognitive dysfunction (disorientation to person, place, or time; hallucinations; or other cognitive conditions requiring physician or pharmacologic intervention). Information pertaining to complications was derived from the daily progress notes of the primary surgical service, the medical consultation team(s), and the anesthesia pain service. Perioperative complications were followed until complete resolution, or until the last documented date of evaluation.

Identified study patients were then matched (1:1) with historical controls (n = 100) who underwent conventional total hip or total knee replacement surgery using traditional (non-TJRA) anesthetic techniques. Matching criteria included: (1) type of surgical procedure (primary *v* revision total hip or total knee arthroplasty); (2) surgeon; (3) date of surgery (within 5 years to account for potential changes in surgical practice); (4) age; (5) gender; and (6) American Society of Anesthesiologists physical classification.

Traditional (non-TJRA) anesthetic techniques were defined as no preoperative administration of analgesic adjuvants (opioids, nonsteroidal anti-inflammatory agents, COX-II inhibitors), intraoperative general or neuraxial anesthesia without peripheral nerve block, and intravenous opioids during the intraoperative and postoperative (patient-controlled analgesia) periods. Patients receiving traditional anesthetic techniques had access to either morphine or hydromorphone patient-controlled analgesia during the initial (36-48 hours) postoperative recovery period. Patients were subsequently converted to oral opioid analgesics (oxycodone/acetaminophen) as tolerated. Data collection for control patients was performed as described above for all study patients.

Statistical Analysis

The primary outcome of the investigation was hospital length of stay. Secondary outcomes included time to ambulation, joint range of motion, discharge eligibility, and variables associated with perioperative analgesia. All outcomes were analyzed as continuous variables with use of techniques for matched pairs. A one-sample *t* test of the paired differences was used to test for significant differences between groups. Linear regression models were developed to account for potential confounding variables that were not matched within the study design. Nonparametric alternatives were used as appropriate.

The mean length of stay in the hospital after total knee and total hip arthroplasty has been reported to be 4 ± 1.5 days, with no significant difference between total knee and total hip arthroplasty patients.[21] Based upon this standard deviation, the present study had a 90% power to detect a 0.5 day difference in hospital length of stay between the study patients and matched controls, with 100 patients per group ($\alpha = 0.05$). P values ≤ .05 were considered statistically significant.

Data collection was performed using the Mayo Clinic electronic medical record in conjunction with surgical, medical, and anesthesia patient care databases. The electronic medical record ensures that all patient documentation is available for review, with no concern over loss or misplaced medical information. Study endpoints included objective, standardized, and clearly defined clinical assessments derived from the documentation of nursing staff, physical therapists, medical physicians, surgeons, and anesthesia providers. Documentation within the medical record is presumed to be accurate and valid. Data collection endpoints were available for all patients.

Results

Consecutive patients undergoing major joint replacement surgery using the Mayo Clinic TJRA protocol (n = 100) and matched historical controls using traditional anesthetic techniques (n = 100) were retrospectively reviewed. Four patients were incompletely matched for type of procedure. In these cases, primary joint replacement surgery (3 TKA and 1 THA) was substituted for revision joint replacement surgery. Patient demographics, surgical diagnosis and procedure, and anesthetic technique(s) for study participants and matched controls are listed in Table 2. Differences included a prolonged surgical duration ($P < .001$) and higher frequency of neuraxial ($P = .01$) vs. general ($P = .02$) anesthesia among control patients.

Patients receiving the TJRA protocol had significantly improved analgesia with fewer side effects when compared with control patients. Verbal analog pain scores were significantly lower among TJRA patients both at rest ($P < .001$) and with activity ($P < .001$) during the entire hospital stay (Table 3). Opioid requirements were significantly less among TJRA patients from the pre-/intraoper-

Table 2. Patient Characteristics

Patient Characteristic	TJRA (n = 100)	Controls (n = 100)	*P*
Patient demographics			
Age (y; range)	68.5 (61.5-75)	68.5 (61.5-75.5)	NS
Gender*			
Male	47	49	NS
Female	53	51	NS
BMI	29.8	30.4	NS
Diagnosis			
Degenerative arthritis	97	96	NS
Rheumatoid arthritis	3	4	NS
Surgical demographics			
Type of surgery†			
Primary TKA	49	52	NS
Revision TKA	29	26	NS
Primary THA	15	16	NS
Revision THA	7	6	NS
Preoperative range-of-motion (degrees)			
Lower value (range)	5 (0-5)	0 (0-7)	NS
Upper value (range)	100 (95-100)	100 (90-115)	NS
Surgical duration (min; range)	107 (88-127)	126 (104-157)	<.001
Anesthetic technique			
General anesthesia	69	51	.02
Neuraxial anesthesia	31	49	.01
Lumbar plexus catheter			
Psoas compartment	68	0	—
Femoral	32	0	—
Sciatic nerve block‡	99	0	—

NOTE: Values are presented as number of patients (n) unless otherwise indicated.

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by the square of height in meters); NS, not significant; THA, total hip arthroplasty; TJRA, total joint regional anesthesia protocol; TKA, total knee arthroplasty.

*Two patients could not be gender-matched based upon other established matching criteria.

†Three patients undergoing total knee arthroplasty and 1 patient undergoing total hip arthroplasty could not be matched based upon other established matching criteria.

‡One patient within the TJRA group did not receive a single-injection sciatic nerve block because of a pre-existing neurologic deficit.

ative period until the beginning of postoperative day 2 ($P = .04$). Opioid-related side effects such as nausea ($P < .001$), vomiting ($P = .01$), and urinary retention ($P < .001$) were also significantly reduced for TJRA patients throughout most of the perioperative period (Table 4). There was no significant difference in the frequency of pruritus between groups. Fewer TJRA patients received thromboprophylaxis on the day of surgery when compared with matched controls (38% *v* 72%; $P < .001$).

Postoperative milestones (bed to chair transfer, discharge eligibility, and hospital dismissal) were achieved significantly sooner in patients receiving the multimodal TJRA protocol (Table 3). The ability to transfer from bed to chair occurred a mean of 0.2 ± 0.6 days sooner among TJRA patients when compared with their matched control ($P = .001$). Nearly all patients were able to accomplish this milestone on postoperative day 1. Discharge eligibility was also achieved a mean of 1.7 ± 1.9 days sooner among TJRA patients when compared with matched controls ($P < .0001$). In many cases, patients in both groups remained hospitalized despite achieving discharge eligibility. The most common reason for this was social disposition, such as arranging patient transportation, nursing home, or swing bed availability, or in-home readiness. Hospital length of stay was 3.8 days for TJRA patients and 5.0 days for controls ($P < .001$). At the time of hospital dismissal, joint range of motion was significantly improved among TJRA patients (90° *v* 85°; $P = .008$) (Table 3). A significant number of matched patient pairs (n = 44) had incomplete joint range of motion data at their 6 to 8 week surgical follow-up. However, among the matched pairs with complete data, the small gains in range of motion observed at hospital dismissal persisted at 6 to 8 weeks postoperatively (106° *v* 99°; $P = .03$).

Severe postoperative complications were similar between groups (Table 5). However, postoperative ileus occurred significantly more often among control patients ($P = .01$). Postoperative feedings were delayed in all 8 patients who experienced a postoperative ileus. Two (2%) control patients experienced a postoperative wound infection. Cultures from the 2 deep infections yielded coagulase-negative staphylococcus in 1 patient and beta-hemolytic streptococcus in another. Both required surgical debridement and prolonged antibiotic therapy. Five (5%) control patients and 1 (1%) patient from the

TJRA group experienced superficial wound erythema treated successfully with perioperative antibiotics.

Discussion

Several investigations have previously examined the use of peripheral nerve block and supplemental intravenous opioids in patients undergoing major orthopedic surgery.[4,15-19] However, a review of the literature demonstrates that studies incorporating peripheral nerve block into a multimodal analgesic regimen—in the complete absence of intravenous opioids—are lacking. This investigation is the first study to demonstrate that perioperative outcomes after major (nonminimally invasive) orthopedic surgery may be improved in the absence of intravenous opioids. Patients receiving the TJRA protocol had significantly shorter hospital lengths of stay, earlier ambulation, improved joint range of motion,

Table 3. Perioperative Outcomes

Perioperative Outcome	TJRA (n = 100)	Controls (n = 100)	*P*
Verbal analog pain score at rest (0-10)*			<.001
PACU	0	0	.02
POD 0	0	5	<.001
POD 1	0	4	<.001
POD 2	0	3	<.001
POD 3	0	3	<.001
Verbal analog pain score at daily physical therapy session (0-10)*			<.001
POD 0	0	6	<.001
POD 1	2	5	<.001
POD 2	2	3	<.001
POD 3	1	3	<.001
Morphine equivalents (mg)†			.04
Pre-/intraoperatively	20	30	<.001
PACU	0	0	<.001
POD 0	10	15	<.001
POD 1	20	38	<.001
POD 2	20	20	NS
POD 3	12.5	10	NS
Out-of-bed to chair			<.001
POD 0	17	2	<.001
POD 1	97	91	NS
POD 2	99	99	NS
POD 3	97	98	NS
Ambulation			<.001
POD 0	0	0	<.001
POD 1	88	35	<.001
POD 2	98	80	<.001
POD 3	100	97	NS
Meets discharge eligibility‡			<.001
POD 0	0	0	NS
POD 1	0	0	NS
POD 2	48	4	<.001
POD 3	81	30	<.001
POD 4	97	53	<.001
Hospital length of stay (d)*	3.8	5	<.001
Joint flexion at discharge (degrees)*	90	85	.008

NOTE. Values are presented as number of patients (n) unless otherwise indicated.

Abbreviations: NS, not significant; PACU, postanesthesia care unit; POD, postoperative day; POD 0, day of surgery; TJRA, total joint regional anesthesia protocol.

*Values presented as median.

†Values presented as median (includes all oral and intravenous opioids).

‡Discharge eligibility includes: (1) satisfactory analgesia; (2) satisfactory oral intake without nausea or vomiting; (3) satisfactory unassisted ambulation as per physical therapy documentation; and (4) stair-climbing if steps were present within the patient's home.

Table 4. Perioperative Opioid-Related Side Effects

Perioperative Side Effect	TJRA (n = 100)	Controls (n = 100)	*P*
Nausea			<.001
PACU	14	17	NS
POD 0	17	44	<.001
POD 1	22	55	<.001
POD 2	7	17	.03
POD 3	6	10	NS
Vomiting			.01
PACU	11	6	NS
POD 0	6	20	.003
POD 1	10	27	.002
POD 2	1	4	NS
POD 3	2	2	NS
Urinary retention*			<.001
PACU	34	61	<.001
POD 0	45	70	<.001
POD 1	40	67	<.001
POD 2	22	35	.03
POD 3	16	16	NS
Pruritus			NS
PACU	1	0	NS
POD 0	1	1	NS
POD 1	4	4	NS
POD 2	3	3	NS
POD 3	1	3	NS

NOTE. Values are presented as number of patients (n) unless otherwise indicated.

Abbreviations: NS, not significant; PACU, postanesthesia care unit; POD, postoperative day; POD 0, day of surgery; TJRA, total joint regional anesthesia protocol.

*Urinary retention requiring urinary catheterization.

Table 5. Postoperative Complications

Postoperative Complication	TJRA (n = 100)	Controls (n = 100)
Peripheral nerve catheter complications	5	—
Local anesthetic toxicity or high spinal	0	1
Neurologic injury	1	0
Myocardial infarction	0	0
Deep venous thrombosis or pulmonary embolism	2	0
Renal dysfunction	1	2
Localized bleeding complications	1	3
Wound infection	0	2
Cognitive dysfunction	5	8
Postoperative ileus*	1	7
Joint dislocation	0	0

NOTE. Values are presented as number of patients (n).

Abbreviation: TJRA, total joint regional anesthesia protocol.

*$P = .01$.

lower perioperative pain scores, and a reduction in postoperative nausea and vomiting when compared with patients treated with traditional postoperative intravenous opioids (patient-controlled analgesia). TJRA patients also had significantly lower opioid requirements when compared with controls, which may have accounted for the significant reduction in urinary retention and postoperative ileus formation among these patients.

The TJRA clinical pathway was initially developed at our institution to manage patients undergoing minimally invasive total hip or knee replacement surgery. It was a collaborative effort by the Departments of Anesthesiology and Orthopedic Surgery to optimize both anesthetic and surgical goals in the management of *minimally invasive* orthopedic surgical patients. Implementation of the TJRA clinical pathway improved the perioperative outcomes of this unique patient population (i.e., minimally invasive surgical patients) by significantly improving perioperative analgesia, minimizing or eliminating opioid-related side effects, and maximizing postoperative rehabilitation to facilitate early hospital dismissal.[5] However, the results of the current investigation suggest that the documented beneficial effects of this multimodal analgesic regimen may be applicable to a wider population of orthopedic surgical patients (i.e., conventional [nonminimally invasive] surgical patients).

The use of a pre-emptive, multimodal, analgesic regimen within our study population resulted in clinically significant improvements in postoperative analgesia (i.e., $\geq$2 point difference in VAS pain scores)[22] with fewer opioid-related side effects. The use of nonopioid analgesics and our emphasis on peripheral nerve block greatly enhanced our ability to successfully manage postoperative pain while minimizing opioid requirements. These beneficial outcomes allowed patients to more aggressively participate in physical therapy, resulting in improved surgical outcomes (joint range of motion), and shorter hospital lengths of stay. Interestingly, most patients experienced a delay in hospital dismissal despite achieving discharge eligibility. Forty-eight percent of TJRA patients achieved discharge eligibility on postoperative day 2. However, the mean time to discharge was delayed for an additional 1.8 days. Most delays were due to patient disposition, including awaiting nursing home placement, "swing bed" availability, arranging patient transportation, lack of home readiness by family members, or patient expectations of requiring a longer length of stay. These findings emphasize the need to address patient expectations *prior to* hospitalization, and to involve social services early in the patient's perioperative course. Advantages achieved by advanced anesthetic or surgical techniques may go unrecognized if the entire health care system (physicians, nursing staff, physical therapy, pharmacy, and social services) does not coordinate their efforts to develop a comprehensive patient care plan that begins with hospital admission. Preoperative patient education sessions may be beneficial to describe the perioperative course, establish expectations, and alleviate patient concern through early discharge planning.

Importantly, the limitations of this retrospective investigation must be recognized. First, the logistics of performing a retrospective investigation make it difficult to reliably capture minor study endpoints. However, the well defined study endpoints of the current investigation (hospital length of stay, time to ambulation, joint range of motion, medication administration) are routinely included within our electronic medical record. The variability of minor study endpoints may have resulted in a lower incidence of complications or adverse events that may otherwise appear in prospective studies. Secondly, the current investigation examined a system-wide change in the perioperative management of orthopedic surgical patients when compared with historical controls. The development of a multimodal analgesic regimen, the administration of preoperative oral analgesics, the utilization of intra- and postoperative peripheral nerve block, and the avoidance of intravenous opioids were all changes that were implemented simultaneously. As a result, it is difficult to establish whether the improvement in perioperative outcomes was the result of a single independent variable, or the cumulative effect of several variables working synergistically with one another. Finally, the duration of postoperative follow-up was limited to 6 to 8 weeks. Complications or advances in joint range of motion occurring beyond this point could not have been reliably identified.

In summary, a comprehensive, preemptive multimodal analgesic regimen featuring peripheral nerve block may improve the perioperative outcomes of patients undergoing total hip and knee replacement surgery when compared with intravenous opioids alone. Improved perioperative outcomes may include a reduced hospital length of stay, earlier ambulation, improved joint range of motion, superior analgesia, fewer opioid-related side effects, and a reduction in urinary retention and postoperative ileus formation. The TJRA clinical pathway represents our institution's multimodal approach to perioperative pain management. Multimodal analgesia incorporating peripheral nerve blockade enhances patient rehabilitation by maximizing patient comfort, while minimizing opioid-related side effects. Further investigations are war-

ranted to identify whether or not many of the short term benefits achieved in this study can be translated into long term (>6 months) clinical benefit for patients, or improved health care economics for medical institutions.

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