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SHORT COMMUNICATION

Choice of loco-regional anesthetic technique affects operating room efficiency for carpal tunnel release

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Abstract Intravenous regional anesthesia (Bier block) is indicated for minor procedures such as carpal tunnel release but must be performed in the operating room. We hypothesize that preoperative peripheral nerve blocks decrease anesthesia-controlled time compared to Bier block for carpal tunnel release. With IRB approval, we reviewed surgical case data from a tertiary care university hospital outpatient surgery center for 1 year. Unilateral carpal tunnel release cases were grouped by anesthetic technique: (1) preoperative nerve blocks, or (2) Bier block. The primary outcome was anesthesia-controlled time (minutes). Secondary outcomes included surgical time and time for nerve block performance in minutes, when applicable. Eighty-nine cases met criteria for analysis (40 nerve block and 49 Bier block). Anesthesia-controlled time [median (10th–90th percentiles)] was shorter for the nerve block group compared to Bier block [11 (6–18) vs. 13 (9–20) min, respectively; $p = 0.02$). Surgical time was also shorter for the nerve block group vs. the Bier block group [13 (8–21) and 17 (10–29) min, respectively; $p < 0.01$), but nerve blocks took 10 (5–28) min to perform. Ultrasound-guided nerve blocks performed preoperatively reduce anesthesia-controlled time compared to Bier block and may be a useful anesthetic modality in some practice environments.

Keywords Ultrasound · Anesthesia · Conduction · Nerve block · Bier block · Operating room efficiency

Peripheral nerve block (PNB) techniques in the ambulatory setting provide selective anesthesia and postoperative analgesia for upper extremity surgery [1, 2], and use of a block room may improve operating room (OR) efficiency compared to general anesthesia by decreasing anesthesia-controlled time (ACT) [3, 4]. Intravenous regional anesthesia (IVRA) also known as Bier block is indicated for minor surgical procedures such as carpal tunnel release [5] and typically performed in the OR; yet, PNB may have advantages over IVRA in terms of intraoperative cardiovascular stability and decreased time to achieve discharge eligibility [6]. Recently, distal PNB techniques with ultrasound have been described [7–9] which may further improve procedural efficiency [10]. The effect, if any, of preoperative PNB compared to IVRA on ACT for minor surgery is unknown. We designed this study to test the hypothesis that preoperative US-guided PNB decreases ACT compared to IVRA for outpatient carpal tunnel release.

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With Institutional Review Board approval (University of California, San Diego School of Medicine; San Diego, CA, USA), primary open unilateral carpal tunnel release cases were identified from the operating room scheduling and regional anesthesia databases of a tertiary care university ambulatory surgery center for a 1 year period. Cases involving multiple surgical procedures or general anesthesia were excluded. Choice of anesthetic technique was determined by the operating room and regional anesthesiologists according to routine clinical practice; cases performed under monitored anesthesia care were divided into one of two categories depending on the regional anesthesia technique: (1) PNB; or (2) IVRA (Bier block).

Peripheral nerve block group All PNB procedures (ultrasound-guided median and/or ulnar nerve blocks) were performed preoperatively in a dedicated "block room" by senior residents or fellows under the direct one-on-one supervision of an attending regional anesthesiologist [3, 4]. After sterile skin preparation with chlorhexidine gluconate (ChloraPrep One-Step, CareFusion, Leawood, KS, USA) and local anesthetic skin infiltration with 1 % lidocaine, a 22 gauge B-bevel block needle was guided in-plane lateral to medial using a linear 6–13 MHz ultrasound transducer (HFL38, SonoSite M-Turbo, Bothell, WA, USA) to deposit 5–10 ml of plain 1.5 % mepivacaine around the median nerve visualized in short axis at the mid-forearm [7]. In similar fashion, ultrasound-guided ulnar nerve block at the mid-forearm was performed using an in-plane needle guidance technique with 5–10 ml of 1.5 % mepivacaine [7].

Bier block group For patients undergoing IVRA (Bier block), a 22 gauge angiocatheter was inserted into a peripheral vein in the distal operative extremity preoperatively in addition to an angiocatheter placed in the contralateral arm for intravenous fluid and medication administration. In the operating room, patients were positioned supine with the operative arm abducted 90° at the shoulder with the hand pronated and resting on a hand table. The operative limb was elevated with a double tourniquet applied to the upper arm; then the limb was exsanguinated with the aid of an Esmarch bandage. The distal tourniquet was inflated, followed by the proximal tourniquet to 250 or 100 mmHg over the patient's systolic blood pressure; then the distal tourniquet was deflated. An injection of 40 ml of 0.5 % lidocaine was given via the angiocatheter into the operative extremity prior to angiocatheter removal.

ACT in minutes was the primary outcome in this study. Within one case, ACT was defined as patient in-room to induction complete (anesthesia ready) plus surgical closure to out-of-room [11]. Secondary outcomes included surgical time (surgical incision to surgical closure) in minutes, time for PNB performance in minutes when applicable; demographic and procedural information collected were limited to the databases employed.

Normality of distribution was determined using the Kolmogorov–Smirnov test (NCSS-PASS Statistical Software, Kaysville, UT, USA). For continuous normally distributed data, Student's t test was used for statistical analysis; the Mann–Whitney U test was used for data with distributions other than normal. Categorical variables were compared using the Z test or Barnard's exact test ($n < 5$ for any cell). Statistical significance was accepted when $p < 0.05$.

Over the 1 year study period, 198 carpal tunnel release cases were performed. After applying exclusion criteria, 89 cases involving 73 patients met criteria for analysis. Sixteen patients had both left and right carpal tunnel surgeries performed on separate dates within the year. Forty cases employed preoperatively placed, ultrasound-guided PNB, and 49 cases employed IVRA administered in the OR. None of the cases were performed under local anesthesia alone.

Demographic and procedural data are shown in Table 1. Patients in the PNB group were, on average, older than patients in the IVRA group although ASA physical status was similar between groups (Table 1). Both ACT and surgical duration were longer for the IVRA group (Table 2). Ultrasound guided PNB procedures took a median of 10 (5–28) min to perform using 20 (9–20) ml of local anesthetic volume. There were no reported intraoperative conversions to general anesthesia or postoperative complications related to regional anesthesia procedures.

Ultrasound-guided PNB techniques performed preoperatively reduce ACT for carpal tunnel release surgery

Table 1 Patient variables

	IV regional anesthesia ($n = 49$)	Peripheral nerve blocks ($n = 40$)	p value
Age (years)	56 (41–71)	64 (53–81)	<0.01
Male/female (n)	14/35	11/29	0.91
ASA physical status	2 (2–3)	2 (2–3)	>0.99
Open/endoscopic (n)	47/2	37/3	0.49

Values are reported as median (10th–90th percentiles) or number of subjects (n), as appropriate

ASA American Society of Anesthesiologists

Table 2 Anesthesia-controlled time (ACT) and surgical duration

	IV regional anesthesia ($n = 49$)	Peripheral nerve blocks ($n = 40$)	p value
ACT (min)	13 (9–20)	11 (6–18)	0.02
Surgery time (min)	17 (10–29)	13 (8–21)	<0.01

Values are reported as median (10th–90th percentiles)

compared to IVRA administered in the operating room. Previous studies have shown that RA performed in a "block room" decreases ACT compared to general anesthesia for major upper extremity surgery [3, 4] through a parallel-processing model. The subsequent patient undergoes the PNB procedure while the previously scheduled patient is still in the operating room. Preoperative PNB for carpal tunnel release surgery has been described [12–15], but the present study is the first to examine the effects of preoperative PNB on ACT for minor hand surgery compared to a common intraoperative RA technique such as IVRA. The median reduction in ACT of 2 min is statistically significant, but the clinical significance is yet to be determined. Since routine practice in this outpatient surgery center includes insertion of the IVRA angiocatheter preoperatively, we speculate that a greater difference in ACT may have resulted if these additional angiocatheters were inserted in the OR instead. Turnover time, the time beginning when the previous patient leaves the OR and ending when the next patient enters the OR, is unaffected by anesthetic technique, leaving ACT as the only OR time interval contributing to OR efficiency directly influenced by choice of anesthesia [3]. Using computer modeling, Dexter and colleagues have shown that even complete elimination of ACT fails to facilitate the addition of surgical cases [16]. Therefore, decreasing ACT, and even surgical time as in the present study, is unlikely to result in more surgeries performed. However, perception of delays associated with regional anesthesia by surgeons remains a challenge [17], so perhaps modest reductions in ACT may have positive implications in systems-based practice.

The reduction in ACT in the present study depends on availability of a block room similar to the results of previous studies [3, 4], and the time required to perform PNB (median 10 min) negates any potential ACT advantage if these procedures were performed in the OR. A dedicated block room may not be appropriate or available in every practice [18], and any additional personnel required will increase costs which may or may not be offset by new revenue generated.

In the present study, surgical time is reduced by a median of 4 min when PNB is utilized compared to IVRA. It is possible that preoperative distal PNB for carpal tunnel release provides better surgical anesthesia and operating conditions, thus fewer interruptions for additional local anesthetic supplementation, than IVRA administered in the OR which has less time for local anesthetic diffusion. We can also speculate that the surgical field is less distorted with PNB since injections are performed further away from the surgical field. Unfortunately, the OR scheduling database does not include surgical case details such as need for local anesthetic supplementation by the surgeon and quality of operating conditions.

Serious complications from IVRA such as seizures from local anesthetic systemic toxicity, compartment syndrome, loss of limb, and death have been reported [19–22]. Therefore, IVRA is best performed in the hospital setting whereas distal PNB has been described for minor hand procedures including carpal tunnel release outside the OR [23, 24]. The use of IVRA is also limited by duration (<1 h) due to tourniquet pain, and it offers no postoperative analgesia [5]. The necessary minimum tourniquet time prior to cuff deflation to prevent high peak plasma levels of local anesthetic is not well-established, and waiting up to 30 min has been suggested [25], which may adversely affect OR efficiency for short cases.

Limitations of this study include the retrospective design and lack of randomization, both of which introduce potential selection bias. We suspect that this explains the difference in age between the PNB and IVRA groups since patient acuity as reflected by ASA physical status was the same. The results of the present study apply specifically to practices employing similar anesthetic and surgical techniques. Surgeons at the institution involved in this study have not routinely performed carpal tunnel release under local anesthesia although this approach is performed elsewhere [26].

In summary, based on the results of this retrospective cohort study, preoperative ultrasound-guided PNB is associated with decreased ACT and surgical time for carpal tunnel release compared to IVRA.

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Conflict of interest Dr. Mariano has received honoraria for educational programs conducted by SonoSite (Bothell, WA). This company 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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