Neurologic Sequelae After Interscalene Brachial Plexus Block for Shoulder/Upper Arm Surgery: The Association of Patient, Anesthetic, and Surgical Factors to the Incidence and Clinical Course

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We determined the incidence, distribution, and resolution of neurologic sequelae and the association with anesthetic, surgical, and patient factors after single-injection interscalene block (ISB) using levobupivacaine 0.625% with epinephrine 1:200,000 in subjects undergoing shoulder or upper arm surgery, or both, in 693 consecutive adult patients. After a standardized ISB, assessments were made at 24 and 48 h and at 2 and 4 wk for anesthesia, hypesthesia, paresthesias, pain/dysesthesias, and motor weakness. Symptomatic patients were monitored until resolution. Subjects reporting pain or discomfort >3 of 10 and those with motor or extending sensory symptoms received diagnostic assessment. Six-hundred-sixty subjects completed 4 wk of follow-up. Fifty-eight neurologic sequelae were reported by 56 subjects. Symptoms were sensory except for two cases of motor weakness (lesions identified distant from the ISB site). Thirty-one sequelae with likely ISB association were reported by 29 subjects, including 14 at the ISB site, 9 at the distal phalanx of thumb/index finger, 7 involving the posterior auricular nerve, and 1 clinical brachial plexopathy. Sequelae not likely associated with the ISB were reported by 27 subjects with symptoms reported in the median ($n = 9$) and ulnar ($n = 4$) nerves, surgical neuropraxias ($n = 12$), and motor weakness ($n = 2$). Symptoms resolved spontaneously (median 4 wk; range, 2–16 wk) except in the two patients with motor weaknesses and the patient with clinical brachial plexopathy, who received therapeutic interventions. Variables identified as independent predictors of neurologic sequelae likely related to ISB were paresthesia at needle insertion and ISB site pain or bruising at 24 h. In contrast, surgery preformed in the sitting position, as well as ISB site bruising, was identified as a predictor of neurologic sequelae not likely related to ISB. In conclusion, neurologic sequelae after single-injection ISB using epinephrine mainly involve transient minor sensory symptoms.

(Anesth Analg 2005;100:1489–95)

Patient, surgical, and anesthetic risk factors may contribute to neurologic sequelae after shoulder and upper extremity surgery (1–3). In addition, underlying subclinical neuropathies such as those encountered in diabetes, other metabolic neuropathies, or proximal nerve root compression syndromes, such as cervical radiculopathy, may increase a given nerve's susceptibility to injury via a double-crush phenomenon (4–6).

Interscalene brachial plexus block (ISB) is an effective means of providing perioperative analgesia for shoulder and upper arm surgery. When a regional anesthesia technique such as an ISB is used for these procedures, neurologic injury may also result from traumatic, ischemic, or toxic insults related to the ISB (1,7–13). Although major neurologic sequelae or neuropathy after ISB are rare (14,15), a frequent but variable incidence of short- and long-term paresthesia, dysesthesia, or pain unrelated to surgery was reported after single-injection and continuous ISB using ropivacaine 0.6% without epinephrine (16,17).

Epinephrine is a commonly used adjunct to local anesthetics because of its potential to limit systemic toxicity by serving as a marker of intravascular injection and reducing peak plasma concentrations of local anesthetics. In animal models, topically applied epinephrine alone or in combination with lidocaine significantly reduced extrinsic (epineural) blood flow

Accepted for publication October 6, 2004.

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DOI: 10.1213/01.ANE.0000148696.11814.9F

0003-2999/05

(7,8). Theoretically, epinephrine added to local anesthetics for peripheral nerve blocks (PNB) may increase the risk of neurologic injury by producing neural ischemia. The incidence of short- and long-term neurologic sequelae associated with ISB using epinephrine-containing local anesthetics has not been previously examined in a large series of patients (16–18).

The purpose of this prospective observational study was to examine the incidence and evolution of neurologic sequelae after single-injection ISB using epinephrine-containing local anesthetics. Because anesthetic, patient, and surgical factors may contribute to neurologic injury, we examined data related to the block procedure, surgery, and demographic characteristics to determine the association among these factors and postoperative neurologic sequelae.

Methods

After IRB approval and written informed consent, during an uninterrupted 12-mo period beginning July 1, 2003, consecutive ASA physical status I–III patients who consented to ISB for shoulder or upper arm surgery without the use of a tourniquet were recruited. Exclusion criteria were severe bronchopulmonary disease, morbid obesity, hemostatic disorders, known allergy to amino-amide local anesthetics, history of neuropathy, and any preexisting neurologic deficits involving the surgical extremity.

Before the ISB, patients were sedated using 2–5 mg of IV midazolam and, if required, 50–100 μg of fentanyl to ensure comfort while maintaining a conscious and conversant state. All patients received standard single-injection ISBs using Winnie approach (19). A 50-mm, 22-gauge insulated needle (B-Braun/McGaw Medical, Bethlehem, PA) connected to a constant current nerve stimulator (Stimuplex®-HNS 11; B-Braun/McGaw Medical) was used to locate the brachial plexus. The stimulating current frequency was set at 2 Hz, duration at 0.1 ms, and initial stimulating current at 1.0 mA. Needle placement was considered satisfactory when an evoked motor response of the deltoid, biceps, triceps, or forearm musculature was sustained at 0.2–0.4 mA. Resident trainees were allowed three needle insertion attempts (each with two to three redirections) or 7 min of elapsed time from the block initiation, at which point supervising faculty completed the procedure.

The needle-extension tubing assembly was connected via a three-way stopcock to a local anesthetic syringe and a 5-mL syringe containing preservative free 0.9% sodium chloride (NS) solution. Before the local anesthetic injection, a 1-mL test dose of NS was injected. The needle was readjusted if the patient reported paresthesia or pain during either plexus localization or test dose. A paresthesia was defined as patient withdrawal or any report of unpleasant, radiating electric shock-like sensations (20). Levobupivacaine 0.625% (Chirocaine®; Purdue Pharma, Stamford, CT) with epinephrine 1:200,000 was incrementally injected to a total dose of 0.5 mL/kg (minimum, 30 mL; maximum, 40 mL).

An ISB was considered successful when there was surgical anesthesia in the C5-6 dermatomal distribution and the patient could not raise the abducted, straightened arm against gravity within 20 min of the local anesthetic injection. If surgical anesthesia and motor paralysis of the extremity occurred but the onset was more than 20 min, the block was classified as delayed. Intraoperatively, patients received either sedation or general anesthesia (GA) as predetermined by patient or surgeon preference and by the extent of the surgery.

Patients were followed up for neurologic sequelae at 24 and 48 h and at 2 and 4 wk after the ISB via telephone using a standardized questionnaire by a single investigator (MCK) not involved with the procedure. Patients were questioned regarding the presence of motor weakness, sensory symptoms (spontaneous or provoked by movement or pressure), or deficits characterized as anesthesia, hypesthesia, paresthesia, and dysesthesia unrelated to surgery, using previously described definitions (16). Additionally, patients were provided with telephone contact numbers to notify the investigators if there were new or worsening symptoms. Symptomatic patients were asked to identify the specific location of symptoms and the severity of pain/discomfort or disability on a scale of 0–10, (0 = none; 10 = severe pain/discomfort or disability). Based on the patients' reported scores, sequelae were categorized as minor (score $\leq$3), moderate (score $>$3), or severe (score $>$7). Motor deficits were scored as severe.

Patients who reported sensory or motor symptoms in the operated extremity underwent clinical examination and assessment by one of the investigators and the surgeon. Patients with sensory symptoms at sites distinct from the operated extremity, such as the posterior auricular nerve or the ISB injection site, were followed as previously mentioned until symptom resolution. Diagnostic and therapeutic consultation was not sought for patients with minor sensory symptoms. Patients with complaints of motor weakness, moderate or severe sensory symptoms, and worsening or extension of sensory symptoms were sent for further evaluation to either the hand surgery service for sensory symptoms involving the hand, the Anesthesia Pain Service for suspected plexopathy, or the neurology service for motor weakness unrelated to surgery and for any worsening or extension of sensory deficits. Diagnostic evaluation with respect to the need for electroneuromyography was left to the discretion of the consulting service.

Neurologic sequelae at the ISB site, clinical symptoms of brachial plexopathy, and those with symptoms in the distribution of the posterior auricular nerve were classified as probably associated with the ISB. Neurologic symptoms involving the distal phalanx of the thumb and index finger (C6 dermatome) were categorized as possibly associated with the ISB. Symptoms present at the surgical site, those involving single peripheral nerves distal to the ISB site, and motor weakness with intact sensory function were classified as unlikely to be associated with the ISB.

The sample size used for this study was based on a convenience sampling period of 1 yr, assuming that the number of ISBs per annum preformed for shoulder/upper arm surgery would be more than 600 (the mean for the preceding 2 yr). Descriptive statistics were used to define the incidence of neurologic sequelae with respect to onset time, distribution and duration of symptoms, and severity of pain/discomfort and disability. Patients' characteristics, anesthetic variables, and surgical variables were compared among patients without and those with neurologic sequelae likely and unlikely associated with the ISB. For continuous variables, differences among the groups were evaluated using one-way analysis of variance. For discrete variables, differences were analyzed with the χ^2 test or Fisher's exact test.

A backward stepwise multiple-logistical regression analysis using the log-likelihood method was preformed to identify independent variables associated with neurologic sequelae. A change in the χ^2 value of the overall likelihood statistic of 0.05 and 0.1 was required to add and remove a variable at each step. Variables that achieved a probability level of ≤ 0.2 on univariate analysis were entered into the equation. Significance of the relative risk of the variables identified by the model was determined using the confidence interval method. A separate analysis was preformed for neurological sequelae with and without ISB association.

Results

A total of 693 ISBs were performed during the 12-mo study. Motor and sensory block at the shoulder was achieved in 671 of the patients. An additional ISB was performed after surgery in seven patients to facilitate pain control (19). Paresthesias were reported during plexus location by 25 patients and during NS test injection by 15 patients. Two patients were treated with propofol 50 mg IV for symptoms of central nervous system toxicity (brief seizure). There were no cases of cardiac toxicity, pneumothorax, hematoma, or central neuraxial spread. Intraoperative supplementation included sedation in 302 and GA in 391. Postoperative follow-up to 1 mo was completed in 660 cases.

During the 1-mo follow-up period, 80 (12%) patients reported neurologic symptoms. In 24 (3.6%) patients, symptoms resolved within 24–48 h after surgery and were not considered to be neurologic sequelae. It has been our experience that the expected analgesia duration (sensory block) after an ISB using 0.625% bupivacaine with epinephrine 1:200,000 is 19 ± 5 h; therefore, we required 48 h of symptom persistence to exclude patients who had prolonged residual anesthetic effects. Fifty-six (8.5%) patients had symptoms that persisted for >48 h or had symptom onset between 48 h and 1 mo. In all but one case, the symptoms were reported within the first 2 wk. Symptoms were only sensory except for two cases in which patients reported motor weakness without sensory deficits. Two patients reported sensory symptoms at two discrete sites. Of the seven patients who had an additional ISB, one reported hypesthesia at the ISB site.

Table 1 shows the type, distribution, and evolution of neurological symptoms categorized as having a possible or probable association with ISB. Twenty-nine (4.4%) patients reported 31 sensory symptoms. The symptom distribution was as follows: ISB site (n = 14; 2.1%), distal phalanx of the thumb/index finger (C6 dermatome) (n = 9; 1.3%), posterior auricular nerve (n = 7; 1%), and one case of brachial plexopathy. Paresthesias during the ISB procedure were reported by 7 of 29 patients. The median duration of symptoms was 6 wk with a range of 2–12 wk.

Table 2 describes the characteristics of the symptoms in the remaining 27 (4.1%) patients with neurologic sequelae not likely to be associated with ISB. Twelve (1.8%) patients with sensory symptoms in the distributions of the supraclavicular nerve (n = 5), axillary nerve (n = 4), and posterior brachial cutaneous branch of the radial nerve (n = 3) were diagnosed on examination to have surgery-related neuropraxias. Two patients with motor weakness were found to have lesions distant and distinct from the ISB site. The remaining 13 (2.0%) patients had sensory symptoms in the distribution of either the median (n = 9; 1.4%) or ulnar (n = 4; 0.6%) nerve. None of the patients with symptoms not likely associated with the ISB reported paresthesias during the procedure. The median duration of symptoms was 6 wk with a range of 3–12 wk.

Discomfort or disabilities from the neurologic symptoms were classified as minor (score ≤3) in 50 (88%) patients. Excluding one patient reporting dysesthesia along the posterior auricular nerve distribution, consultations were ordered for five patients reporting moderate or severe symptoms. Diagnostic and therapeutic interventions were prescribed for three of five patients; two patients with motor weakness and one patient with pain/dysesthesia in the upper extremity. The two patients with motor weakness underwent electroneuromyography. In one patient, the

Table 1. Type and Distribution of Neurologic Symptoms Likely Associated with Interscalene Block (ISB)

Symptom type/distribution[a]	ISB association	*n*	Onset <48 h	Onset >48 h	Paresthesia elicited	Discomfort score (0–10)	Duration (wk)
Hypesthesia		16	10	6	5	1 (0–4)	6 (2–12)
ISB site	Probable	3	2	1	3	0 (0–2)	4 (4–6)
Posterior auricular nerve	Probable	6	6	0	1	1 (0–2)	7 (4–12)
Tip of thumb/index finger	Possible	7	2	5	1	1 (1–4)	6 (4–6)
Paresthesia		4	1	3	0	1.5 (1–5)	6 (4–10)
ISB site	Probable	2	—	2	0	1	5.5 (4–7)
Tip of thumb/index finger	Possible	2	1	1	0	1	6 (4–8)
Pain dysesthesia		11	5	6	2	2 (1–5)	6 (3–9)
ISB site	Probable	9	4	5	1	1 (1–4)	6 (3–6)
ISB site with radiation (Plexopathy)	Probable	1	1	—	0	5	9
Posterior auricular nerve	Probable	1	—	1	1	4	4

Data are presented as median (range).
[a] Twenty-nine subjects reported symptoms, two at more than one site.

Table 2. Type and Distribution of Neurologic Symptoms Not Likely Associated with Interscalene Block (ISB)

Symptom type/distribution[a]	*n*	Onset <48 h	Onset >48 h	Paresthesia elicited	Discomfort score (0–10)	Duration (wk)
Hypesthesia	9	3	6	0	2 (0–3)	4
Ulnar nerve	2	1	1	0	2 (1–3)	4
Supraclavicular/axillary/radial/nerve	7	2	5	0	2 (0–3)	4
Paresthesia	14	7	7	0	2 (1–5)	6 (4–10)
Median nerve	9	5	4	0	2 (1–3)	6 (4–9)
Ulnar nerve	2	2	0	0	3	6–8
Supraclavicular nerve	3	1	2	0	2 (1–5)	6 (4–9)
Pain dysesthesia	2	0	2	0	2.5 (2–3)	7 (6–8)
Supraclavicular nerve	2	0	2	0	2.5 (2–3)	7 (6–8)
Motor weakness	2	1	1	0	3.5 (2–5)	18 (10–26)
Shoulder (abductors)	1	1	0	0	2	10
Hand (flexor pollicis/digitorum)	1	0	1	0	5	26

Data are presented as median (range).
[a] Twenty-seven subjects reported symptoms.

site of the neurologic lesion was identified at the C5-6 nerve root level proximal to the ISB site and was attributed to disk herniation confirmed by magnetic resonance imaging. In the second patient, the site of neurologic lesion was identified distal to the ISB site at the forearm and was attributed to anterior interosseus nerve entrapment. The first patient was treated with cervical epidural steroid injections with resolution of symptoms at 10 wk, and the second patient underwent surgical decompression of the anterior interosseus nerve with resolution of symptoms at 26 wk. The third patient was evaluated in the Anesthesia Pain Clinic on the fifth postsurgical day for worsening of symptoms of pain/dysesthesia at the ISB site with diffuse radiation along the forearm and hand. Neurologic evaluation was negative for sensorimotor deficits. A diagnostic electroneuromyography was recommended but not performed because symptoms decreased within 1 wk of initiating oral gabapentin therapy. Complete symptom resolution occurred by 9 wk. Finally, two patients who reported paresthesias in the median nerve distribution did not exhibit sensorimotor deficits at examination but were referred for additional consultation. No interventions were recommended.

The univariate associations among patient characteristics, anesthetic and surgical variables with neuropraxias in patients likely with and without neurologic sequelae, and those not likely associated with the ISB are shown in Table 3. Of the variables examined, paraesthesia during the ISB procedure and pain or bruising at the injection site at 24 h were different among the groups. Binary logistic-regression models identified paresthesias during needle placement (odds ratio; 95% confidence interval) (13.1; 4.7–36.5), bruising at the ISB site at 24 h (5.6; 1.1–27.7), and pain at the ISB site at 24 h (3.4; 1.5–7.7) as independent predictors of neurologic sequelae with likely association with the ISB. In contrast, surgery performed in the sitting positioning (4.0; 1.2–13.7) and block site bruising (4.6; 1.2–17.1) were identified as independent predictors of neurologic sequelae not likely associated with the ISB. The relative risk and 95%

Table 3. Group Characteristics

	Neurologic sequelae			
	None	Likely association with ISB	Unlikely association with ISB	P-value
Number of subjects	637	29	27	
Age	47 ± 15	49 ± 13	51 ± 13	0.44
Body mass index (kg/m^2)	27.4 ± 5.0	27.2 ± 4.9	26.9 ± 5.1	0.89
Sex				
Male	410	14	15	0.17
Female	227	15	12	
Diabetes mellitus	30	2	2	0.68
Side of injection				
Right	377	11	19	0.31
Left	280	14	12	
Number of attempts				
≤3	541	23	23	0.27
>3	96	8	4	
Block completion time (min)	6.0 ± 3.5	7.2 ± 3.8	5.7 ± 3.5	0.19
Paresthesia				
None	605	23	27	
During needle placement	18	7	0	0.005
During injection	14	1	0	
Successful block				
Yes	595	26	27	
Delayed	22	2	0	0.40
Failed	20	2	0	
Type of surgery				
Closed	322	11	12	
Open	279	17	13	0.58
Complex	36	1	2	
Position during surgery				
Sitting	403	22	21	0.13
Supine/lateral	234	7	6	
Surgery duration (min)	91 ± 41	83 ± 29	99 ± 42	0.30
Complications in first 24 h				
None	457	13	21	
Pain	118	2	3	0.003
Bruising	162	14	3	

Data presented as mean ± SD or number of cases.
ISB = interscalene block.

confidence intervals associated with the presence of the variables in the models are shown in Figure 1.

Discussion

Long-term severe neurologic deficits (neuropathy) after ISB are rare, with a reported incidence of 2.9 per 10,000 (14), whereas transient neurologic sequelae presenting with symptoms such as paresthesia, dysesthesia, or pain unrelated to surgery occur more frequently (16–18). Methodological factors such as technique, choice of local anesthetic drugs/adjuncts, duration of follow-up, and categorization of symptoms with respect to etiology and distribution may influence the reported incidence. In the present study, the ISB procedure was standardized with respect to technique, local anesthetic drug dose and adjunct (epinephrine), and long-term follow-up (one month) was completed in 95% of subjects. Appearance of new symptoms is unusual after one month (16).

In comparison to studies examining the incidence of long-term neurologic sequelae in brachial plexus distribution after an ISB, the 3.3% and 0.1% incidence of likely anesthesia-related sequelae at one and three months in the present study is less than the 7.9% and 3.9% incidence at one and three months reported in a study of 520 ISB cases (single injection, 286 cases; catheter, 236 cases) (16). Our findings are similar to the 2.4% and 0.3% incidences reported in a long-term follow-up of 700 cases receiving ISB catheters (17). The differences between these reports are most likely because of the differences in categorization of symptoms to likely ISB association.

Injury at the level of the brachial plexus roots/trunks generally produces symptoms of diffuse plexopathy. In the present study, only 1 of the 660 patients (0.15%) reported symptoms suggestive of a clinical brachial plexopathy. At the ISB injection site, the C6 nerve root or superior trunk (C5-6) are exposed to a

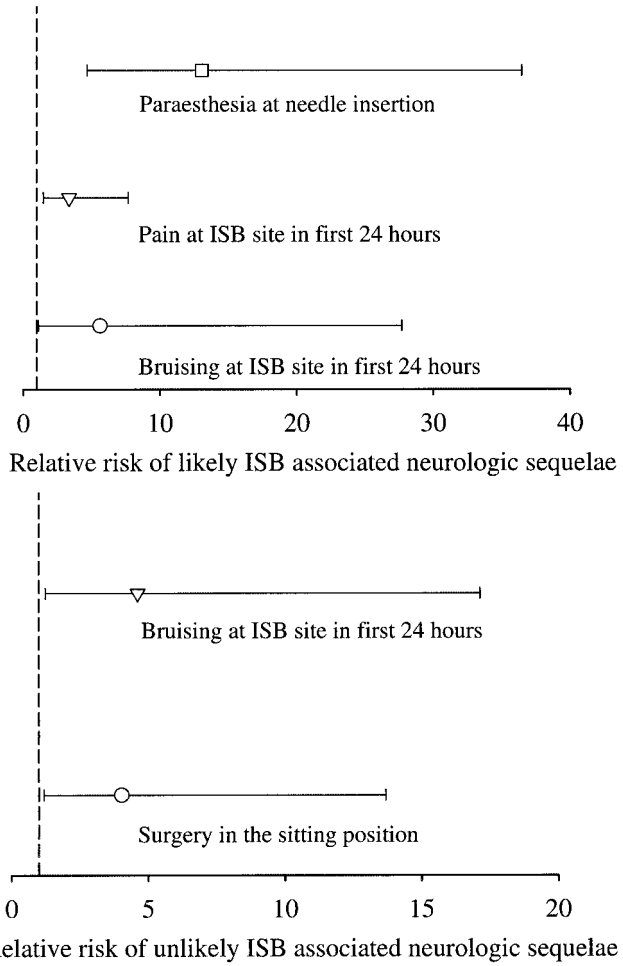

Figure 1. Relative risk associated with the variables identified as independent predictors of neurologic sequelae after interscalene block (ISB) for shoulder or upper arm surgery. Upper graph shows variables identified as significant independent predictors of neurologic sequelae likely related to ISB. These included paresthesia at needle insertion and pain or bruising at the ISB site at 24 h. In contrast, surgery in the sitting position and bruising at ISB site were identified as predictors of neurologic sequelae not likely related to ISB (lower graph). The symbols represent relative risk, and the error bars represent the ±95% confidence interval associated with variables in the model.

large mass of a local anesthetic drug. We postulate that the nine (1.3%) cases of hypesthesias confined to the distal phalanx of the thumb and index finger (C6 dermatome) could therefore possibly represent a form of ISB-related injury. In animal studies, topical application or extra-fascicular injections of bupivacaine (0.5%–1.0% with and without epinephrine) did not produce significant long-term axonal degeneration or damage to the blood-nerve barrier (21,22). However, a concentration-dependent breakdown of that barrier with endoneurial edema and slight degenerative changes in nerve fibers occurred after extraneural injections of local anesthetics (23). This may contribute to a transient, reversible form of nerve injury presenting as sensory symptoms after an ISB.

The great auricular nerve and cervical cutaneous branches lie in close proximity to the ISB injection site. Paresthesias were elicited during plexus location in 30% of patients who developed sensory symptoms in the distribution of the posterior auricular nerve, suggesting a possible contribution of needle trauma. Because of this clinical correlation, sensory symptoms at the ISB site and those along the distribution of posterior auricular nerve were also categorized as sequelae with possible ISB correlation.

Sensory symptoms in peripheral nerve distributions most likely represent a more distal lesion site, i.e., a specific mononeuropathy. In the present study, 13 patients (2%) reported sensory sequelae in the median or ulnar nerve distribution. This frequency is comparable to the incidence of sensory hand sequelae at two weeks (3%) reported by Urban and Urquhart (18) after 266 ISB procedures. Similar to their study, the sensory sequelae involving these nerve distributions produced only minor discomfort and resolved spontaneously. In a prospective evaluation of peripheral neuropathy in 1502 adults after noncardiac surgery under predominately GA and neuraxial anesthesia (PNB in only 11 cases), Warner et al. (24) reported 0.5% and 1.2% incidences of ulnar neuropathy and carpal tunnel syndrome, respectively. Underlying subclinical neuropathy, male gender, elbow flexion, and tissue edema were considered to be risk factors for postoperative median and ulnar neuropathy. In the present study, the incidence of hypesthesias/paresthesias in the ulnar nerve distribution in the hand was 0.6% (four patients), with three of four patients being male; the fourth, female patient reported bilateral symptoms suggestive of preexisting subclinical neuropathy. The incidence of paresthesias in the median nerve distribution in the hand was 1.4% (nine patients). No paresthesias were elicited during the ISB in these patients. The comparable incidences of symptoms indicative of peripheral mononeuropathies in the median and ulnar nerves in patients undergoing shoulder/upper arm surgery with those undergoing all noncardiac procedures under various types of anesthesia suggests a multifactorial etiology for this peripheral neuropathies, as described by Warner et al. (4,24).

We believe that the paresthesias and hypesthesias in the median/ulnar nerve distributions noted in the present study, as well as the paresthesias of the hand reported by Urban and Urquhart (18), and the carpal tunnel/cubital tunnel syndrome (representative of medial and ulnar neuropathies) reported by Borgeat et al. (16,17), may represent a multifactorial etiology including patient and surgical factors and not neurologic injuries related to the ISB procedure.

Incidental nerve injuries (axillary, suprascapular, and musculocutaneous nerves) have been reported in 1.8% of patients undergoing rotator cuff repair, shoulder stabilization, and prosthetic shoulder arthroplasty

(2,3). Additionally, patients undergoing open reduction of humeral fractures are susceptible to radial nerve injury. The overall incidence of sensory sequelae in the cutaneous distributions of axillary and the posterior brachial cutaneous branch of the radial nerve (all underwent open repair of humeral fracture) for patients undergoing open surgery in the present study was 2% (7 of 325 cases).

A limitation of the present study is that not every patient reporting neurologic sequelae received an electroneuromyographic study to identify the site of neurologic lesion. The sensitivity of electroneuromyography, however, has been demonstrated to be low for minor sensory symptoms. In the study of Borgeat et al. (16), 31 of 50 (62%) electroneuromyography studies were negative despite persistent paresthesias or dysesthesias. In the present study, because 88% of the patients with neurologic sequelae reported minor sensory symptoms, we do not believe that electroneuromyography would have added significantly to identifying the site of the lesions.

In summary, neurologic sequelae after single-injection ISB for shoulder/upper arm surgery using epinephrine-containing local anesthetics mainly involved minor sensory symptoms in the distributions of the median and ulnar nerves in the hand, distal innervation of the C6 dermatome (distal phalanx of the thumb/index finger), posterior auricular nerve, and the ISB site. Factors that increased the odds of developing neurologic sequelae after the ISB included paraesthesia at needle location and pain/bruising at the ISB site. Etiologies other than ISB should be considered for sequelae in the peripheral (median/ulnar) nerve distributions of the brachial plexus. This study suggests that the incidence of neurologic sequelae after single-injection ISB consisting of epinephrine added to a local anesthetic solution is not different from that reported previously using comparable doses of long-acting local anesthetic solution without epinephrine for similar surgeries.

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