SCIENTIFIC ARTICLE

Incidence of Failure of Continuous Peripheral Nerve Catheters for Postoperative Analgesia in Upper Extremity Surgery

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Purpose To explore the incidence of failure of continuous peripheral nerve blockade (CPNB) after upper extremity operations.

Methods Patient data regarding postoperative CPNB were retrospectively obtained from our institution's regional anesthesia database. Documented information on the first postoperative day included pain assessment ratings (numerical verbal pain scale, patient-reported breakthrough pain upon perceived return of sensation, appearance of the catheter site, complications, time of return of sensation, day of return of sensation, residual blockade, patient satisfaction with the block, and whether patient would receive the block again).

Results A total of 207 patients received CPNB for postoperative analgesia. The failure rate on the first postoperative day for infraclavicular (133 patients) and supraclavicular (58 patients) CPNB was 19% and 26%, respectively. Interscalene CPNB (16 patients) yielded 3 incidences of failure. No significant difference was found between supraclavicular and infraclavicular block techniques. In addition, no significant differences were found between the incidences of CPNB failures with potentially more painful surgeries involving bone compared with potentially less painful soft tissue procedures.

Conclusions The CPNB technique used for hand surgery postoperative analgesia was associated with nontrivial failure rates. The potential of CPNB failure and resulting breakthrough pain upon recovery from the primary nerve block is important to help establish patient expectations. *(J Hand Surg Am. 2014;39(2):324–329.*

Type of study/level of evidence Therapeutic IV.

Key words Analgesia, failure, indwelling pain catheter, postoperative pain.

Continuous peripheral nerve blockade (CPNB) for postoperative analgesia entails the percutaneous insertion of perineural catheters to bathe peripheral nerves with local anesthetic. The CPNB catheter is placed after a standard primary regional anesthetic block. Continuous peripheral nerve blockade markedly improves pain relief and reduces the need for opioid analgesics along with the risk of opioid-related side effects such as nausea, emesis, sedation, pruritus, respiratory depression, and

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Received for publication September 14, 2013; accepted in revised form November 4, 2013.

No benefits in any form have been received or will be received related directly or indirectly to the subject of this article.

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0363-5023/14/3902-0017$36.00/0
http://dx.doi.org/10.1016/j.jhsa.2013.11.011

substance dependence.[1,2] However, additional oral or intravenous pain management is mandatory with pain catheters in the event of catheter failure or breakthrough pain. Perineural catheters with attached infusion devices allow for the continuous infusion of local anesthetic in the ambulatory setting and facilitate prolonged postoperative pain relief.[3–6]

Variable success rates for this analgesic approach have been reported.[3,7,8] Secondary block (infusion) failure is defined as a lack of sensory changes to touch from baseline over the distribution of nerve blockade, as assessed by physical examination.[3,7,8] Grant et al[7] presented a prospective study of 228 patients in which 90% of patients had a functional and patent catheter at 24 hours after surgery. Ilfeld et al[3] reported a catheter failure rate of 20% among a 25-patient cohort. In addition, Klein et al[8] reported a catheter failure rate of 14% in a 40-patient cohort after 24 hours. Many of these studies were limited by their sample size and did not compare different catheter placement sites for failure incidence. These reported failure rates were also within the confines of prospective, randomized, controlled trials and do not reflect real clinical practice with self-reported pain control as the primary outcome measure.

At our institution, patients are instructed to use the CPNB infusion as pain management for 48 to 72 hours after surgery. They are also provided with oral opioids and advised to use them as needed. Failure of CPNB before the end of the treatment period is a concern, because patients may expect pain-free recovery. Unexpected return of pain may result in patients presenting to the emergency department or contacting the physician on call for assistance, and result in dissatisfaction and inconvenience regarding the postoperative analgesia. This study aimed to determine the failure rates of various CPNB for upper extremity orthopedic operations at a single academic institution. The primary outcome measure of this study was secondary block failure, defined as patient-reported breakthrough pain upon return of sensation on the first day after surgery. The secondary outcome measures were comparative block failure rates, pain scores at rest and activity, and adverse events associated with CPNB.

MATERIALS AND METHODS

Our institutional review board approved the protocol for this study. Information used was recorded prospectively in our institution's regional anesthesia database for clinical informatics over a 30-month period (February 2010 to October 2012). The data were retrospectively reviewed for all patients who underwent upper extremity orthopedic surgery at our academic institution with a regional peripheral nerve block with subsequent postoperative analgesia provided by a CPNB catheter and infusion device.

Regional anesthesia was provided by a dedicated team (resident/fellow and attending) that generally followed the standard practice. Peripheral nerve blocks were performed with ultrasound guidance, and nerve catheter placement occurred with ultrasonographic visualization without nerve stimulation. The CPNB catheters (Arrow StimuCath kit; Teleflex Inc., Research Triangle Park, NC) were secured with Steri-Strips (3M, St. Paul, MN), benzoin (PDI, Inc., Orangeburg, NY), and OPSITE adhesive film (Smith and Nephew, Memphis, TN). Patients initially received a dose of local anesthetic sufficient to render the limb anesthetic for the surgical procedure. The CPNB was provided with either ropivacaine 0.2% or bupivacaine 0.2% (6–10 mL/h) administered via a perineural catheter and infusion delivery system (On-Q PainBuster; I-Flow LLC, Lake Forest, CA). There was no patient-controlled setting for the continuous infusion.

Patient data were recorded in the regional anesthesia database for quality assurance to measure functionality and efficacy of postoperative pain management. Documented information consisted of the date of the procedure, age of the patient, past history of chronic pain, time of nerve block administration, type of block performed, operative side, technique of guidance for catheter placement, name of surgeon, type of surgical procedure, and complications of block placement. Patients were contacted the day after surgery. We contacted ambulatory patients by telephone and evaluated inpatients directly. The information obtained included pain scores at rest and activity (numerical verbal pain scale: 0–10, where 0 = no pain and 10 = worst possible pain), patient-reported breakthrough pain upon perceived return of sensation (yes/no), appearance of the catheter site (clear, erythematous, leakage, or catheter out), complications (allergic reaction, hematoma, intravascular puncture, local anesthetic toxicity, paresthesias, pneumothorax, seizure, wrong site blocked, or Horner syndrome), time of return of sensation, day of return of sensation, residual nerve blockade (yes/no), patient satisfaction with the block (yes/no), and whether the patient would receive the block again (yes/no).

Inclusion criteria entailed patients who had undergone an upper extremity operation and subsequently received CPNB. Patients were excluded from the study if they had undergone lower extremity or abdominal surgery, or if follow-up data were incomplete (Fig. 1).

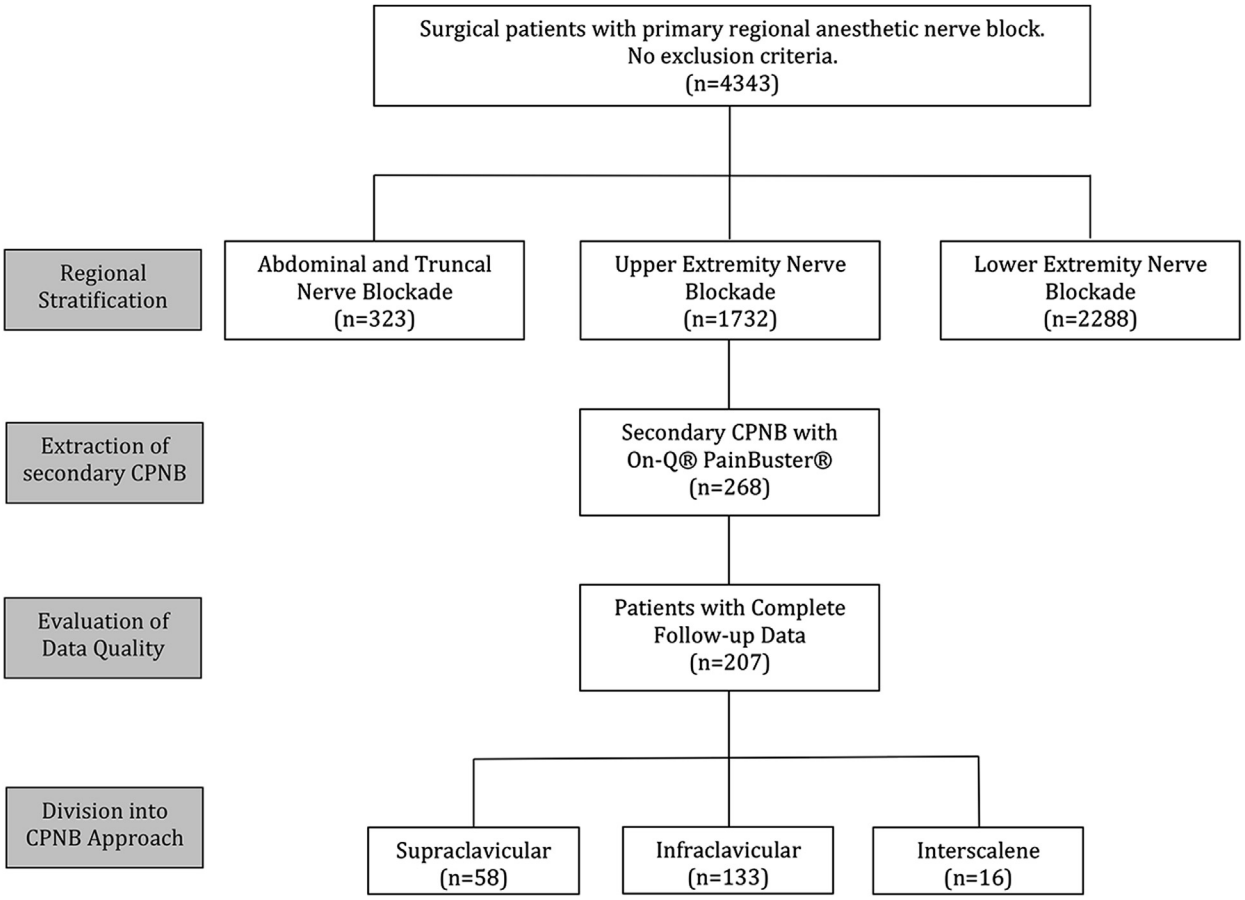

FIGURE 1: Data extraction and stratification.

Statistical methods

Descriptive statistics were used to characterize demographic, outcome, and adverse events data. Data are presented as mean ± standard deviation (SD) and number (percentages). The primary outcome of the study, block failure, was reported as an incidence (percentage). We compared CPNB failure rates via chi-square and Fisher exact test as appropriate. Confidence intervals (CI) were calculated at a confidence level of 95% via 2-proportion data analysis. Secondary outcome measures of interest including pain scores at rest and activity were compared using unpaired Student *t* tests with equal variance. All data were determined to be normally distributed using QQ plots and the Kolmogorov-Smirnov test. Statistical significance was set at $\alpha = .05$ with correction for multiple comparisons for secondary outcome measures.

RESULTS

The regional anesthesia clinical informatics database yielded information for 4,343 patients who received a primary regional anesthetic block. This information was extracted and further stratified to identify all patients who had received CPNB with an On-Q PainBuster infusion device for postoperative analgesia (Fig. 1).

A total of 207 patients underwent upper extremity surgery, with a mean (± SD) age of 51 ± 17 years (range, 11−86 y); they had received infraclavicular (133), supraclavicular (58), and interscalene (16) nerve blockade. Twenty-six of these patients maintained inpatient status for the first 24 hours, whereas the remaining 181 were ambulatory. Ten surgeons contributed patients to this group. Operative procedures performed included amputation, arthrodesis, arthroscopy, arthroplasty, biopsy, hardware removal, mass removal, open reduction internal fixation, osteotomy, and tendon repair of the upper extremity. One complication was identified in the group, an occurrence of intravascular puncture during catheter placement.

The block failure rate was 26% for supraclavicular block and 19% for infraclavicular block (Fisher exact test; $P = .334$; 95% CI, −6% to 20%). Among the 16 interscalene nerve blocks, there were 3 failures. In addition, no significant differences were found between the incidences of CPNB failure with potentially more painful surgeries involving bone (such as open

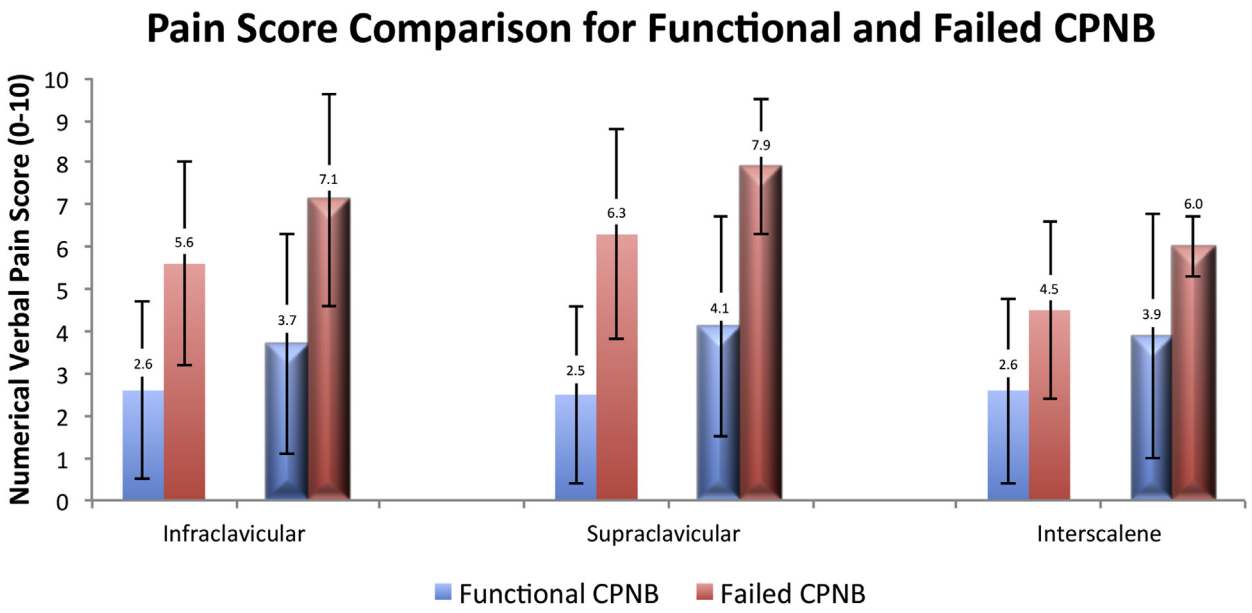

FIGURE 2: Upper extremity numerical verbal pain scale (0 = no pain and 10 = worst possible pain) at rest (flat bars) and with activity (3-dimensional bars) on postoperative day 1.

reduction internal fixation, osteotomy, and arthrodesis) compared with potentially less painful soft tissue procedures (such as arthroscopy, tendon repair, and mass removal) (Fisher exact test; $P = .208$; 95% CI, −18% to 3%). Figure 2 shows the mean (± SD) pain score for the nerve blocks as well as failed and working CPNBs. Comparisons of failed and functional CPNB were significantly different for pain assessment ratings at rest and activity (Student t test; $P < .001$). Patient satisfaction and the desire to have a block for future surgery was high, with no difference among the blocks (Table 1) ($P = .136$; 95% CI, −2% to 14%).

TABLE 1. Patient Satisfaction and Interest in Future Block Data

Location of Catheter	Satisfied Patients, %	Patients Who Would Receive Block Again, %
Infraclavicular	94	97
Supraclavicular	88	95
Interscalene	94	94

There was no statistically significant difference among blocks ($P > .05$).

DISCUSSION

Postoperative pain management is a critical aspect of surgical practice. Appropriate analgesia may dramatically improve the patient's experience and may also permit improved range of motion and accelerated progression in therapy and recovery. Functional CPNB has been shown to provide significantly better analgesia than opioid (parenteral and oral) for postoperative pain.[2] Opioid-related side effects such as nausea, emesis, pruritus, sedation, and respiratory depression may also be averted with CPNB.[2,4,7,9] In addition, 3% of patients exposed to chronic opioid use may develop long-term abuse, addition, or aberrant drug-related behavior, which may possibly be avoided by the use of CPNB.[10] Despite the numerous merits of CPNB, failure of the CPNB to adequately provide pain relief is a challenging circumstance for the patient, the surgeon, and the anesthesiologist. Consequently, it is important to establish realistic expectations for the patient before undergoing a surgical procedure, particularly with regard to the potential for failure.

This study found varying failure rates among different CPNB approaches. The incidence of failure for the supraclavicular approach was 26%, the highest among the blocks evaluated. The infraclavicular approach has been proposed to be a better approach for CPNB compared with a supraclavicular CPNB, because the approach may provide a more stable catheter placement and yields fewer block failures.[11] The catheter may be less likely to dislodge with patient movement when placed below rather than above the clavicle. The failure rates for upper extremity CPNB were 14%[8] and 20%[3] in prospective studies of 40 and 25 patients, respectively. Our findings correspond with the higher limit of this range. In contrast to protocol-specific sensory testing outcome

measures used in prospective studies, we relied on a clinically meaningful measure of patient-reported pain after perceived resolution of block.

A number of mechanisms of postoperative CPNB failure include the heterogeneous nature of catheter insertion techniques, anatomic variation, and equipment discrepancy. Catheters may also be incorrectly placed in relation to the target nerve(s) for adequate postoperative analgesia.[12] Catheter migration after correct placement is a possibility,[13] but it does not explain many block failures.[14,15] Other commonly reported causes of CPNB failure include dislodgement or obstruction of the catheter tubing[16,17] and fluid leakage at the catheter site.[5,17] Infusion pump malfunction or disconnection has also been described.[18–20] Catheter placement technique and patient handling instructions may be modified to reduce the incidence of dislodgement and leakage. Failure rates varied among the CPNB methods, which may be attributed to more stable anatomy of the block site, eliminating a greater range of motion that may place undue traction on the catheters, and subjecting the catheters to a higher risk of dislodgement. Another source of technical failure could be the genetic susceptibility of the patient, because single-nucleotide polymorphisms, small variations in the deoxyribonucleic acid sequence, have been implicated in local anesthetic metabolism.[21] Pain is a multifactorial entity that may be affected by psychological factors such as anxiety and pain-sensitive personality.[22]

As with all medical procedures, there are inherent risks in the placement of a CPNB. Rare but serious complications include myonecrosis with excessive bupivacaine,[23] systemic local anesthetic toxicity,[24–26] and prolonged Horner syndrome.[27] Peri-catheter hematoma formation and intravascular puncture are also reported.[28] The incidence of clinically relevant bacterial infection has been reported at 0% to 3%, without a consensus on whether the location of the nerve block affects the incidence.[9,15] Permanent neurologic injury is rare, with a documented 0.2% incidence of neurologic deficits lasting longer than 6 weeks.[29] Complications in our patient cohort included 1 case of intravascular puncture, which resolved without further intervention. There were no incidences of infection or permanent nerve injury.

This study has a number of limitations. There was a heterogeneous patient population with multiple surgeons and procedures. Although this may have introduced more variability, we wanted to assess the CPNB technique in a setting reflective of normal clinical practice. Patient data were available only at 1 time point, the first postoperative day. The CPNB catheter protocol allowed for 72 hours of administration, and we expected that there would be an even greater incidence of CPNB failure with increasing time from the operation. Although the retrospective analysis allowed for the review of data during routine clinical care, pain assessment was documented only at 1 point and did not provide serial measurements to determine the exact time of block failure. This study focused on patients' subjective perception of block success rather than a protocol-defined block success measure. We also relied on patient self-reporting of return of sensation and did not evaluate this with sensory testing. However, when considering the efficacy of these blocks, patient perception likely represents the most important clinical measure. There are variables that may affect the incidence of CPNB failure, including variations in the anesthesiology teams performing the block and catheter placement, different techniques to secure the catheter, various local anesthetic drugs and doses, and variable postoperative management protocols that are not controlled for. Despite some of these limitations, this large retrospective study provides data on CPNB failure rates during routine clinical care beyond small, prospective, well-controlled studies.

Continuous peripheral nerve blockade provides improved postoperative pain management, decreased opioid supplementation, decreased opioid-related side effects, and increased patient satisfaction. However, failure rates of up to 26% in this study present a noteworthy caveat to this technique. Therefore, it is important to establish appropriate patient expectations before surgery based on the potential of failure of CPNB followed by breakthrough pain upon recovery from the primary nerve block. The overwhelming majority of patients reported satisfaction with the CPNB and endorsed the desire to undergo future CPNB if presented with the opportunity. This suggests that even with early block failure, CPNB techniques were well received. Future studies could be directed at techniques to improve the effectiveness of CPNB and to limit failure.

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