

Continuous Versus Single-Injection Peripheral Nerve Blocks: A Prospective Cohort Study Comparing Procedural Time and Estimated Personnel Cost

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Abstract: *Background and Objectives:* Continuous peripheral nerve blocks (CPNB) provide many additional benefits compared to single-injection peripheral nerve blocks (SPNB). However, the time and costs associated with CPNB provision have not been previously considered. The objective of this study was to compare the time required and estimated personnel costs associated with CPNB and SPNB.

Methods: This IRB-exempt observational study involved provision of preoperative regional anesthesia procedures in a “block room” model by a dedicated team during routine clinical care. The primary outcome, the time to perform ultrasound-guided popliteal-sciatic blocks, was recorded prospectively. This time measurement was broken down into individual tasks: time to place monitors, prepare the equipment, scan and identify the target, perform the block, and clean up post-procedure. For peripheral nerve block catheters, time to insert, locate, and secure the catheter was also recorded. Cost estimates for physician time were determined using published national mean hourly wages.

Results: Time measurements were recorded for 24 nerve block procedures (12 CPNB and 12 SPNB). The median (IQR; range) total time (seconds) taken to perform blocks was 1132 (1083-1290; 1060-1623) for CPNB versus 505 (409-589; 368-635) for SPNB (Table 1; $p < 0.001$). The median (IQR) cost attributed to physician time during block performance was \$35.20 (\$33.66-\$40.11) and \$15.69 (\$12.73-\$18.32) for CPNB and SPNB, respectively.

Conclusions: CPNB requires approximately 10 more minutes per procedure to perform when compared to SPNB. This additional time should be considered along with potential patient benefits and available resources when developing a regional anesthesia and acute pain medicine service.

Keywords: Cost, Continuous Peripheral Nerve Block, Peripheral Nerve Block, Regional Anesthesia, Single-Injection Block, Time.

INTRODUCTION

Continuous peripheral nerve blocks (CPNB) provide many additional benefits compared to single-injection peripheral nerve blocks (SPNB) including prolonged analgesia, reduced opioid analgesic use, higher patient satisfaction, decreased time to meet discharge criteria for certain surgeries, and improved quality of recovery [1, 2]. While these benefits are well known, the time, additional resources, and associated costs associated with CPNB provision have not been extensively studied. Previous studies evaluating procedural time for CPNB have included needling time only and have not typically measured time required for set-up, catheter insertion, and catheter dressing [3-5];

elements that are crucial to the success of CPNB but require additional time. The potential for case delays remains an important consideration for orthopedic surgeons when deciding whether or not to recommend regional anesthesia to their patients [6]. For anesthesiology practices considering the use of CPNB, total procedural time and personnel costs associated must be taken into account in addition to downstream patient benefits when developing a staffing model for a regional anesthesiology and acute pain medicine service.

The objective of this study was to measure and compare the total procedural time associated with CPNB and SPNB. We hypothesized that CPNB will be associated with greater performance time. Procedural time differences between CPNB and SPNB would be utilized to estimate case delays and plan regional anesthesia services appropriately.

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METHODS

This observational study was deemed exempt by the IRB (Stanford University School of Medicine, Stanford, CA) since the performance of peripheral nerve blocks, single-injection and continuous, were part of routine clinical care, no patient clinical data were being collected, and the recording of procedural times had no potential for patient harm.

The procedural performance of ultrasound-guided popliteal-sciatic blocks, CPNB and SPNB, was prospectively observed during a 2-month period at a tertiary care academic hospital (Stanford University Medical Center, Stanford, CA). The blocks selected to be timed were done so consecutively when study personnel were available. Block selection was chosen as clinically indicated and as requested by the surgical team. All regional anesthesiology procedures were performed by a dedicated team that performs their blocks in the surgical admission unit prior to surgery ("block room" model) [7]. This team consisted of an experienced attending regional anesthesiologist and senior anesthesiology residents and fellows; all regional anesthesiology procedures were performed by trainees. Although the attendee who supervised all the procedures was the same, the residents and fellows who actually did the blocks varied. The regional anesthesia service performs many CPNBs, and personnel at our institution are very familiar with the both CPNB and SPNB techniques. All peripheral nerve blocks were performed with ultrasound alone (without electrical stimulation) using a short-axis, in-plane needle guidance technique. Each SPNB was performed with a 22 gauge insulated needles (Stimuplex[®], B. Braun Medical Inc., Bethlehem, PA). CPNB catheters (Arrow[®] StimuCath kit, Teleflex Inc., Research Triangle Park, NC) were inserted with ultrasonographic visualization after the initial local anesthetic bolus (20-30 ml mepivacaine 1.5% or ropivacaine 0.25-0.5%) was injected *via* the placement needle. CPNB catheters were secured with benzoin (PDI Inc., Orangeburg, NY), Steri-Strips (3M, St. Paul, MN), and OPSITE adhesive film (Smith and Nephew, Memphis, TN), and a perineural infusion of ropivacaine 0.2% (6-8 ml/hour) was initiated postoperatively using an elastomeric portable infusion device (On-Q[®] PainBuster[®], I-Flow/Kimberly-Clark, Lake Forest, CA).

The primary outcome was the total time required to perform the procedure (measured in seconds). The start time was defined as the time when standard American Society of Anesthesiologists (ASA) monitors were first being applied, and the end time was defined as the time when clean-up was complete after block performance. As secondary outcomes, the total procedural time was further broken down into individual tasks including time to place monitors, prepare the equipment, scan and identify target structures, perform the block (needling time), and clean up. For peripheral nerve catheters, the time to insert and locate the catheter with ultrasound, and secure the catheter was also recorded. Each step of each procedure was performed in the same order as per routine clinical practice and as directed by the one attending anesthesiologist. An independent observer not involved in the clinical care was responsible for recording all

procedural times and was present in the block area. The regional anesthesiology team was aware of the time measurement, and none of the personnel involved was blinded to the type of procedure. Data collection did not continue postoperatively.

An estimated cost of the physician's time when performing CPNB or SPNB was also determined. The Healthcare provider salary costs were derived from the 2012 national mean hourly wages of the US Bureau of Labor Statistics [8] (\$111.94/hour listed for an anesthesiologist).

Statistical Analysis

A convenience sample was utilized for this pilot observational study. Normality of distribution was determined using QQ plots and the Kolmogorov-Smirnov test. Non-parametric data results are reported as median and interquartile range (IQR). Mean point estimates with 95% confidence intervals of manpower costs are also presented. Procedural times and estimated physician costs between CPNB and SPNB were compared using the independent-sample Mann-Whitney U Test. A $p < 0.05$ was considered statistically-significant for the primary outcome (IBM SPSS for Windows statistical package Version 20, Armonk, NY). All secondary outcome results were considered suggestive and not conclusive [9].

RESULTS

Time measurements were recorded for 24 nerve block procedures (12 CPNB and 12 SPNB). The median (IQR; range) total time (seconds) taken to perform blocks was 1132 (1083-1290; 1060-1623) for CPNB versus 505 (409-589; 368-635) for SPNB (Fig. (1); $p < 0.001$). The times required

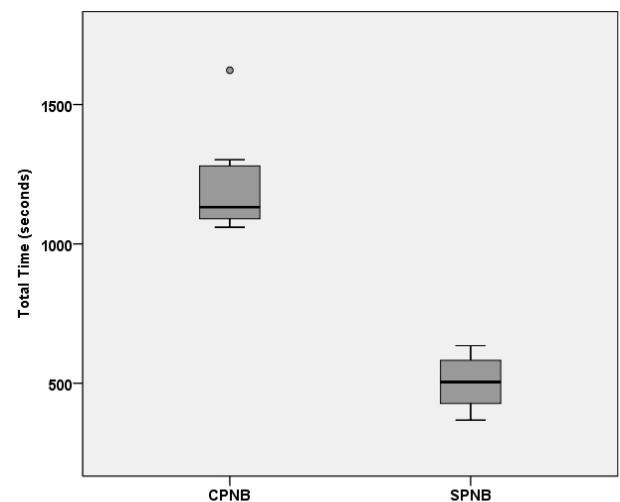


Fig. (1). Box plots showing the total time (seconds) taken to perform continuous peripheral nerve blocks (CPNB) versus single-injection peripheral nerve blocks (SPNB). The bold black horizontal line inside each box is the median, the height of the box represents the interquartile range, the whiskers extend to a distance of 1.5 times the interquartile range, and the circle represents an outlier. A $p < 0.001$ between block comparison obtained using independent-samples Mann-Whitney U Test.

to perform various tasks involved in nerve block placement (time to place standard ASA monitors, prepare the equipment, scan and identify the target structures, perform the block, insert and locate the catheter with ultrasound, secure the catheter and clean-up post-procedure) are shown in Table 1.

The median (IQR) cost attributed to physician time during block performance was \$35.20 (\$33.66-\$40.11) and \$15.69 (\$12.73-\$18.32) for CPNB and SPNB, respectively. The mean (95% confidence interval) personnel cost per CPNB based on additional time was \$21.39 (\$17.40-\$25.38; $p < 0.001$).

DISCUSSION

CPNB procedures require additional time to perform when compared to SPNB. The total procedural time per block, and not only needling time, should be considered when determining the appropriate staffing model and resource allocation for a regional anesthesiology and acute pain medicine service. The present study is the first to catalog the individual steps, and time required for each, when performing a peripheral nerve block. Preparing, locating and securing the catheter, and cleaning up after the block accounted for 55% of the additional time attributed to performing CPNB. While there is a potential increase in cost related to increased physician time to perform CPNB, this limited cost analysis did not evaluate cost-effectiveness or cost reductions associated with providing more effective analgesia with CPNB [10].

For CPNB, the additional 10 minutes of time per block and associated physician cost should be weighed against the potential downstream patient benefits (e.g., prolonged pain control, lower incidence of opioid-related side effects) compared to SPNB [1, 2]. Avoiding unplanned admissions for outpatients [11] and decreasing time to achieve discharge criteria [12, 13] have also been credited to CPNB and offer

potential cost savings to the hospital [10, 14]. However, the costs associated with assigning personnel to staff a regional anesthesiology and acute pain medicine service often come from the anesthesiology group while costs savings do not tend to benefit the group directly. It is important for anesthesiology groups to negotiate with the hospital for necessary resources when implementing services that have broader system benefits.

The procedural time difference may not be clinically relevant depending on the context. For example, practices that use a parallel processing model [15] with a team or practitioner dedicated to performing and managing a regional anesthesiology and acute pain medicine service (“block room”) may not be negatively affected by an additional 10 minutes of procedural time. In fact, a block room model may contribute positively to operating room efficiency in addition to the postoperative benefits of employing regional anesthesia techniques [16]. The increased time to perform CPNB compared to SPNB however could negatively impact operating room efficiency. If blocks are performed in a procedure room or the surgical admissions unit immediately prior to surgery, the additional time taken to perform the CPNB could delay patients being transferred to the operating room and therefore postpone the surgical start. The greatest impact on operating room efficiency would likely be seen when nerve blocks are done in the operating room with the surgical team present and waiting to start surgery. The extra 10 minutes to perform a CPNB would lead to a significant delay in this setting.

The study has a number of potential limitations. The primary aim of the study was to determine the time taken to perform the blocks, and secondarily to determine the personnel cost for the additional time calculated. For the cost analysis, we only examined the personnel cost savings, and did not do a cost-effective study. Costs of equipment and disposables were not included [17], and block efficacy and outcomes such as reduced readmissions, additional physician

Table 1. Timing breakdown for providing continuous peripheral nerve blocks (CPNB) versus single-injection peripheral nerve blocks (SPNB).

	CPNB	SPNB	P Value
Timed Events (seconds)			
Monitor Application	89 (62-111)	80 (69-95)	0.843
Preparation	302 (246-362)	71 (49-106)	<0.001
Scanning	163 (117-227)	141 (104-162)	0.266
Needling	180 (126-244)	179 (127-249)	1
Catheter Insertion	72 (53-86)	-	
Catheter Location	60 (39-131)	-	
Securing Catheter	174 (161-189)	-	
Cleanup	83 (57-126)	21 (18-26)	<0.001
Total Time (seconds)	1132 (1083-1290)	505 (409-589)	<0.001

Results presented as median (interquartile range). Time recorded in seconds. P values obtained using independent-samples Mann-Whitney U Test.

interventions, and analgesic requirements were not considered. To limit variations in timing heterogeneity, we only evaluated one nerve block site and limited personnel performing the procedure. We appreciate this may undermine the generalizability of our results. Timing will vary among different nerve blocks, with diverse clinical skills and practices [18], and with various regional anesthetic techniques and equipment [19]. The relative time difference (CPNB took on average 2.3 times longer than SPNB) between these techniques may be more generalizable than the absolute timing difference (additional 10 minutes of time per block). The study was also conducted at a single institution utilizing specific equipment and with residents performing the blocks. These characteristics may limit the study results in terms of the generalizability and applicability to other centers. The study focused on the procedure time and we did not look at time saving logistics e.g. early versus in-room block placement, procedure room compared to operating room setting.

In conclusion, CPNB is associated with an increased time to perform of approximately 10 minutes per block when compared to SPNB. The increased time associated with CPNB should be considered when planning or streamlining a regional anesthesia service. The additional time and cost per block with CPNB must however be balanced with all the potential patient benefits that CPNB offers compared to SPNB.

AUTHOR CONTRIBUTION

1. Author: Brendan Carvalho MBBCh, FRCA
 - a. Contribution: designed study, analyzed results, wrote initial draft and edited final manuscript.
 - b. Attestation: All authors have reviewed and approved the final manuscript.
2. Author: Romy Yun, M.D.
 - a. Contribution: helped design study, primary person conducting study and collecting data, helped edit manuscript
 - b. Attestation: All authors have reviewed and approved the final manuscript.
3. Edward R. Mariano, M.D., M.A.S.
 - a. Contribution: consulted on study design, gave analysis input, extensively edited manuscript
 - b. Attestation: All authors have reviewed and approved the final manuscript.

CONFLICT OF INTEREST AND FINANCIAL DISCLOSURES

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These companies had absolutely no input into any aspect of the present study conceptualization, design, and implementation; data collection, analysis and interpretation; or manuscript preparation. None of the other authors has any personal financial interests to disclose.

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