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Neurologic Complications of 405 Consecutive Continuous Axillary Catheters

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Continuous axillary brachial plexus block may theoretically increase the risk of neurologic complications because of catheter-induced mechanical trauma or local anesthetic toxicity. In this study, we retrospectively reviewed the frequency of complications using current techniques and applications. There were 405 continuous axillary catheters in 368 patients. A preexisting neurologic condition was present in 41 (10.1%) patients, including 30 patients with a preoperative ulnar neuropathy. In 305 (75.3%) cases, the axillary catheter was placed to facilitate rehabilitation after major elbow surgery. Catheters were typically placed postoperatively, after documentation of the patient's normal neurologic examination. The local anesthetic infusion contained bupivacaine in 355 (88.7%) patients and mepivacaine in 45 (11.1%) patients. The mean infusion rate was 10 ± 2 mL/h. Catheters remained indwelling for 55 ± 32 h. In 31 patients, the axillary catheter was replaced because of technical problems or inadequate analgesia. There were 9 complications in 8 patients for an overall frequency of 2.2%. Complications included one each of the following: localized infection (treated with catheter removal and antibiotics), axillary hematoma, and retained catheter fragment requiring surgical excision. In addition, two patients reported signs and symptoms of systemic (preseizure) local anesthetic toxicity. Four (1.0%) patients reported new neurologic deficits postoperatively. In two patients, the neural dysfunction was non-anesthesia related. All four had continuous catheters placed after major elbow surgery. We conclude that the risk of neurologic complications associated with continuous axillary blockade is similar to that of single-dose techniques.

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Continuous axillary brachial plexus block is used in the perioperative management of patients undergoing complex upper-extremity procedures. Indications include major orthopedic surgery requiring early painful postoperative mobilization with continuous motion devices (1), postoperative sympathectomy in patients undergoing upper-extremity replantation procedures (2), and the diagnosis and treatment of chronic pain syndromes (3,4). In the majority of patients, brachial plexus catheters remain indwelling to provide sympathectomy or analgesia for 24–48 h (5,6). However, long-term applications using tunneled catheters have also been reported (3,4).

Initial descriptions of continuous techniques involved placement of a plastic or Teflon® catheter to provide intraoperative anesthesia. Catheters were typically removed upon completion of the surgical procedure. The success rate was less than that associated with single-dose techniques, often requiring supplementation with additional regional blocks or general anesthesia (7). However, recent advancements in needle and catheter technology have facilitated performance of continuous techniques and the ability to successfully maintain brachial plexus catheters. Despite increasing popularity, no large series has evaluated the risk of neurologic complications using current techniques and applications. In this study, we retrospectively reviewed the risk of complications after 405 consecutive continuous axillary catheters.

Methods

After IRB approval, the medical records of all patients receiving continuous axillary brachial plexus blockade at the Mayo Clinic from 1990 to 2000 were retrospectively reviewed. Demographic data including age, race, sex, weight, and height were recorded. Preexisting medical conditions such as diabetes mellitus, reflex sympathetic dystrophy (complex regional pain syndrome), or neurologic disorders (proximal neuropathy, mononeuropathy, or distal sensorimotor peripheral neuropathy) were also noted.

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The indication for catheter placement was categorized as postoperative elbow rehabilitation (acute pain management), replantation (sympathectomy), or chronic pain management (diagnostic or therapeutic). Timing of catheter placement was defined as preoperative, intraoperative (preincision under general anesthesia or postclosure under general anesthesia), or within the postanesthesia care unit. Surgical duration and the use of a tourniquet were recorded. The technique used to localize the brachial plexus (nerve stimulation or loss of resistance), elicited motor response during nerve stimulation, and the distance of catheter insertion were documented. The local anesthetic initial loading dose, addition of epinephrine, local anesthetic infusion, and time of catheter removal were recorded. Supplemental IV opioid use was also noted.

Daily neurologic assessments of the operative limb were routinely performed and recorded in the patient's hospital record by the primary surgical service. Postoperative complications including neurologic dysfunction (new or worsening of preexisting deficits), infection, and hematoma were noted. Neurologic complications were characterized with regard to symptomatology (pain, paresthesias, numbness, weakness) and nerve involvement. Subsequent outpatient and inpatient follow-up visits were reviewed to determine the duration of symptoms and degree of neurologic recovery. Data are reported as mean ± SD.

Results

There were 405 continuous axillary catheters in 368 patients (Table 1). Mean patient age was 39 ± 15 (range, 7–79) yr. There were 48 preexisting neurologic conditions in 41 patients. The most common preoperative neurologic diagnosis was ulnar neuropathy, which was present in 30 patients. In 305 (75.3%) patients, the axillary catheter was placed to facilitate rehabilitation and allow the use of continuous passive motion (CPM) after major elbow surgery. Other indications for catheter placement included the need for prolonged sympathectomy after digit replantation (20 patients, 4.9%) or treatment of a complex regional pain syndrome involving the upper extremity (18 patients, 4.4%). A tourniquet was used in 369 patients (91.1%), with a mean tourniquet inflation time of 89 ± 48 min.

Catheters were typically placed in the postanesthesia care unit, after documentation of the patient's normal neurologic examination. In only 78 (19.3%) patients, the axillary catheter was placed before the surgical incision and used intraoperatively. A stimulating needle was used to identify the brachial plexus in 362 (89.4%) patients. Catheters were advanced 10.6 ± 6.0 cm. Bupivacaine (0.125%–0.75%) or mepivacaine (0.5%–1.25%) was administered as an initial loading dose in 351 (86.7%) patients. The mean volume of the initial loading dose was 31 ± 12 mL. The local anesthetic infusion solution contained bupivacaine (0.125%–0.25%) in 355 (87.7%) patients and mepivacaine (0.5%–1.25%) in 45 (11.1%) patients. The mean infusion rate was 10 ± 2 mL/h. Mepivacaine solutions were used more often toward the end of the study period. In 31 (7.7%) patients, the axillary catheter was replaced one or more times because of technical problems or inadequate analgesia.

Table 1. Patient, Catheter, and Surgical Characteristics

Characteristic	*n*	(%)
Sex		
Men	244	60.2
Women	161	39.8
Preexisting conditions		
Diabetes mellitus	11	2.7
Reflex sympathetic dystrophy	30	7.4
Proximal neuropathy (C5-8 radiculopathy)	2	0.5
Peripheral neuropathy	2	0.5
Mononeuropathy	44	10.9
Surgical characteristics		
Indication for catheter		
Elbow rehabilitation	305	75.3
Replantation	20	4.9
Chronic pain syndrome	18	4.4
Other	62	15.3
Regional anesthetic technique		
Time of catheter placement		
Postoperative	327	80.7
Preoperative[a]	78	19.3
Technique		
Nerve stimulator	362	89.4
Loss of resistance	18	4.4
Other/unspecified	25	6.2
Paresthesia with catheter placement	60	14.8
Local anesthetic loading dose[b]		
Bupivacaine (0.125%–0.75%)	236	58.3
Mepivacaine (0.5%–1.25%)	115	28.4
Lidocaine (1%–2%)	40	9.9
2-Chloroprocaine	21	5.2
Epinephrine added to loading dose	217	53.6
Volume of loading dose (mL)	31 ± 12	
Catheter characteristics		
Local anesthetic infusion[c]		
Bupivacaine (0.125%–0.25%)	355	87.7
Mepivacaine (0.5%–1.25%)	45	11.1
Infusion rate (mL/h)	10 ± 2	
Catheter duration (h)	55 ± 31	
Catheter replaced (inadequate analgesia; technical problems)	31	7.7

[a] Includes 18 axillary catheters placed in nonsurgical patients for management of chronic pain condition.
[b] Some patients received a local anesthetic mixture in the loading-dose injection. Loading-dose local anesthetic and volume were reported in more than 95% of patients. The reported mean ± SD is for patients in which the loading dose and volume were known.
[c] Local anesthetic solution and infusion rate were reported in 99% of patients. The reported mean ± SD is for patients in which the solution and infusion rate were known.

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Table 2. Supplemental IV Opioid Requirements During Axillary Analgesia

	0–24 h		24–48 h		48–72 h	
Indication for catheter placement	Supplemental IV opioid required, *n* (%)	Morphine mg/h[a] for patients requiring supplemental IV opioid	Supplemental IV opioid required, *n* (%)	Morphine mg/h[a] for patients requiring supplemental IV opioid	Supplemental IV opioid required, *n* (%)	Morphine mg/h[a] for patients requiring supplemental IV opioid
Elbow rehabilitation, $n = 305$	189 (62%)	1.5 ± 1.2	153 (50%)	1.64 ± 1.3	61 (22%)	1.3 ± 1.1
Digit replantation, $n = 20$	7 (35%)	1.7 ± 1.4	9 (45%)	1.5 ± 1.2	5 (25%)	1.6 ± 0.5
Chronic pain syndrome, $n = 18$	5 (28%)	1.6 ± 1.5	5 (28%)	2.0 ± 1.6	3 (17%)	2.3 ± 1.1

[a] Reported as morphine equivalents for patients receiving meperidine.

Supplemental IV opioid analgesia was required in 189 (62%) patients undergoing elbow surgery, 7 (35%) patients undergoing digit replant, and 5 (28%) nonsurgical, chronic pain patients during the first 24 h after catheter placement. Twenty-seven of the 31 (87%) patients who required catheter replacement also required IV opioids. Supplemental opioid consumption, in morphine equivalents (mg/h), is reported in Table 2.

There were 9 complications in 8 patients, resulting in an overall frequency of 2.2%. Three patients experienced nonneurologic, catheter-related complications. One patient developed an axillary hematoma after catheter insertion. The hematoma resolved spontaneously and without sequelae. A second patient presented with persistent axillary pain several days after hospital dismissal. Subsequent evaluation demonstrated a 4-cm retained catheter fragment diagnosed by ultrasonography. The patient underwent surgical excision of the retained catheter fragment and recovered uneventfully. The third patient developed a local skin infection in the axilla after 48 h of axillary analgesia. Cultures were positive for *Staphylococcus aureus*. The catheter was removed and antibiotic therapy initiated. The patient fully recovered and suffered no permanent sequelae.

There were also five patients with neurologic complications (Table 3). Two patients developed signs and symptoms of systemic local anesthetic toxicity. In both patients, the episode was transient and did not proceed to overt seizure activity or cardiac dysrhythmias. Four patients reported new postoperative neurologic deficits. All had uneventful catheter placements without the elicitation of paresthesias and had undergone major elbow surgery with tourniquet inflation times ≤100 min. The deficits were diagnosed upon block resolution in two patients, and at the time of surgical follow-up in the remaining two patients. Symptoms consisted of pain/paresthesias in three patients, and profound numbness/weakness in another. In two of the four patients, the neurologic complication was non-anethesia related. Neurologic recovery was good in two patients, poor in the patient with profound sensorimotor deficits, and unknown in the remaining patient.

Discussion

Although the risk of neurologic complications from "single-dose" axillary block has been well established and ranges from 0.2% to 19% (8–11), the safety of continuous axillary catheter techniques is relatively unknown. Our series of 405 consecutive continuous axillary blocks is the first large series to examine the incidence of complications, including neurologic injury, associated with axillary catheters and their use for acute perioperative analgesia, as well as chronic pain management.

Theoretically, the risk of nerve injury may be increased during continuous regional techniques as a result of mechanical trauma or local anesthetic toxicity. Several laboratory and clinical investigations have previously sought to address the neurotoxic potential of sustained or repeated exposure to local anesthetics. In an animal model, Kytta et al. (12) noted disruption of myelin sheaths and myositis after either twice daily sciatic block or a 3-hour sciatic nerve infusion with 0.5% bupivacaine. Functional recovery, as assessed by depression of the amplitude of the sciatic nerve action potential, was not complete at three weeks.

However, there are no confirmatory human studies to support these laboratory findings. In the largest study involving axillary catheters for intraoperative anesthesia, Sada et al. (7) described 597 continuous axillary brachial plexus blocks performed for protracted surgical procedures using a 5-cm 23-gauge Teflon® IV catheter. Lidocaine 1.5% or mepivacaine 1.5% were used for the initial loading dose, with subsequent "top-up" injections consisting of bupivacaine 0.5%. Local anesthetic toxic reactions occurred in 17

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Table 3. Neurologic Complications

Age(yr)/ sex	Preexisting condition	Catheter indication	Tourniquet time (min)	Insertion technique	Local anesthetic (loading dose)	Local anesthetic (infusion)	Catheter duration	Comments
15/M	None	Humeral osteotomy and capsular release	75	Nerve stimulation; median nerve response	Bupivacaine 0.25% with epinephrine, 20 mL	Bupivacaine 0.125% at 14 mL/h; increased to bupivacaine 0.25% at 10 mL/h	5 days	Pressure sore on lateral wrist from compressive dressing POD #3. New superficial radial nerve numbness diagnosed on POD #6. Marked improvement at 4 wk.
48/M	Previous ulnar nerve transposition	Ulnar humeral arthroplasty and capsular release	80	Nerve stimulation; ulnar nerve response	Mepivacaine 1% with epinephrine, 40 mL	Mepivacaine 0.5% at 15 mL/h	48 h	New onset median and radial numbness with weakness diagnosed on POD #21. EMG confirmed severe neuropathies at the level of the elbow. Symptoms present at last follow-up at 4 mo.
32/F	None	Anterior capsular release (elbow)	29	Nerve stimulation	Unspecified	Bupivacaine 0.25% at 8 mL/h	48 h	New onset ulnar and median paresthesias diagnosed 1 mo postoperatively. Resolved after 7 wk.
25/F	None	Capsular release and ulnar nerve exploration	100	Nerve stimulation; radial nerve response	Mepivacaine 1%, 30 mL	Mepivacaine 1% at 14 mL/h; replaced because of inadequate analgesia POD #3	48 h	Preseizure activity on POD #1.
				Fluoroscopic guidance	Bupivacaine 0.25%, 10 mL	Bupivacaine 0.25% at 15 mL/h	72 h	New ulnar paresthesia diagnosed on POD #7, before discharge. No follow-up.
55/M	C5 radiculopathy	Digit Replantation	346	Loss of resistance	Bupivacaine 0.5%, 25 mL	Bupivacaine 0.25% at 12 mL/h	5 days	Perioral numbness and confusion on POD #5; symptoms resolved with catheter removal.

POD = Postoperative day, POD #1 = operative day, EMG = electromyelogram.

(2.9%) cases, whereas nerve injury was noted in 3 (0.5%) cases. There was one axillary hematoma in a heparinized patient which compromised circulation to the upper extremity. Unfortunately, the study did not involve conventional equipment, including needles and catheters manufactured specifically for continuous peripheral nerve block, or use the catheters to provide postoperative analgesia. Grant et al. (6) described 228 patients undergoing continuous peripheral nerve block, the majority of which were continuous interscalene techniques, for ambulatory surgical procedures. The catheters remained indwelling for only 24 hours, and were removed before patient dismissal. There were no neurologic complications.

The frequency of nerve injury during continuous brachial plexus block may also be compared with that of patients undergoing multiple (repeated) axillary blocks, as investigated by Horlocker et al. (13). A total of 1614 blocks were performed in 607 patients, including 188 patients who received multiple blocks within 1 week. The overall incidence of neurologic complications was 8.4%. However, only 11% of the nerve injuries were specifically related to the anesthetic technique, with the remaining 89% being a result of the surgical procedure. These clinical studies suggest that concerns for neurologic dysfunction in patients undergoing multiple single-dose or continuous techniques may be unfounded (13).

Patient, surgical, and anesthetic variables may all contribute to perioperative nerve injury. Although needle- or catheter-induced trauma and local anesthetic toxicity have been identified as anesthetic-related risk factors (14), the presence of preexisting neurologic deficits, perioperative positioning, tourniquet ischemia, and surgical traction may also increase

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the frequency and severity of postoperative nerve dysfunction (8,15–17). Four patients in our series of 405 blocks reported perioperative neurologic complications. In two of the four patients, the etiology of the nerve injury was non-anesthesia related. It is also likely that the late-occurring ulnar and median paresthesias in the third patient were the result of a surgical neuropraxia or continuing inflammatory response (Table 3). Similar results to these were noted by Hebl et al. (15) who reported a transient, subacute worsening of ulnar nerve function after ulnar nerve transposition. Overall, the frequency of neurologic complications may have been underestimated because of the retrospective nature of the study. However, because all patients underwent serial daily neurologic evaluations, it is unlikely that a significant neurologic deficit went undiagnosed.

Importantly, all patients with neurologic deficits had undergone major elbow surgery to restore joint range of motion, including osteocapsular arthroplasty and distraction interposition arthroplasty. Perioperative nerve injury, particularly to the ulnar nerve, occurs in up to 25%–30% of these patients (18,19). Postoperatively, the patients are placed in a CPM device for up to 24 hours a day to maintain joint mobility (1,18). Patients are able to tolerate this aggressive rehabilitation through a multimodal analgesic approach that relies on a functioning axillary catheter. The axillary catheters are placed postoperatively after documentation that the patient's neurologic status has remained unchanged from the preoperative examination. Clinicians must be aware of the risk of neuropraxia associated with these procedures, and follow the patient's neurologic function closely in the postoperative period. A balance between the density of the sensory block (patient comfort) and ability to assess neural integrity is imperative.

The efficacy of continuous axillary infusions is demonstrated by those patients of the 305 undergoing major elbow surgery who did not require IV opioid supplementation on the operative day (38%), and on the second postoperative day (50%) (Table 2). However, maintaining this level of analgesia is labor intensive. For example, 31 of the 405 (7.7%) catheters required replacement because of technical problems and/or inadequate analgesia. Presumably, the continuous movement of the upper extremity in the CPM device, as well as during physical therapy, results in catheter displacement.

In addition to four neuropraxias, our series noted five additional complications related to axillary catheter placement. There were two patients who reported preseizure signs and symptoms of local anesthetic toxicity with neither progressing to overt seizure activity or cardiac dysrhythmias. In 1 patient, 0.25% bupivacaine had been infused at a rate of 12 mL/h for 5 days. Scant data are available to determine the maximum local anesthetic dose over time administered with indwelling peripheral nerve catheters. Previous studies have evaluated infusion intervals of 24–48 hours (5,20). However, the overall frequency of systemic symptoms may be increased compared with that of single-dose axillary blocks. Brown et al. (21) reported 8 seizures after 6620 axillary blocks, for a seizure rate of 1.2/1000 procedures. Additional data are needed to allow the safe management of long-term catheters and extended local anesthetic infusions.

Our series also included a superficial axillary infection in a nonsurgical patient that was treated with antibiotics and catheter removal. The patient was being treated for reflex sympathetic dystrophy, and did *not* receive the usual two days of antibiotic therapy that is commonly administered to surgical patients. Interestingly, the risk of systemic or local infection at the catheter site seems to be extremely small in postoperative patients despite positive catheter tip cultures in up to 27% of patients (22). At present, there are no definitive recommendations regarding continuous catheter use and routine antibiotic prophylaxis. Finally, there was one patient with a retained catheter fragment. No description of the catheter's integrity, such as "catheter removed—tip intact," was noted at the time of catheter removal. Obviously, meticulous technique and clear documentation are critical to identify catheter breakage at the time of removal so that appropriate management and surveillance may be initiated.

In summary, the frequency of neurologic complications associated with continuous axillary catheter placement seems to be similar to that of single-dose techniques. However, the presence of an indwelling catheter and extended local anesthetic infusions may increase the risk of infection and/or systemic toxicity. As continuous peripheral nerve blocks expand in their popularity and application, large prospective studies will be necessary to determine the overall risks, benefits, and optimal management of these valuable regional techniques.

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