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Postoperative Analgesia Following Sciatic Nerve Blockade Administered by Nurse Anesthetists Supervised by Regional Anesthesia Faculty in an Academic Hospital

L. Lollo[1*] and A. Stogicza[2]

[1]Department of Anesthesiology and Pain Medicine, University of Washington, P.O.Box 356540, 1959 NE Pacific St, BB-1469 Seattle, WA 98195-6540, USA.
[2]University of Washington, Seattle, WA, USA.

Authors' contributions

This work was carried out in collaboration between both authors. Author LL designed the study, wrote the protocol, and wrote the manuscript. Author AS managed the literature searches and analyses of the study. Both authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

Introduction: Assessment of expertise in regional anesthesia techniques is traditionally based upon quota fulfillment of procedures during training. Validation of practitioner proficiency in performing procedures in surgical specialties has moved from simple measurement of technical skills to evaluation of global patient outcomes. Complete absence of pain as a result of nerve blockade is the most important clinical endpoint but patient, technical and procedural factors influence results. The purpose of this study was to measure the postoperative pain scores and

**Corresponding author: Email: lollomd@uw.edu;*

associated analgesic medication requirements for patients administered sciatic nerve blockade by nurse anesthetists and determine patient or procedural factors that influenced this outcome.
Methods: Either nerve stimulator or ultrasound guided sciatic nerve blockade was administered by nurse anesthetists under the supervision of regional anesthesia faculty. Patient demographic data that was collected included gender, body mass index, surgical procedure, and pre-existing chronic pain with associated opioid use. Patient self-reported pain scores and opioid analgesic dosages in the preoperative, intraoperative, immediate postoperative and 24 hour post procedure intervals were recorded.
Results: 22 nurse anesthetists administered sciatic nerve blockade to 48 patients during a 36 month interval. Transition from a nerve stimulator to ultrasound guided sciatic nerve block technique resulted in lower mean pain scores. Patients reporting chronic opioid use were observed to have elevated perioperative opioid analgesic requirements and pain scores compared to opioid naïve patients.
Conclusion: Effective analgesia is a prime measure for assessing expertise in regional anesthesia and continuous evaluation of this outcome in everyday practice is proposed.

Keywords: Regional anesthesia; sciatic nerve; ultrasound; chronic pain; outcomes.

1. INTRODUCTION

Proficiency in regional anesthesia (RA) techniques is a vital part of the practice of anesthesiology. An expert in regional anesthesia demonstrates the acquisition of all the skills necessary to safely perform an appropriately selected peripheral nerve block in a timely manner that is successful with regards to complete analgesia [1]. Anesthesiology training programs have adopted multimodal curricula in order to enhance the learning experience that include web-based didactic instruction, rehearsal of procedures with simulator and cadaver models, rotations with expert regional anesthesia faculty and robotics, all aimed towards improved technical competency of trainees performing these techniques and visuospatial coordination during use of ultrasound guided procedures [2-4]. Improvements in global procedure scores and performance times for trainees and practitioners administering axillary and inter-scalene brachial plexus nerve blockade were related to the number of procedures completed and weeks in training but the fulfillment of a minimal quota of procedures during training does not equate with technical expertise [5,6]. Cumulative summation (CUSUM) statistical methodology is an approach that has been applied to measure clinical outcomes and the number of repetitions necessary to acquire the minimal standard of technical expertise for any given procedure has demonstrated resident operator variability [7].

Regional anesthesia skills are a core component of anesthesiology training programs but peripheral nerve blockade techniques are being adapted in other medical specialty and non-physician based training programs. Podiatry residents administering sciatic nerve blockade (SNB) had an overall success rate of complete analgesia in 72.4% of patients irrespective of the number of months in training [8]. Emergency medicine residents have received training in administering femoral nerve blockade and paramedics have been instructed on digital nerve block techniques for reduction of finger dislocations in the field [9,10]. There has been an exponential growth in the number of epidural, facet joint and transforaminal injections of the lumbar spine performed by providers not formally trained in anesthesiology [11]. Analyses have focused on complication rates and safety but little is known of the quality of the analgesia following peripheral and neuraxial nerve blockade techniques performed by non-anesthesiologist practitioners [12,13].

Peripheral nerve blockade is considered successful if no further analgesia or intervention is required for further pain relief [14]. Several patient variables influence a subjective sensory stimulus such as pain but objective measurement of this critical parameter in order to assess adequate nerve blockade is an important clinical marker of technical proficiency in regional anesthesia procedures that are fundamental skills commonly used in daily practice. One outcomes analysis compared nurse anesthetist administered regional anesthesia to general anesthesia but the study was limited to measuring differences in postoperative recovery room times, analgesics, emesis and antiemetic medication dosages between the two groups [15]. The purpose of this study was to measure the perioperative pain scores and opioid analgesic requirements as an assessment of the success rate for nurse anesthetist administered SNB. Secondary study objectives were to observe if changes in the technique from nerve stimulator to ultrasound guided SNB and repetition of procedures by the same operators, and if specific patient demographics influenced this outcome.

2. MATERIALS AND METHODS

After receiving institutional review board approval from the University of Washington Human Subjects Division, patients provided written informed consent prior to undergoing elective foot and ankle surgery and were enrolled for participation in this prospective study of the perioperative analgesic effects of popliteal sciatic nerve blockade administered by a certified registered nurse anesthetist under supervision of regional anesthesia faculty specialized in ultrasound imaging. All certified nurse anesthetists had completed a training program in the performance of sciatic nerve blockade techniques prior to the study period. The lower extremity regional anesthesia training curriculum for all resident physician, nurse anesthetist and pain fellowship trainees for the institution is outlined in Table 1. All procedures were performed at Harborview Medical Center, Seattle. The preoperative data collected were age, gender, ASA physical status, height, weight, calculated Body Mass Index (BMI), recent traumatic lower extremity injury, pre-existing lower extremity neuropathy or chronic pain, worst pain score in the preceding 24 hour interval and maintenance preoperative 24 hour opioid dosage converted to mg of intravenous Morphine Sulfate (MS).

All patients received general inhalational endotracheal anesthesia with sevoflurane and intraoperative analgesia in the form of intravenous fentanyl, morphine and/or hydromorphone for their surgery. Postoperative analgesia in those patients with inadequate pain relief following sciatic nerve blockade was administered as intravenous fentanyl, morphine and/or hydromorphone in bolus doses and oral oxycodone in the immediate postoperative period. Intermittent patient controlled analgesic infusion of hydromorphone with an interval rate of 0.2 mg every 6 minutes and an escalation dose of 0.4 mg without a 6 hour maximum dose lockout restriction in the 24 hour period following surgery was prescribed to all patients for relief of self-reported breakthrough pain. Oral oxycodone was prescribed at an initial dose of 5 mg every 3 hours and individually titrated for each patient in order to achieve a maintenance schedule that resulted in adequate analgesia and allowed cessation of the hydromorphone infusion.

In order to quantify the opioids administered to patients in equivalent dosing units and to compare the opioid usage between patients as a result of the variety of analgesic narcotic medications administered peri-operatively due to both patient and prescribing practitioner preferences, all dosages were converted to equipotent values in mg of intravenous Morphine Sulphate (MS) using standardized opioid conversion formulae. The dose of intraoperative opioid administered was recorded for each patient.

Postoperative popliteal sciatic nerve blockade by the lateral approach at a point 10 cm proximal to the popliteal crease was performed in the Post Anesthesia Care Unit (PACU) by nurse anesthetists supervised by regional anesthesia physician faculty with added expertise in ultrasound guided imaging. All procedures were performed with two supervising faculty attending present and local anesthetic was injected when the observers were in concordance with the nerve stimulator or ultrasound image findings. All patients were administered

Table 1. Harborview Medical Center lower extremity specific regional anesthesia instructional curriculum for resident physicians, nurse anesthetists and pain fellowship trainees

Curricular Intervention
Regional anesthesia related didactic lectures (Year - long)
Half-day cadaver based regional anesthesia anatomical review workshop
Half-day ultrasound phantom and live model based training workshop
Half-day intensive regional anesthesia review didactic workshop
Half-day Advanced Pain Life Support (APLS) emergency and complications simulator workshop

25 ml 0.375% (93.7 mg) bupivacaine for the SNB using a Life-Tech ProBloc II 20 Gauge 100 mm 30 degree bevel needle. The procedure was performed in the first 18 months of the study with the use a Life-Tech Tracer III nerve stimulator (NS) and the dose of local anesthetic was injected when toe plantar flexion was observed at a current of less than 0.6 mA. In the second 18 month interval the procedure was performed under ultrasound (US) guidance using a SonoSite M Turbo with a linear 38mm probe to locate the sciatic nerve in the short axis view proximal to its branch point. Local anesthetic was administered when the needle tip was visualized within the paraneural space and after injection of normal saline demonstrated circumferential spread around the sciatic nerve and both of its branches or the "donut effect" of the distribution of the solution.

The patient self-reported pain level using a standard institution wide 10 point pain score scale was recorded by the Post Anesthesia Care Unit (PACU) registered nurse at time of discharge from the PACU and by the floor RN at 24 hours after sciatic nerve blockade. Observation of toe plantar flexion and the total postoperative opioid dose at the time of discharge from the PACU and 24 hours postoperatively were also recorded. All opioid doses were converted to mg of intravenous MS using a standardized conversion formula.

3. RESULTS

During a study period of 36 months 22 nurse anesthetists administered SNB to 48 enrolled patients. Preoperative demographic data for the patients included age, American Society of Anesthesiologists (ASA) physical status, gender, body mass index (BMI) and if applicable preoperative opioid doses in mg of intravenous MS and these re summarized in Table 2. Table 2 summarizes the mean intraoperative and postoperative opioid doses and the postoperative pain score at 1 hour and at 24 hours after placement of the SNB. Voluntary motor activity of foot motion was present in all patients administered SNB.

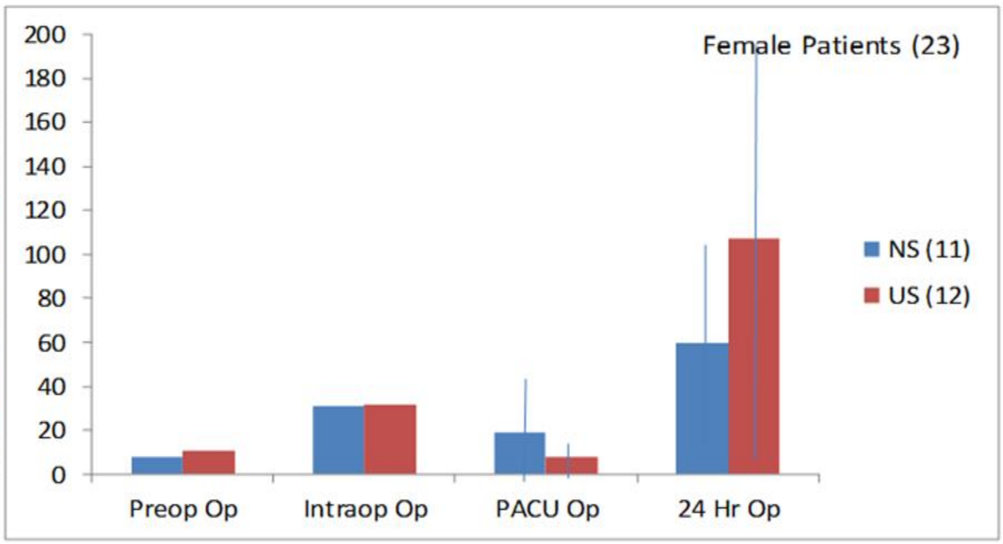
Table 2. Patient demographics and perioperative pain scores and opioid doses following sciatic nerve blockade performed by 22 nurse anesthetists (CRNAs) in 48 patients

	Nerve stimulator	Ultrasound guided
	Female	
CRNAs performing SNB	10	9
Patients (n)	11	12
Age	55.27 (15.22)	48.83 (15.3)
ASA status	2 (1)	2 (1)
BMI	26.33 (3.72)	26.42 (4.56)
Preoperative pain score	4 (3)	6 (4)
Preoperative opioids	7.73 (16.03)	10.5 (13.43)
Intraoperative opioids	31.03 (13.98)	31.43 (16.47)
1 hour discharge pain score	3 (3)	2 (3)
1 hour discharge opioids	19.32 (25.2)	8.05 (8.4)
	Male	
CRNAs performing SNB	7	9
Patients (n)	13	12
Age	53.23 (15.6)	48 (16.35)
ASA status	2 (1)	2 (1)
BMI	27.57 (3.33)	33.18 (18.36)
Preoperative pain score	4 (3)	5 (3)
Preoperative opioids	9.62 (22.59)	6.84 (11.57)
Intraoperative opioids	45.9 (23.6)	37.09 (17.11)
1 hour discharge pain score	1 (2)	2 (3)
1 hour discharge opioids	13.32 (22.14)	3.83 (7.49)
24 hour pain score	3 (2)	4 (3)
24 hour opioids	58.64 (43.91)	62.78 (62.73)

Arithmetic mean data are presented (SD), SNB = Sciatic Nerve Blockade, BMI = Body Mass Index, Opioid dose equivalents calculated as mg of intravenous morphine sulfate

The elective surgical procedures which the patients underwent are summarized in Table 3.

Perioperative opioid analgesic requirements are presented in Fig. 1. The demographic data for patient subgroups categorized for preoperative chronic maintenance opioid therapy as either opioid naïve (ON) or tolerant (OT) are summarized in Table 4. The mean perioperative pain scores and opioid dosage requirements for patients reporting preoperative chronic opioid use are illustrated in Figs. 2 and 3. Fig. 4 illustrates results for nurse anesthetists who were observed over the course of the study period with respect to mean pain scores as a function of repeat attempts at SNB by either NS or US guided techniques.



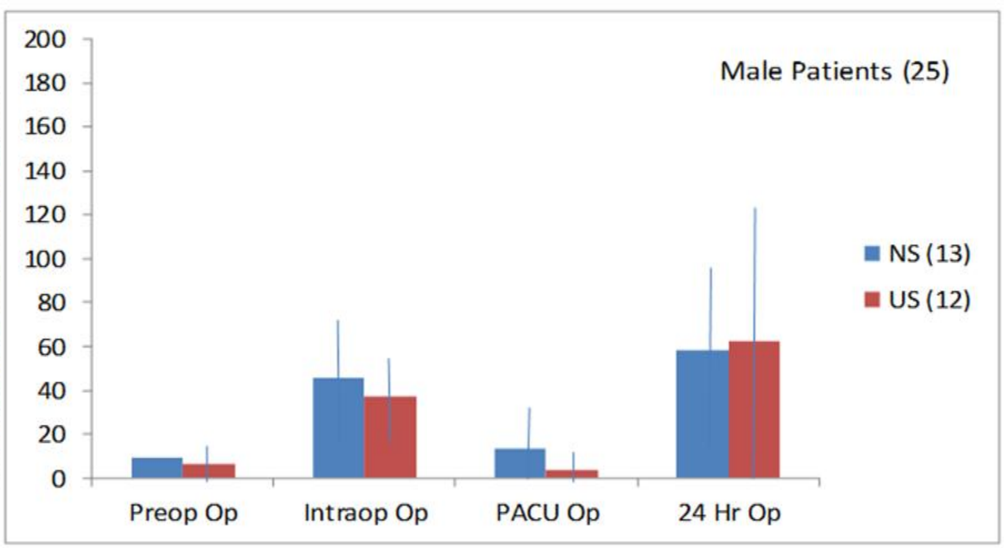


Fig. 1. Opioid (Op) requirements expressed as mg intravenous morphine sulphate in the 24 hour perioperative period for nurse anesthetist administered sciatic nerve blockade by nerve stimulator (NS) or ultrasound (US) guided technique in the preoperative (Preop), intraoperative (Intraop), immediate postoperative (PACU) and 24 hours after nerve blockade (24 Hr)

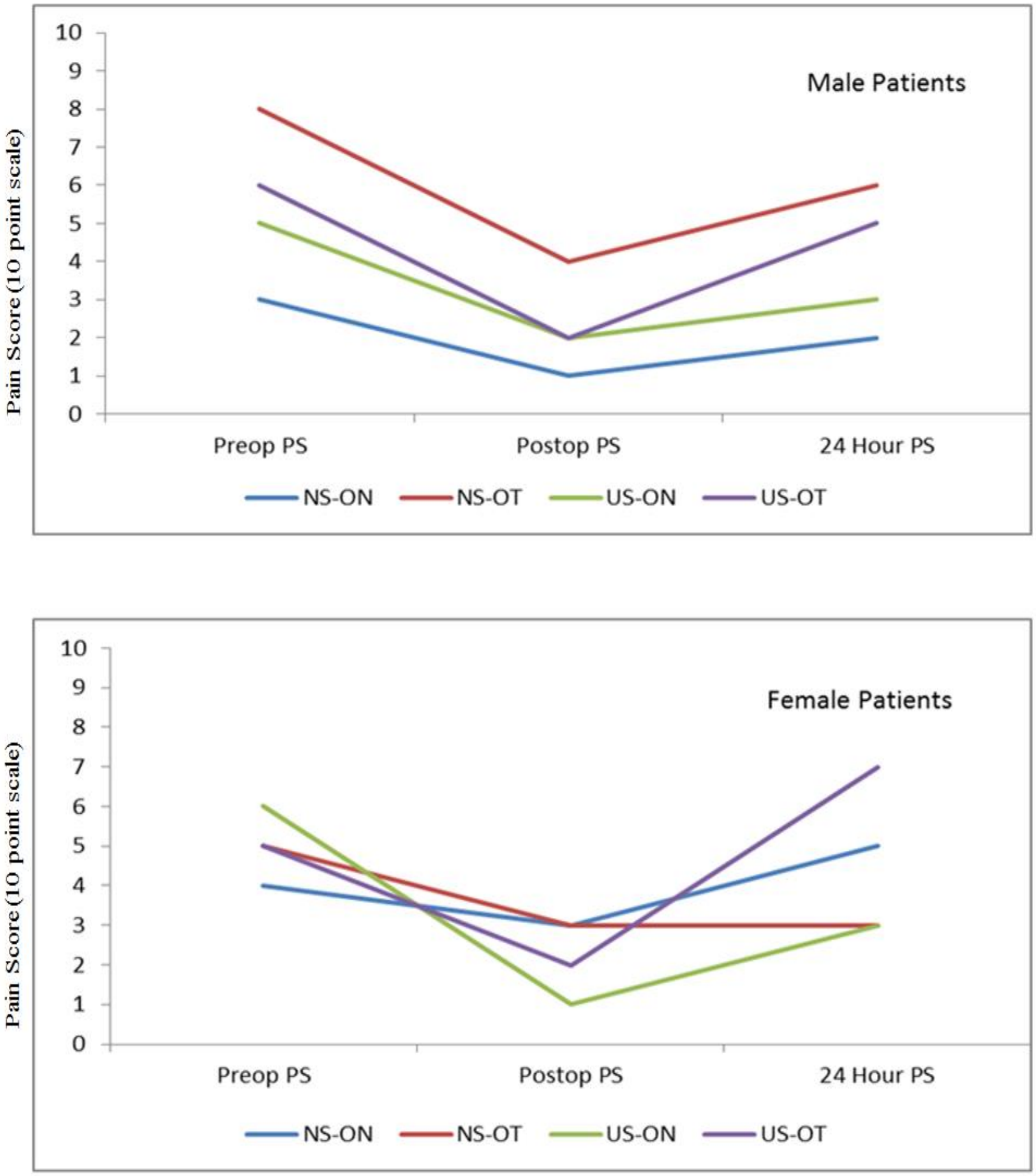


Fig. 2. Mean Perioperative Pain Scores (PS) for nurse anesthetist administered sciatic nerve blockade by nerve stimulator (NS) and ultrasound (US) guidance in patients that were opioid naïve (ON) and tolerant (OT)

Preop PS – immediate preoperative pain score. Postop PS – one hour after SNB administration.
24 Hour PS – highest patient reported pain score at 24 hours following SNB administration

4. DISCUSSION

In all patient categories and procedure groups the demographic characteristics were similar for gender, age, ASA physical status, BMI and intraoperative opioid doses. Patients that were administered either NS or US guided SNB demonstrated no significant preoperative differences between these groups. All groups were subdivided by sexual characteristics because gender based differences in pain perception is a recognized phenomenon [16]. The mean pain scores for opioid naïve and tolerant female patients were higher than the values calculated for males at the time of PACU discharge and at 24 hours. The mean morphine equivalent analgesic requirements for opioid naïve and tolerant females were higher in the recovery room interval and at 24 hours than the same dosages measured for males. The mean total intraoperative opioid dosage administered to females in all groups was lower than those calculated for all male patient groups. The absence of a standardized dosage protocol for intraoperative opioid administration makes these observed gender differences in pain medication requirements difficult to interpret. Female patients required lower intraoperative opioid analgesic dosages and higher levels in PACU but the opposite observation was made in male patients. Male patients had a higher mean BMI in all categories and when measured on a body weight basis the gender differences in intraoperative opioid analgesic requirements are reduced.

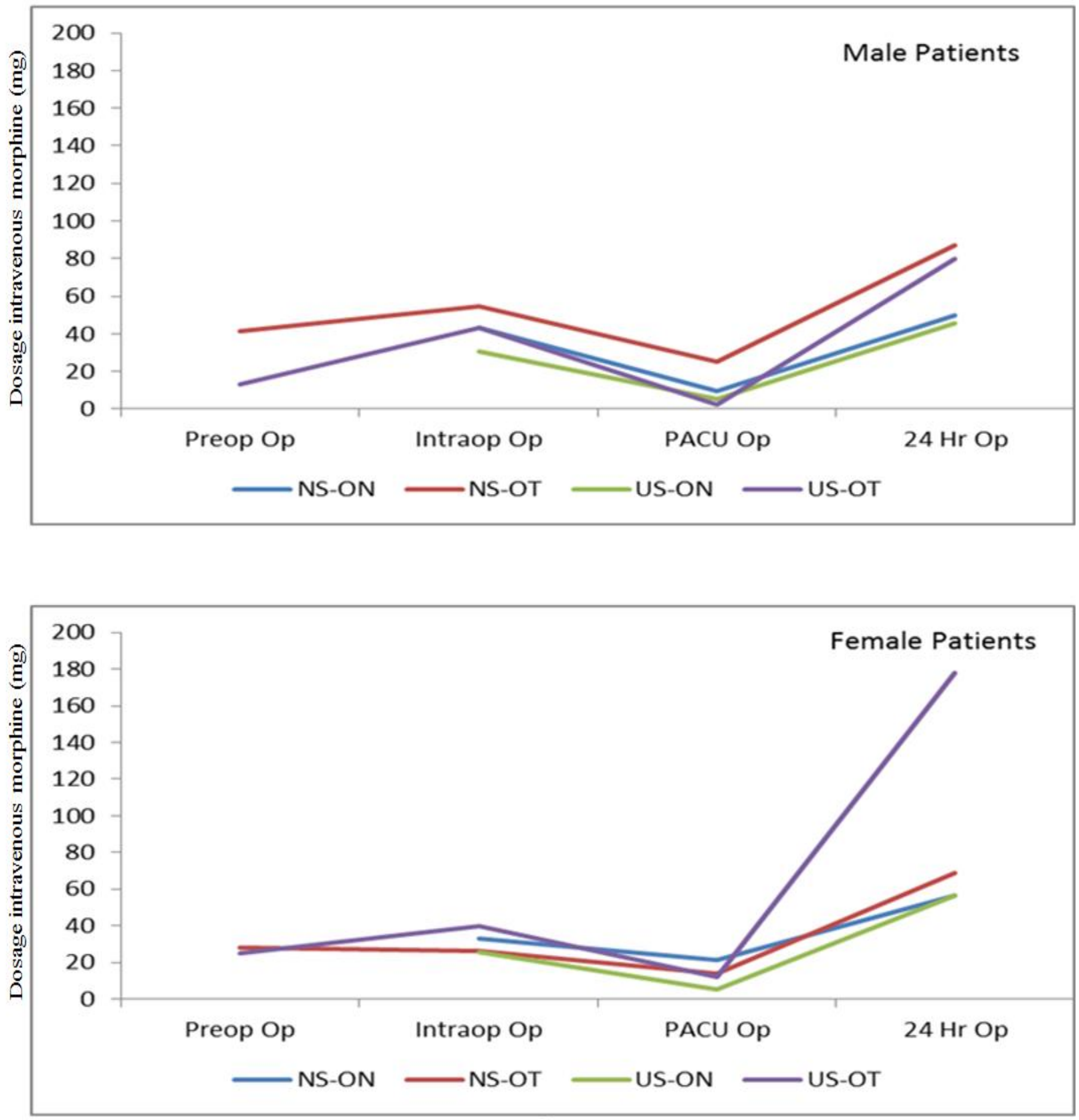


Fig. 3. Mean perioperative opioid doses in mg intravenous morphine sulphate for nurse anesthetist administered SNB by nerve stimulator (NS) or ultrasound (US) guided technique in patients that were opioid naïve (ON) and tolerant (OT)

Preop – preoperative. Intraop – Intraoperative. PACU – immediate postoperative.
24 Hr – total cumulative dose 24 hours after sciatic nerve blockade

There were no statistically significant demonstrable differences in the postoperative pain scores between the NS and US groups but mean pain scores trended lower in the latter cohort. Improved pain control associated with the use of US guided SNB compared to NS techniques, and specifically the location of injection near the sciatic nerve branch point and spatial distribution of local anesthetic around the nerves upon injection, have been previously reported [17-19].

Levels of electrical current used during nerve stimulator guided SNB that are associated with successful analgesic results are those that cause toe plantar flexion or foot inversion at less than 0.6 mA [20]. Current levels less than 0.3 mA that elicit the same twitch response increase the risk of nerve injury because the needle tip may be within the sciatic nerve or one of its branches [21]. In this study the current levels that were considered acceptable for effective NS guided SNB were within the clinically effective range of less than 0.6 mA and greater than the injury range of 0.3 mA.

Table 3. Surgical procedures performed on patients receiving sciatic nerve blockade

Procedure type	Number (%)
Total ankle arthroplasty	6 (12.5)
Open fracture reduction	20 (41.7)
Foot osteotomy	12 (25)
Talar fusion	8 (16.7)
Multi tendon transfer	2 (4.1)
Total	48 (100)

Local anesthetic injection within the paraneural compartment proximal to the sciatic nerve branch point during ultrasound guided SNB has been shown to be highly effective when compared to other injection sites and was selected as the universal needle localization point in this study [22]. This approach is possible using conventional ultrasound technology and poses a lower risk of nerve injury than the subparaneural or intraepineural injection technique that require high definition imaging processors not readily available in many centers [23].

Lower immediate PACU postoperative opioid dosage requirements for analgesia in the US groups were recorded when compared to the NS groups, which supports this reported finding, but pain scores were not significantly reduced. The comparison between patient groups that were administered either US or NS guided procedures demonstrated reduced postoperative opioid requirements for all US patient groups but the differences were not statistically significant. Small patient sample sizes prohibited statistical analysis but decreased postoperative opioid analgesic dosage requirements were observed in US guided SNB as demonstrated in Fig. 1.

The small sample sizes in some subcategories precluded statistical analysis of the data. Opioid tolerant patients reported higher pain scores and required higher opioid analgesic dosages in the observed perioperative period than opioid naïve patients. Patients with opioid tolerance are challenging with regards to achieving adequate postoperative analgesia even after having received a successful peripheral nerve block [24].

Similar patient subgroup analysis with respect to body mass index, acute lower extremity trauma and type of operative procedure did not demonstrate any marked differences in pain scores or perioperative analgesic opioid consumption.

Nurse anesthetists who were observed over the course of the study period demonstrated a reduction in mean pain scores with repeat attempts at SNB and these scores were lower for US as compared to NS guidance techniques. Data were available for 4 nurse anesthetists for each repeat attempt at SNB.

There were several methodological limitations to this study. The lack of randomization with regards to the use of either NS or US guidance technique employed for performing SNB is a source of selection bias in the results. Reduction in the variability in technical expertise among nurse anesthetists was addressed by the completion of a universal training protocol prior to the study period. The low number of patients enrolled and procedures performed, prohibit generalizations from these results to be made regarding procedural outcomes or level of operator proficiency.

Patient selection bias resulted from observations of a small sample of the total number of SNB performed by nurse anesthetists and is a study limitation. Lack of universal assessment of nurse anesthetist administered SNB success rates prevent any generalizations to be made concerning either clinical proficiency or regional anesthesia expertise. The small patient sample numbers in the opioid usage subgroup led to inferences that might impact clinical outcomes.

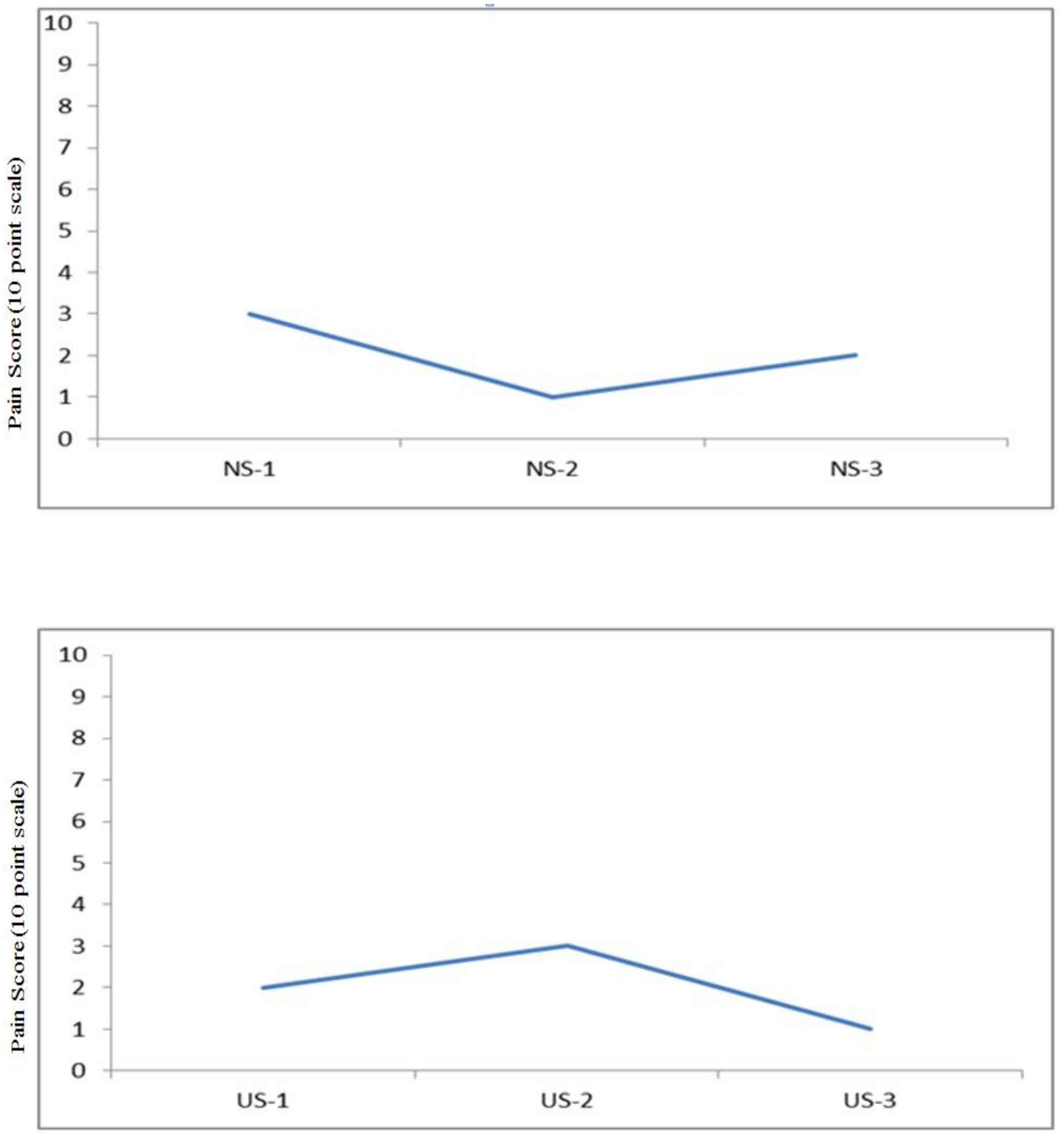


Fig. 4. Mean pain scores for nurse anesthetist administered SNB as a function of repetition of the procedure over time with the use of nerve stimulator (NS) and ultrasound (US) guidance

Vertical axis – pain score. Horizontal axis – sequential number of nerve block procedures

Small patient sample sizes and lack of practitioner randomization with respect to level of training and regional anesthesia technical expertise as drawbacks to global evaluation of procedural proficiency has been reported in prior assessments of these skills [8,25]. Small numbers of procedural observations on large numbers of trainees have been reported as a source of methodological bias [26]. Reduction of the bias effects of small sample size, nonrandom selection of practitioner and nerve block technique, and trainee cohort variability in training has been attempted by the employment of multiple standard observers and protocols [27].

Use of a discrete and finite numbering system such as the 10 point pain scale was not the ideal tool for measurement of pain levels and did not allow more accurate recording of pain related data as could have been possible with a continuous Visual Analog Scale (VAS). Pain is a subjective sensation and its perception is influenced by multiple patient and practitioner factors. Measurement of analgesia in order to objectively quantify outcomes of pain relieving procedures is a challenge.

Table 4. Demographics and perioperative pain scores and opioid dosages expressed in mg intravenous morphine sulphate for opioid naïve (ON) and opioid tolerant (OT) patients receiving nurse administered sciatic nerve blockade by either nerve stimulator (NS) or ultrasound (US) guided technique

	Opioid naive	Opioid tolerant	Opioid naïve	Opioid tolerant
Block technique:	**NS**	**NS**	**US**	**US**
female (n = 23)				
Number (n)	8	3	7	5
Age (yrs)	55 (16.2)	56	53.6 (18)	42.2 (7.9)
BMI	26 (3.94	27.3	27 (5.8)	25.6 (2.3)
ASA	2	2	3	2
Preoperative Pain Score	4 (3)	5	6 (3)	6 (5)
Preoperative Opioid Dose	0	28.3	0	25.2 (5.7)
Intraoperative Opioid Dose	32.9 (13.8)	26	25.4 (13.8)	39.9 (17.5)
1 Hour Pain Score	3 (3)	3	1 (2)	4 (2)
1 Hour Opioid Dose	21.3 (29)	14	5.3 (7.6)	12 (8.6)
24 Hour Pain Score	5 (2)	3	3 (3)	7 (2)
24 Hour Opioid Dose	56.2 (35.2)	69.1	56.7 (79.4)	178 (58.1)
Male (n = 25)				
Number (n)	10	3	6	6
Age (yrs)	54.1 (17.3)	50.3	49.8 (14.2)	48.2 (19.5)
BMI	27.7 (3.6)	27	39.8 (24.4)	25.6 (6.3)
ASA	2	2	2 (1)	2 (1)
Preoperative pain score	3 (3)	8	5 (3)	6 (3)
Preoperative opioid dose	0	41.7	0	13.7 (13.5)
Intraoperative opioid dose	43.3 (20.7)	54.4	30.9 (10.6)	43.3 (20.9)
1 hour pain score	1 (1)	4	2 (3)	2 (2)
1 hour opioid dose	9.8 (15)	25.1	5.2 (9.1)	2.4 (6)
24 hour pain score	2 (2)	6	3 (3)	6
24 hour opioid dose	50 (38.9)	87.4	45.6 (38.5)	80 (80.2)

Data expressed as mean (SD) where appropriate

5. CONCLUSION

Nurse anesthetist administered SNB demonstrated some improvement in immediate postoperative pain scores when US guidance was used in comparison to NS guided procedures. Study method limitations prevented assessment of regional anesthesia technical expertise among nurse anesthetists but a downward trend in mean pain scores was observed as SNB was repeated over time. Chronic opioid use and patient subjective pain quantification influence the desired clinical outcome of successful nerve blockade. Adequate analgesia is an important parameter for assessment of proficiency in regional anesthesia techniques and should be included in practitioner procedure logs [28]. Future studies need to address the limitations of this study which include the absence of standard intraoperative and postoperative opioid medication and dosage regimens and using the VAS continuum instead of the discrete pain score. Assessment and recording of pain control outcomes for all RA procedures throughout the practitioner's career, instead of sporadic and periodic technical performance evaluations, should be part of everyday clinical practice and provide individual and group feedback for improvement regarding this important clinical measure.

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ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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