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Pain Patterns in Anterior Cruciate Ligament Reconstruction, and the Utility of Sciatic Nerve Blockade for Postoperative Analgesia

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Abstract

Pain Patterns in Anterior Cruciate Ligament Reconstruction and the Utility of Sciatic Nerve Block for Postoperative Analgesia

Introduction: In anterior cruciate ligament reconstruction (ACLR) with hamstring autograft, a significant degree of posterior knee pain is expected from the tendon harvesting procedure. However, pain patterns are not as predictable for non-hamstring ACLR.

Methods: In this observational study, patients underwent general anesthesia and preoperative femoral nerve block for non-hamstring ACLR. As the primary outcome measure, we identified patients with postoperative pain scores persistently at five or above (out of 10), despite treatment with opioids, as having probable sciatic-related pain. These patients then received sciatic nerve block.

Results: 10 patients (20%) out of 50 reported pain scores consistently at or above five despite at least two doses of opioids and 20 minutes in recovery. In this group, pain scores were significantly higher at 10, 20 and 30 minutes, ($p<0.024$) compared to those without persistent pain, but rapidly fell after rescue sciatic block, to a similar level. Pain scores at discharge and 24 hours did not significantly differ between the two groups.

Conclusion: Most patients had appreciable pain on arrival in recovery; however, a subset maintained moderate level pain scores despite administration of multiple doses of opioids. These patients rapidly improved with sciatic nerve block, suggesting that a major portion of the pain was related to sciatic nerve innervation. A population-based clinical decision algorithm is proposed which would treat 50% of likely qualifiers with sciatic block within 10 minutes of admission to recovery, based on a pain score threshold of 7/10. Such an algorithm would reduce immediate postoperative opioid consumption and the duration of discomfort, while likely reducing length of stay.

Keywords: Postoperative; Pain; Regional Anesthesia; Nerve Block; Femoral; Sciatic; Anterior Cruciate Reconstruction

Introduction

Reconstruction of the anterior cruciate ligament (ACL) is one of the most common orthopedic procedures performed on young adults [1]. Various grafts may be used to substitute for the torn ligament, including the patient's own patellar tendon, semitendinosus tendon, or quadriceps tendon; allografts derived from cadaver tendons are also commonly used. When the graft is harvested from the hamstring, posterior pain in the sciatic nerve distribution is predictable and expected; practitioners may therefore opt to provide preoperative sciatic nerve blockade [2]. However, the utility of sciatic nerve blockade is not as evident for non-hamstring ACL reconstruction. In these circumstances, femoral nerve block (FNB) is frequently provided as a preoperative intervention, and has been shown to provide excellent analgesia in combination with intensive multimodal analgesia [3].

A portion of the incision, as well as the osseous interventions, utilized for ACL reconstruction occurs over the proximal tibia, a transition zone between innervation by the femoral nerve and the sciatic nerve, which may lead to considerable postoperative pain, even in the presence of an effective femoral nerve block. Our primary aim in this study was to characterize the degree of postoperative pain and adequacy of analgesia in patients undergoing non-hamstring ACL reconstruction under general anesthesia with preoperative FNB, and secondarily to evaluate the efficacy of a "rescue" sciatic nerve block provided in such patients.

Methods

After approval by the University of Pittsburgh Institutional Review Board, 50 ASA/PS 1 or 2 patients were recruited, aged 18 – 52, who were scheduled for ACL reconstruction with single bundle cadaveric allograft or with patellar tendon autograft. Exclusion criteria included patients scheduled for hamstring autograft, patients with contraindications to peripheral nerve block, patient refusal of regional anesthetic in addition to general anesthesia, and failed femoral nerve block. Patients were consented for a preoperative femoral nerve block (FNB) and possible postoperative sciatic nerve block (SNB) if necessary. All patients received preoperative acetaminophen 1000 mg PO and perphenazine 8mg PO, unless contraindicated [4].

FNBs were performed for all patients in the pre-operative holding area using midazolam 1 – 2mg IV and fentanyl 50 – 100mcg IV for anxiolysis and procedural analgesia. The inguinal crease area was prepped with chlorhexidine. FNBs were then performed using anatomic landmarks with peripheral nerve stimulation or with ultrasound guidance using a linear high frequency probe (Sonosite S-Nerve with 6-12 MHz linear transducer, Bothell, WA) to identify the femoral nerve and adjacent vascular structures. For allograft patients, FNBs were performed using a single-injection technique with 20ml of 0.5% ropivacaine or 0.25% bupivacaine (per the attending anesthesiologist's discretion); along with 50 mcg clonidine. FNB for autograft patients were performed by placing a continuous infusion catheter and instilling 20ml of 0.2% ropivacaine as a bolus. Adequacy of FNB was determined by testing motor and sensory blockade at ten minute intervals from the time of completion of the block. Patients with failed femoral block (i.e. those with no evidence of motor/sensory block prior to going to OR, or with preservation of quadriceps motor function and sensory function over anterior thigh by the time of arrival in PACU) were excluded from the study.

After transfer to the OR, patients were provided a standardized general anesthetic, including propofol induction with subsequent propofol maintenance infusion and 50 – 70% inhaled nitrous oxide; volatile agents were not used for maintenance of anesthesia. Airway control was performed with endotracheal tube or laryngeal mask. All patients received a ketamine bolus of 0.5 mg/kg, up to 50 mg, just after induction. Intra-operative opioid analgesics were administered based on vital signs at the discretion of the anesthesiologist. While it was recommended to maintain the fentanyl and hydromorphone dose at or below 100 mcg and 1 mg, respectively, practitioners were free to administer higher doses if this was felt to be clinically necessary, based on hemodynamic perturbations and/or respiratory rate.

On arrival to the PACU, all patients had initial numeric rating score (NRS) pain scores determined at rest, on a ten point verbal pain scale; pain scores were reassessed at ten minute intervals. Analgesics were administered by nurses on a PRN basis based on our standard postoperative clinical management parameters. Patients with NRS scores greater than five out of ten received intravenous hydromorphone; ketorolac was also administered at the discretion of the anesthesiologist. For those with scores between three and five, oral opioids were administered. Effectiveness of the FNB was ascertained by confirming sensory loss over the anterior thigh and complete motor blockade of the quadriceps muscles.

Patients that had persistent pain scores greater than or equal to five out of ten on the NRS scale after 20 minutes in the PACU , despite an adequately functioning FNB, and at least two doses of postop analgesics noted above, were administered a single–injection SNB. This decision was based on patient desire for the nerve block, pain score as noted, and non-responsiveness to opioid analgesics.

Patients receiving SNB were placed in the lateral decubitus position and the skin prepped withchlorhexidine. Using anatomic land marks with peripheral nerve stimulation or ultrasound guidance, an infragluteal sciatic nerve block was performed using a 20 mL injection of 0.2% ropivacaine. NRS pain scores were then re-assessed immediately after the SNB, and upon PACU discharge.

Total analgesic usage in the perioperative period was recorded for each patient. Patients with femoral catheters were discharged home with a disposable On-Q (I-Flow LLC, Lake Forest, CA) disposable infusion device to administer 5mL/hr of 0.2% ropivacaine, with instructions to remove the catheter at home on post-operative day three. All patients were discharged from the hospital with a prescription for oxycodone 5 mg tablets, dosed as one-to-three tablets as needed for pain every four hours.

All patients were called on post-operative day (POD) 1. Catheter patients were called each day for three days, at which time the catheter was removed. NRS pain scores at the time of the follow up call were recorded, as well

as total opioid usage in the first 24 hours after surgery. During the follow up phone call, patients were asked about the return of sensation and motor function.

The primary outcome measure of this observational study is the determination of the proportion of patients who reported poor postoperative analgesia (NRS greater than or equal to 5) despite the presence of a functional FNB and administration of at least two doses of opioids, thus triggering our intervention of a rescue SNB. Secondary outcomes include response of the patients' NRS scores to rescue block, total opioid doses, pain scores at PACU discharge and 24 hours, and doses of opioid administered after the block in those who required SNB. As this is an observational study, we chose a convenience sample of 50 patients, based on our prior impression that approximately 25% of patients undergoing this type of surgery had poor postoperative pain control, and subsequently met our criteria for SNB. The primary outcome measure was reported with simple descriptive statistics. Patient demographic data such as gender, type of peripheral nerve block, and surgery performed, were compared using Fisher's exact test. Continuous variables were analyzed using Student's t-test; pre- and post-block NRS were compared with a paired t-test for the group requiring rescue block. In addition, a sensitivity analysis was performed using non-parametric tests to confirm that outcomes analyzed above did not change. All statistical analysis was performed using IBM SPSS version 21.

Results

Patient demographics are reported in Table 1. When segregated on the basis of persistently elevated pain scores, no significant difference was found between the groups for age, sex, or type of procedure. In addition, there was no statistically significant difference for preoperative NRS pain scores, preoperative fentanyl dose for the FNB, or intra-operative opioid analgesia administered. One patient was excluded for a non-functioning femoral block in PACU. Descriptive data are presented in Table 2.

Mean NRS pain scores on arrival in PACU were 3.7 (3.7) for all patients. Ten out of 50 (0.2, or 20%; 95% CI 0.11-0.33) patients reported sustained NRS pain scores in the PACU rated at greater than or equal to five out of 10 on the NRS pain scale, despite receiving multiple doses of opioids. All of these patients received SNB.

The group with persistently elevated pain scores (FNB-SNB group), reported higher pain scores on arrival to PACU, though this did not reach statistical significance (5.35 vs. 3.23 for FNB-only group, P value = 0.10). At ten minutes and 30 minutes after arrival in PACU, the FNB-SNB group NRS score (i.e., before the SNB was administered) was significantly higher than those of the FNB group (Table 2, Figure 1). NRS pain scores for the two groups were similar upon discharge from PACU, and at the time of the follow-up phone call on POD1. The dose of oral analgesics during the first 24 hours did not differ between the two groups. The administration of parenteral opioids was significantly less after the block was performed for patients in the FNB-SNB group, compared to before this intervention (mean 0.1 mg hydromorphone post-block vs. 0.67 mg pre-block, p=0.026, paired t-test); while oral opioids were not significantly different. Two of ten patients in this group received parenteral opioids after SNB, and one patient received a single dose of oral opioids.

Four patients received more than the recommended amounts of intra-operative opioids (specified as 1 mg hydromorphone and/or 100 mcg fentanyl), but only one of these patients had persistently elevated pain scores, and subsequently received a postoperative sciatic block. Alternatively, eight patients received no intra-operative opioid drugs, of which two received postoperative SNB. These small sample sizes preclude subset analysis to determine statistical significance.

Table 1. Patient Demographics

	FNB Only	FNB-SNB	P value
N	40	10	
Age, y (SD)	27.45 (9.5)	29.1 (11.0)	0.614
Male, n (%)	32 (80)	7 (70)	0.671
BMI (SD)	27.1 (5.3)	25.4 (3.8)	0.383
Patellar Tendon Autograft, n (%)	32 (80.5)	7 (70)	0.671
Ropivacaine 0.2% for Cather, n (%)	5 (12.5)	0 (0)	0.056
Ropivacaine 0.5% for FNB, n (%)	26 (65)	7 (70)	
Bupivacaine 0.25% for FNB, n (%)	9 (22.5)	3 (30)	

Table 2. Clinical Comparison of FNB and FNB-SNB Groups

	FNB Only	FNB-SNB	P value
N	40	10	
Preop NRS Pain Score (SD)	1.10 (1.63)	1.7 (1.57)	0.300
Preop fentanyl, mcg (SD)	82.50 (24)	80.00 (25.82)	0.774
Preop midazolam, mg (SD)	1.75 (0.44)	2.00 (0)	0.001
Intraop ketamine, mg (SD)	37.50 (16.01)	37.5 (13.18)	1.000
Intraophydromorphone, mg (SD)	0.43 (0.43)	0.30 (0.46)	0.825
Intraop fentanyl, mcg (SD)	33.13 (53.53)	36.25 (40.16)	0.406
NRS Pain score PACU-arrival (SD)	3.23 (3.67)	5.35 (3.59)	0.102
NRS Pain score PACU at 10 min, (SD)	4.21 (3.26)	6.90 (2.08)	0.017
NRS Pain score PACU at 20 min, (SD)	4.32 (2.86)	6.80 (1.69)	0.016
NRS Pain score PACU at 30 min, (SD)	4.00 (2.68)	6.20 (1.79)	0.024
NRS Pain score PACU- Discharge (SD)	2.26 (1.42)	2.60 (0.97)	0.486
PACU hydromorphone, mg (SD)	0.69 (0.60)	0.77 (0.34)	0.760
PACU oxycodone, mg (SD)	1.75 (2.41)	2 (3.50)	0.353
PACU ketorolac, mg (SD)	1.5 (6.62)	3 (9.49)	0.343
POD 1 Pain Score, value (SD)	4.06 (2.17)	3.8 (2.49)	0.741
24-hour oxycodone consumption, mg (SD)	20.75 (13.28)	25.50 (9.85)	0.337

FNB: femoral nerve block; FNB-SNB: femoral and sciatic nerve block

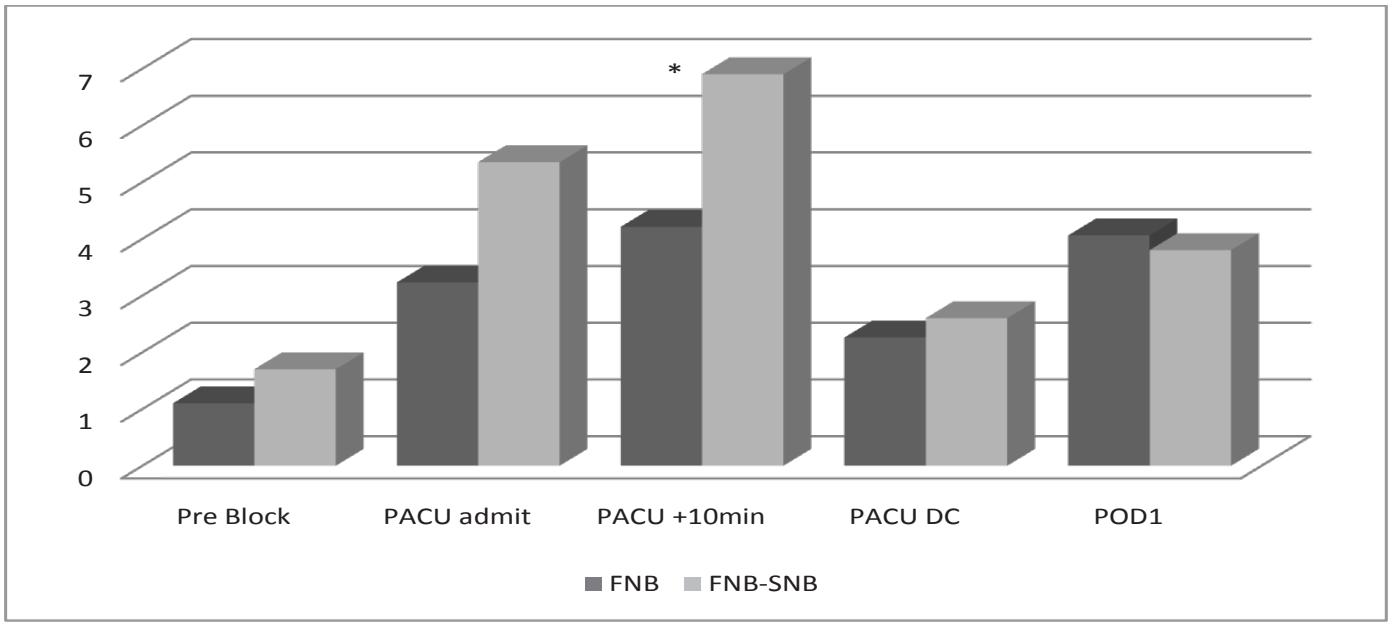

Figure 1. Comparison of reported Numeric Rating Score (NRS) pain scores for femoral nerve block (FNB) and femoral + post-op sciatic nerve block (FNB-SNB) study groups. Pre Block: NRS pain scores prior to FNB in pre-op holding area. PACU admit: NRS pain scores immediately recorded at time of arrival to post anesthesia care unit. PACU +10min: NRS pain scores after 10 minutes in PACU. PACU DC: NRS pain scores at time of discharge from the PACU. POD1: Reported NRS pain scores at time of post-op call and evaluation. Asterisk denotes significant difference between groups at this time point.

Discussion

One of the great frustrations in anesthesia practice is to provide what should be an effective analgesic block, only to find that the patient awakens after surgery in considerable pain. We noted in our practice that this occurred in a notable minority of patients who had undergone femoral nerve block for non-hamstring ACL reconstruction (with either allograft or autograft). We observed clinically that providing such patients with an SNB in PACU resulted in rapid resolution of the pain and a satisfactory experience. In this study, we sought to quantify the fraction of patients for whom such

uncontrolled pain occurred, and for whom the additional block was efficacious under conditions quite similar to those of a private, orthopedic-based anesthesiology practice, with (i) a mixture of allograft and autograft cases, (ii) preoperative femoral nerve blockade, (iii) a target range of intra-operative opioid analgesics, and (iv) readily measured clinical endpoints for providing the postoperative SNB.

In this study, we identified a subset (10 of 50, 20%) of patients who had persistently high pain scores in PACU, despite effective femoral block and multiple doses of opioid analgesics, and who subsequently received an SNB. Both groups of patients (those who did and those who did not receive SNB) had similar pre-operative demographics, pre-operative pain scores, peri-operative analgesic requirements, and pain scores at the time of PACU discharge as well as on POD1. The FNB-SNB, however, was found to have higher pain scores at 10, 20, and 30 minutes after arrival to the PACU, despite supplemental analgesics.

Mean NRS scores were in the "moderate" range for both groups of patients immediately after surgery, though scores were significantly mitigated for the FNB group as analgesics were provided. The degree of postoperative pain experienced did not vary with the type of graft (allograft versus patellar tendon autograft) utilized. Opioid administration was similar in both groups, despite the divergent pain scores, but these doses brought mean NRS pain scores down to the "mild" range for the FNB group (i.e. ≤3/10), and not for the FNB-SNB group. However, there was a notable reduction of both pain scores and opioid requirements after the rescue block was performed in the FNB-SNB group, substantiating the benefit of the additional block.

Our data distributions lend themselves to an easy algorithm to allocate patients to earlier use of SNB without a trial of opioids. One can use the term "Rule of Sevens" as the statistical mnemonic. Upon PACU arrival, the pain score value in the FNB-SNB group that lies at the upper bound of one standard deviation approximates 7.0 (7.03 to be exact); this is rephrased as 32% of patients in the FNB-SNB group would qualify for immediate SNB. When this value (exact NRS=7.03) is evaluated against the normal distribution of the FNB group pain scores after PACU arrival, the probability value of NRS pain scores <7 is P=0.85, meaning that 15% of FNB patients (along with 32% of FNB-SNB patients) would have had pain scores of 7 or higher upon PACU arrival, and would be eligible for immediate postoperative SNB without a trial of opioids (under the "Rule of Sevens" algorithm). Using the upper bound of one standard deviation in the FNB-SNB group as the threshold for PACU NRS pain scores for immediate SNB in all such ACL patients is reasonably conservative since the difference between the FNB and FNB-SNB groups was a statistical trend, not yet reaching statistical significance. At the 10-, 20-, and 30-minute time points upon PACU arrival, NRS mean pain score differences between FNB and FNB-SNB were significantly different (significance values at these time points were $P \leq 0.024$). Therefore, the NRS pain score values at 10 minutes (but not at 20-30 minutes) are sufficient for the clinical decision for immediate SNB and aborting any further trial of opioids. The mean NRS pain score values at 10 and 20 min after PACU arrival in the FNB-SNB group were 6.9 and 6.8, respectively. Applying the "Rule of Sevens" specifically at the 10-minute time point (with the 6.9 NRS pain score value from the FNB-SNB group evaluated against the FNB distribution), the approximate probability value of NRS pain < 7 is P=0.80 (exact P=0.7954), indicating that only 20% of remaining FNB group patients (along with 50% of remaining FNB-SNB patients) would receive immediate SNB based on the 10-minute NRS pain score of 7 or higher (with no further trial of opioids). Table 3 demonstrates the epidemiologic implications of early SNB and opioid avoidance, summarized as: applying the "Rule of Sevens" to 1000 such ACL patients at PACU admission and at 10 minutes after admission would lead to ~50% of patients avoiding escalating opioids (and/or 30+ minutes of discomfort) via earlier use of SNB as soon as an NRS postop pain score of 7 is identified. Such a strategy would also likely reduce PACU length of stay in rapid-turnover ambulatory surgery contexts.

The innervation of the knee is complex and involves the femoral, sciatic and obturator nerves [5]. Per the work of Horner and Dellon, the medial femoral cutaneous branch of the femoral nerve provides innervation to the medial aspect of the joint and the prepatellar plexus (these may or may not traverse the adductor canal)[6]. The saphenous branch of the femoral nerve innervates the anterior and inferior knee capsule, as well as the cutaneous structures inferior and medial to the patella. In addition, the branches of the femoral nerve to the vastusmedialis and the vastusintermedius provide innervation to the knee joint capsule. The obturator nerve has been shown to provide a contribution to the subsartorial plexus, which contributes to knee joint innervation, in a minority of patients. The lateral aspect of the joint is innervated by branches from the common peroneal and from the superior lateral genicular nerve (which branches from the sciatic nerve above the joint). Finally, the posterior portion of the capsule receives innervation from both the posterior branch of the obturator nerve, and from the posterior articular branches of the tibial nerve. Of importance, incisions for arthroscopically-guided ACL repair would typically involve the anterior/medial joint for insertion of ports, the distal patellar and infero-patellar region for cutaneous incisions, and the proximal tibia as well as the inter-condylar region of the femur, where drilling

occurs in order to anchor to anchor the graft. In addition, the incisions/dissection for harvesting will vary with the graft type [7]. These areas of incision and/or manipulation suggest that in many patients, not only the femoral nerve, but also the sciatic nerve, may innervate affected structures.

acceptance, all of which have a subjective component. While we chose persistently elevated pain scores after two doses of analgesia, over at least 20 minutes of postoperative observation, other practitioners might opt for alternative thresholds, which may affect the

Table 3. "Rule of Sevens" NRS Pain Score PACU scenario analysis of avoided pain and opioids in ~50% of patients with earlier-applied postoperative sciatic nerve block

Admission scenario: 1000 ACL patients, with 500 patients assuming the FNB pain distribution pattern (75 patients with NRS pain scores 7 or higher), and 500 patients assuming the FNB-SNB pain distribution pattern (160 patients with NRS pain scores 7 or higher).	o None of these 235 patients will have undergone a trial of opioids, instead receiving immediate SNB o 425 patients remain in the FNB pain pattern pool, and 340 patients remain in the FNB-SNB pain pattern pool, therefore 765 ACL patients remain for the 10-minute after admission PACU pain scenario
Scenario of 10 minutes after PACU admission: 765 remaining ACL patients	o Calculations assume 50% of 340 FNB-SNB patients will have NRS pain scores of 7 or higher, and 20% of 425 FNB patients will have NRS pain scores of 7 or higher. o This total of 255 patients would receive SNB after terminating a trial of opioids after 10 minutes o 340 patients remain in the FNB pain pattern pool, while 170 patients remain in the FNB-SNB pain pattern pool, while 490 of the original 1000 patients would have received an early SNB (either immediately or at 10 minutes after PACU arrival

NRS: numeric rating score. PACU: post-anesthesia care unit; ACL: anterior cruciate ligament; FNB: femoral nerve block; FNB-SNB: femoral and sciatic nerve block.

Several limitations of the study warrant discussion. This is an observational study, rather than a randomized trial. However, its design reflects the nature of our practice, and provides a quantitative assessment of pain perception after non-hamstring ACL surgery, as well as the utility of rescue sciatic block, within the parameters defined. The study population had some variability with regard to local anesthetic type and concentration for the pre-operative FNB, however all included patients were determined to have adequately functioning FNBs on arrival to the PACU. In addition, while a desired "ceiling" was set on peri-operative opioids to be provided to the patients, the exact amount administered was at the discretion of the attending anesthesiologist caring for the patient, based on perceived clinical necessity. The small numbers of patients who received more than the recommended amount of intra-operative opioids precludes subset analysis to determine statistical significance, but the fraction of these patients requiring SNB was similar to that of our overall population. Finally, while determination of NRS scores is reasonably objective, the criteria for performing rescue SNB were necessarily clinical in nature and specific to our practice, based on reported pain scores, refractoriness to opioid therapy, and patient

fraction of patients who appear to benefit from sciatic block. Both groups of patients had significant pain after these ACL procedures, even in the presence of effective FNB, and patients meeting our threshold for SNB may simply be those who are more refractory to opioids, or those with a larger proportion of the surgical area innervated by the branches of the sciatic nerve.

Conclusion

In conclusion, many patients have moderate peri-articular pain after non-hamstring ACL reconstruction conducted with general anesthesia, even in the presence of a functioning femoral nerve block. This is most likely due to innervation of cutaneous, capsular and osseous structures by contributions from the sciatic nerve, especially to the proximal tibial and intra-articular regions. A significant fraction of these patients continue to have pain despite opioid administration in PACU, and these patients may benefit from postoperative SNB, with rapid reduction in NRS pain scores and diminishment of opioid requirements. Preoperatively, patients having non-hamstring ACLR should be routinely counseled regarding an approximate 20% likelihood of the need for a rescue SNB despite

preoperative FNB use. The described "Rule of Sevens" with respect to NRS pain scores upon PACU admission and at 10 min after admission may help rapidly guide clinicians toward immediate SNB versus a further trial of opioids in the PACU.

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References

1. Collins JE, Katz JN, Donnell-Fink LA, Martin SD, Losina E. Cumulative Incidence of ACL Reconstruction after ACL Injury in Adults. Am J Sports Med. 2013, 41(3):544-549.

2. Fowler SJ, Symons J, Sabato S, Myles PS. Epidural Analgesia Compared with Peripheral Nerve Blockade After Major Knee Surgery: a Systemic Review and Meta-analysis of Randomized Trials. Br J Anaesth. 2008, 100(2):154-64.

3. Williams BA, Kentor ML, Vogt MT, Irrgang JJ, Bottegal MT, et al. Reduction of verbal pain scores after anterior cruciate ligament reconstruction with two-day continuous femoral nerve block: A randomized clinical trial. Anesthesiology. 2006, 104(2):315–327.

4. Williams BA, Kentor ML, Skledar SJ, Orebaugh SL, Vallejo MC. Routine multimodal antiemesis including low-dose perphenazine in an ambulatory surgery unit of a university hospital: a 10-year history. Supplement to: Eliminating postoperative nausea and vomiting in outpatient surgery with multimodal strategies including low doses of nonsedating, off-patent antiemetics: is "zero tolerance" achievable? ScientificWorldJournal. 2007,12 (7):978-986.

5. Hadzic A. Textbook of Regional Anesthesia and Acute Pain Management. New York: McGraw-Hill, 2007.

6. Horner G, Dellon AL. Innervation of the human knee joint and implications for surgery. Clin Orthoped Rel Res. 1994, 301:221–226.

7. Huddleston JI, Csongradi JJ, Goodman SB, Mihm FG, Halbeis CE: "Knee surgery" In: Jaffe RA, Samuels SI, eds. Anesthesiologists Manual of Surgical Procedures, 4th edition. Philadelphia: Lipincott Williams and Wilkins, 2009. Pp 1013-1029.