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Acute and Nonacute Complications Associated with Interscalene Block and Shoulder Surgery

A Prospective Study

Alain Borgeat, M.D., Georgios Ekatodramis, M.D.,† Fabian Kalberer, M.D.,‡ Cedric Benz, M.D.§*

Background: **The incidence, etiology, and evolution of complications after interscalene brachial plexus block (ISB) are not well-known. The authors prospectively monitored 521 patients for complications during the first 9 months after ISB.**

Methods: **A total of 521 adults scheduled for elective shoulder surgery performed with an ISB were included in this prospective study. The ISB procedure was standardized for all patients. Acute complications were recorded. Patients were observed daily (for 10 days) for paresthesias, dysesthesias, pain not related to surgery, and muscular weakness and were evaluated at 1, 3, 6, and 9 months after surgery. Persistence of paresthesias, dysesthesias, pain not related to surgery, or muscular weakness was investigated at 1 or 3 months by means of electroneuromyography. Final evaluation was performed at 9 months.**

Results: **A total of 520 patients completed the study; one was excluded after surgical axillary nerve damage. Two hundred thirty-four patients had an interscalene catheter. Acute complications consisted of one pneumothorax (0.2%) and one episode of central nervous system toxicity (incoherent speech; 0.2%). At 10 days, 74 patients (14%) were symptomatic, and none had muscular weakness. At 1 month, 41 patients (7.9%) had symptoms, and none had muscular weakness. Thirty patients underwent electroneuromyography; sulcus ulnaris syndrome (n = 8), carpal tunnel syndrome (n = 2), and complex regional pain syndrome (n = 1) were diagnosed. At 3 months 20 patients (3.9%) were symptomatic, and none had muscular weakness. All underwent electroneuromyography; carpal tunnel syndrome (n = 2), complex regional pain syndrome (n = 4), plexus neuropathy (n = 1), and plexus damage (n = 1) were diagnosed. At 6 months, 5 patients (0.9%) were symptomatic. At 9 months, 1 patient (0.2%) had persistence of dysesthesia.**

Conclusions: **Interscalene brachial plexus block performed with a standardized technical approach, material, and drugs is associated with an incidence of short- and severe long-term complications of 0.4%. In case of persistent paresthesia, dysesthesia, or pain not related to surgery after ISB, sulcus ulnaris syndrome, carpal tunnel syndrome, or complex regional pain syndrome should be excluded since specific treatment may be required.**

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* Chief of Staff, † Consultant, § Resident, Department of Anesthesiology; ‡ Resident, Department of Orthopedic Surgery.

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Address reprint requests to Dr. Borgeat: University Clinic of Zurich/Balgrist, Forchstrasse 340, CH-8008 Zurich, Switzerland. Address electronic mail to: aborgeat@balgrist.unizh.ch.

INTERSCALENE brachial plexus block (ISB) is appropriate shoulder surgery.[1,2] Reported complications associated with ISB are brachial plexus injury,[3,4] idiopathic brachial plexitis,[5] and unintended spinal[6] or epidural anesthesia.[7] However, there have been very few large studies to date that have examined the incidence of short- and long-term complications associated with ISB anesthesia including the use of interscalene perineural catheter. Moreover, there is practically no information available in the literature on the etiology and evolution of prolonged and long-term complications after ISB. Therefore, we conducted a prospective evaluation of more than 500 ISBs using a standardized technique, material, and drug application.

Methods

After obtaining institutional approval and verbal patient consent, 521 consecutive adult patients of both sexes (classified as American Society of Anesthesiologists physical status I or II; age, 18–75 yr; weight, 45–110 kg) scheduled for elective shoulder or upper arm surgery suitable for ISB were entered in the study. Exclusion criteria were severe bronchopulmonary disease, known allergy to the trial drugs, any previous neurologic damage to the brachial plexus, and known neuropathy involving the arm undergoing surgery.

The ISB procedure was standardized for all patients. On the patients' arrival in the induction room, a 20-gauge intravenous catheter was inserted into a vein in the arm not requiring surgery after premedication consisting of 0.1 mg/kg oral midazolam. All patients received an ISB before induction of general anesthesia, when indicated according to the patient's or surgeon's wish. The interscalene brachial plexus was identified using a nerve stimulator (Stimuplex® HNS 11; B. Braun Melsungen AG, Melsungen, Germany) connected to the proximal end of the metal inner of a short beveled needle (30°; Stimuplex® A; 21- or 22-gauge stimulation needle; G. Braun, Melsungen AG). For practical reasons, the needle bevel orientation was not assessed. Placement of the needle was considered successful when a contraction of the triceps muscle was obtained with a current output of less than 0.5 mA with an impulse duration of 0.1 ms. When a perineural catheter was needed, the cannula-over-needle technique was used with a plastic cannula (Polymedic®, polyplex N50-T; 20-gauge external diame-

ter; te me na, Bondy, France). A catheter (Polymedic®, polyplex N50%, 23 gauge with stylet) was introduced distally between the anterior and middle scalene muscle for up to 3–4 cm. The catheter was subcutaneously tunneled for 3–4 cm through an 18-gauge intravenous cannula and fixed to the skin with adhesive tape. ISB was performed with 40 ml ropivacaine 0.6% for patients weighing less than 60 kg and 50 ml ropivacaine 0.6% for those weighing more than 60 kg. The drug was administered either through the needle for the single injection and or through the interscalene catheter when present. For patients with a catheter, a continuous infusion of 0.2% ropivacaine was started 6 h after the initial ISB. A block was considered successful when a sensory (inability to recognize cold temperature, pins-and-needle–type paresthesia in the tip of the first and third finger) and motor block (inability to extend the arm) involving the radial and median nerve occurred within 20 min after the administration of local anesthetic. All of the blocks were performed by one of the senior consultants of the Department of Anesthesiology.

Any problems during the performance of the block or the insertion of the catheter were recorded. Signs of local anesthetic intoxication, blood aspiration, hematoma, and pneumothorax were classified as short-term complications. All patients were monitored frequently during a 9-month period after the ISB for some motor (weakness) and sensory deficit (loss of feeling); the persistence of paresthesia, defined as an abnormal but not unpleasant sensation, whether spontaneous or provoked; dysesthesia, defined as an unpleasant abnormal sensation, whether spontaneous or evoked; and the presence of pain unrelated to the surgery. Pain unrelated to surgery was defined as one not involving the surgical area, not being related to any radiating pain from the shoulder, and not being elicited by shoulder mobilization. It was graded as minor, average, or severe.

Each patient was examined and questioned according to a standardized manner about the severity (minor, average, severe) and localization of the complications, as well as the importance of disability (none, slightly disturbed, disabled) by a member of the anesthesiology staff each day during the first 5 postoperative days. For the following assessments at day 10 and 1, 3, 6, and 9 months, the patient was examined and questioned independently by one of the anesthesiology staff and the surgeon (F. K.). Asymptomatic patients at day 10 were called at the end of the second and third week after the ISB to inquire about the appearance of paresthesias, dysesthesias, or new pain. If the response to any of these questions was positive, patients were asked to come to the hospital for a formal evaluation and recording of the symptoms by one member of the anesthesiology staff and the surgeon (F. K.).

During the first 10 postoperative days, the appearance of a sudden neurologic deterioration or severe pain was investigated by ultrasonography (Siemens Elegra® 7.5 MHz linear transducer; Siemens Medical Systems, Erlangen, Germany) to exclude hematoma and, if necessary, with a conventional electroneuromyography (Keypoint 4, Dentec, Denmark). At day 10, the patients who reported being severely disabled or experiencing rapidly worsening paresthesias, dysesthesias, or pain not related to surgery underwent electroneuromyography. Complications lasting between 10 days and 1 month after ISB were classified as subacute. Patients elected for an electroneuromyography at 1 month were those who either had an increase in severity of any one of the complications—as compared with the first assessment and therefore classified one step higher on the severity scale— or those with spreading of the localization (lager territories or new ones involved). All complications lasting more than 1 month were classified as prolonged. At 3 months, all symptomatic patients underwent electroneuromyography. A final evaluation was conducted independently at 6 and 9 months by one member of the anesthesiology staff and the surgeon.

Complications lasting more than 9 months were considered as long-term, and those with some sensorimotor deficit, impairing normal daily activities, were considered severe. Electroneuromyographically, the diagnosis of a relevant sulcus ulnaris syndrome was based on the assessment of pathologically reduced nerve conduction velocity of the ulnaris nerve across the sulcus ulnaris, combined with a reduction of the compound motor action potential with increased latencies. The diagnosis of a relevant carpal tunnel compression syndrome resulted from assessment of prolonged distal sensory and motor latencies combined with a pathologic reduction of the compound motor action potential of the median nerve. Evaluation of preserved sympathetic innervation of the hands, sympathetic skin responses, were performed on one hand after stimulation of the controlateral median nerve. The complete loss of sympathetic skin response was used to define a clinically relevant sympathetic disturbance and, coupled with the absence of any other electroneuromyography abnormalities, led to the diagnosis of complex regional pain syndrome (CRPS).

Descriptive statistics were used. Results are presented as mean ± SD as otherwise specified. Demographic data between patients with and without interscalene catheter were compared using the Mann–Whitney test. Incidence of complications between the catheter and single-injection groups were analyzed by the Fisher exact test.

Results

A total of 521 patients were included in the study during a 9-month period. One patient was excluded during the course of the study because he sustained iatrogenic axillary nerve damage related to the surgery.

Table 1. Demographic and Surgical Data

	Without Catheter	With Catheter
n	286	234
M/F ratio	178/108	135/99
Age	42 ± 17	48 ± 14
Weight	79 ± 21	82 ± 18
Surgical time (min)	75 ± 20*	152 ± 38
With general anesthesia	21 (7.3%)*	125 (52%)

* $P < 0.05$.

The demographic data of the 520 remaining patients are summarized in table 1. A total of 234 patients had an ISB with placement of a catheter, and in 286 a single-injection technique was used. The mean current needed to localize the plexus was 0.36 mA (range, 0.2–0.46 mA); the radial nerve (triceps contraction) was stimulated in 98%, of which 20% had a simultaneous response of the musculocutaneous nerve (biceps contraction). The axillary nerve (deltoid contraction) was stimulated in the remaining 2% of the patients. Three blocks were unsuccessful (technical difficulties to achieve the ISB). During the ISB procedure, blood was aspirated three times, the needle was withdrawn and redirected, and the block was performed without event. In two patients who reported some paresthesias in the arm during stimulation, the direction of the needle was changed, and the procedure continued smoothly. During injection of the local anesthetic, 21% of the patients complained about transient burning pain at the point of injection. Among the short-term complications (table 2), one pneumothorax (0.2%) was observed in a patient with Marfan disease, and one patient (0.2%) started to have incoherent speech shortly after the administration of the drug, compatible with a central nervous system intoxication. Fifteen patients (6.4%) complained about some transient pain in the dorsal part of the scapula during placement of the catheter. The interscalene catheter was left in place for a median of 3 days (range, 2–5 days). No displacement or infection was observed.

All symptoms appeared within 23 days after the ISB. No patient had symptom recurrence during the course of the study. During the first period (days 1–9), two patients underwent a brachial plexus ultrasonography after the appearance of sudden pain in the shoulder on the sixth and eight postoperative day, respectively. Ultrasonography was unremarkable in both cases. No electroneuromyography was performed because of the absence of any other sensorimotor symptoms. In these two cases, pain was related to malposition of the abduction splint.

Table 2. Acute Complications after 520 ISB

	n	%
SNC intoxication	1	0.2
Cardiac intoxication	0	—
Pneumothorax	1	0.2
Aspiration of blood	3	0.6
Hematoma	0	—
Spinal anesthesia	0	—
Epidural anesthesia	0	—

ISB = interscalene brachial plexus block.

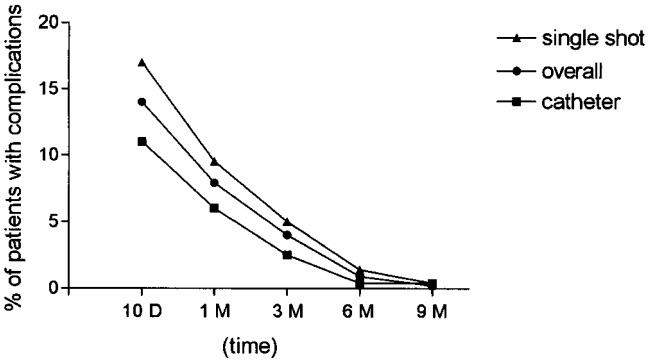

Fig. 1. Percentage of complications related to the time after interscalene block for patients overall, for patients with interscalene catheter, and for patients with single-injection interscalene block. D = day; M = month.

On the tenth day, 74 patients (14%) reported the presence of either paresthesia, dysesthesia, or pain apparently not related to surgery. None had clinical muscular weakness. For all of these patients, the symptoms were mild, and no further investigation was undertaken. In the catheter group, the incidence of complications was 11% (26 patients) *versus* 17% (48 patients) in the single-injection group (nonsignificant; fig. 1).

At 1 month, 41 patients (7.9%) had either the persistence of paresthesia, dysesthesia, or pain apparently not related to surgery. Among those, 10 (0.2%) had the first appearance of paresthesias–dysesthesias between day 15 and 23 after ISB. None had clinical muscular weakness. Of these, 30 underwent electroneuromyography because there was a worsening of the symptoms (one step higher on the scale of paresthesias–dysesthesias from minor to average). Sulcus ulnaris syndrome (n = 8), entrapment neuropathy of the ulnar nerve at the medial epicondyle of the elbow, carpal tunnel syndrome (n = 2), entrapment neuropathy of the median nerve in the carpal tunnel between the longitudinal tendons of forearm muscles that flex the hand and the transverse superficial carpal ligament, and CRPS (n = 1) were diagnosed. The other 19 were unremarkable. The incidence of complications was 6.0% (14 patients) in the catheter group *versus* 9.5% (27 patients) in the single-injection group (nonsignificant; fig. 1). Thirty-three patients had spontaneous resolution of the symptoms during the 10th postoperative day and the first month. Resolution was defined as the disappearance of the symptoms and the inability to provoke them during examination of the patient.

At 3 months, 20 patients (3.9%) still had some symptoms (fig. 1), 2.6% (6 patients) in the catheter group and 4.9% (14 patients) in the single-injection group

Table 3. Nonacute Complications after 520 ISB

	n (%)
Sulcus ulnaris syndrome	8 (1.5)
Complex regional pain syndrome	5 (1)
Carpal tunnel syndrome	4 (0.8)
Plexus neuropathy	1 (0.2)
Severe plexus damage	1 (0.2)

ISB = interscalene brachial plexus block.

(nonsignificant). All underwent electroneuromyography. In these patients, carpal tunnel syndrome (n = 2), CRPS (n = 4), plexus neuropathy (n = 1), and plexus damage (n = 1) were diagnosed. Twelve electroneuromyographic examinations were unremarkable. No patient had muscle weakness. Ten patients had spontaneous resolution of their symptoms between the first and third postoperative month.

At 6 months, five patients (0.9%) had some symptoms: one with the plexus lesion, one with neuropathy, and three with normal electroneuromyography. The incidence of complications was 0.4% (1 patient) in the catheter group and 1.4% (4 patients) in the single-injection group (nonsignificant). Seven patients had spontaneous resolution during the third and sixth postoperative month.

At 9 months, only 1 patient (0.2%) was still symptomatic, the one with a plexus lesion. All other patients, including the patient with neuropathy, had a spontaneous resolution during the sixth and ninth postoperative month The incidence, spontaneous resolution, and time of diagnosis of the non–short-term complications are summarized in tables 3 and 4.

No patient needed supplementary analgesics other than those prescribed by the surgeon for shoulder pain. Except for the patients with sulcus ulnaris syndrome, carpal tunnel syndrome, and CRPS, who had specific treatments (surgical or medical), and the one with the plexus lesion, rehabilitation and return to work or usual activity was not delayed.

Discussion

This prospective study shows that the performance of the ISB as well as the placement of a perineural catheter within the interscalene space following a standardized technique, use of material, and drug application is associated with an incidence of acute and severe chronic complications of 0.4%, that interscalene perineural catheter is not associated with an increased incidence of complications, and that some of the prolonged complications are linked with specific medical conditions requiring specific treatment.

Acute complications associated with ISB have not been extensively investigated. Pneumothorax is a dreaded complication of supraclavicular techniques according to the technique described by Kulenkampff in 1911.[8] The incidence of pneumothorax after ISB is extremely rare, which is in accordance with the results of our study. Indeed, one patient (0.2%) suffered this complication. In 1974, Ward[9] reported an incidence of 3% of symptomatic pneumothorax after ISB. The lower incidence in our investigation may be explained by the improvement in the technique used and new material, including needles. Seizure is a well-recognized complication of local anesthetic toxicity and occurs most frequently after accidental intravascular injections or after rapid absorption of local anesthetic.[10] In one of the very rare epidemiologic studies about this complication, Brown *et al.*[11] showed that the incidence of seizure after brachial plexus anesthesia was 0.2%, an incidence similar to the one observed in the current study. Urban and Urquhart[12] encountered no seizure in 266 patients after ISB. Aspiration of blood was encountered in 0.5%; the needle was redirected, and the ISB was performed without any other complication. No hematoma was subsequently observed.

Nerve injury after brachial plexus anesthesia is a recognized complication. The frequency of peripheral neuropathies reported in the literature after peripheral nerve blockade varies from 0 to more than 5%.[13] Peripheral nerve complications are generally directly attributed to the performance of the block itself, but this concept was challenged by Selander et al.,[14] who indicated that other factors may be responsible as well. Urban and Urquhart[12] found an incidence of postoperative paresthesia of 9.% on the first day after surgery after ISB and 3% after 2 weeks, an incidence lower than the one found in the current trial. Some methodologic differences may explain the discrepancies between the results of Urban and Urquhart and ours. In their study, the technique as well as the drugs given were not standardized, and the incidence of non–short-term complications was not the main outcome of the study. In our investigation, the ISB procedure was standardized, and all patients were frequently checked for the appearance of complications during the first 10 days until 1 month after the ISB. It is known that symptoms may become apparent only 2–3 weeks after ISB (or surgery), depending on the formation of perineural edema, inflammation, and microhematoma, which may explain the delayed appearance of the clinical symptoms.[14] In our study, 0.2% had the first appearance of paresthesia–dysesthesia between the 15th and 23rd day after ISB. In fact, the real incidence of these symptoms may have previously been underestimated, because, with the exception of severe motor impairment, these symptoms are generally considered as minor, and the anesthesiologist does not usually have the opportunity to monitor the patient beyond the first 2 or 3 postoperative days.

To date, complications after ISB have not been prospectively investigated by means of electroneuromyogra-

Table 4. Time of Diagnosis of the Nonacute Complications and Spontaneous Resolution of Symptoms

	10 Days		1 Month		3 Months		6 Months		9 Months
Symptomatic patients	74		41		20		5		1
Spontaneous resolution	—	33		10		7		4	
SUS			8		—		—		—
CTS	—		2		2		—		—
CRPS	—		1		4		—		—
Neuropathy	—		—		1		1*		—
Plexus lesion	—		—		1		1*		1*

* Same patient.

SUS = sulcus ulnaris syndrome; CTS = carpal tunnel syndrome; CRPS = complex regional pain syndrome.

phy. During the course of the study, 50 patients—30 and 20 at 1 and 3 months after surgery, respectively— underwent electroneuromyography because they fulfilled the study criteria. Thirty-one patients had a normal electroneuromyography, all of whom recovered completely at the end of the study period (9 months). It is difficult to explain the reasons for the persistence of paresthesia or dysesthesia in these patients, because the electroneuromyography did not even show the smallest sign of increased latency or decrease of conduction velocity, early signs of neuropraxia, the least severe form of nerve damage. It is not known whether these represent a form of toxic brachial plexus injury that simply resolves or is related to some form of surgical trauma or secondary to positioning.

At 1 month, eight electroneuromyographic examinations were compatible with sulcus ulnaris syndrome. Six patients recovered spontaneously between 1 and 3 months after ISB, while the remaining two had a surgical decompression of the ulnar nerve. Indirect evidence suggests that this syndrome is very common and deserves wider recognition.[15] In the context of shoulder surgery, the possible role of the abduction splint should be noted because the cubital tunnel is narrowed by elbow flexion.[16] This neuropathy often is mild and resolves spontaneously, but early recognition is important because some cases may be associated with prolonged or permanent disability.

Two cases of carpal tunnel syndrome were diagnosed at 1 month and two at 3 months after surgery. All four patients were female and underwent surgery within the following weeks, with uneventful recovery. Whether this occurs by chance or has some link with surgery or the ISB itself remains unclear.

Five cases of CRPS were diagnosed during the course of the study, with diagnosis based on a normal electroneuromyographic examination and a positive sympathetic skin response associated with symptoms of autonomic, motor, and sensory disturbances.[17] All were promptly and successfully treated according to the usual procedure in our hospital. CRPS has been associated in one case with ISB.[18] Prompt recognition of this entity is important because early treatment is associated with the best chance of a successful outcome.[19]

One patient had an idiopathic neuropathy diagnosed 3 months after an uneventful ISB combined with a general anesthesia. The patient started to feel some numbness in her hand 3 weeks after ISB. The symptoms worsened somewhat, and an electroneuromyography performed at 3 months showed the first signs of neuropraxia without any sign of denervation. The symptoms persisted until the sixth postoperative month and then progressively disappeared. The patient had fully recovered at 9 months.

One patient suffered a chronic prolonged complication after an uneventful ISB (no paresthesia, no pain on injection). The recovery during the first week was normal. After 10 days, he started to complain of light paresthesia and some numbness in the hand. After 2 months, the symptoms worsened, and the patient complained of hypoesthesia on the radial site of the forearm and in the middle of the palmar site of the hand without any obvious motor disturbance. Electroneuromyography outlined a damage of the C6 root at the level of the plexus. A second electroneuromyography performed 9 months later showed complete recovery of the plexus. Despite the normal electroneuromyographic examination, the patient still complained of some sensory deficit in his hand. The exact cause of the neurologic trauma after ISB is always difficult to differentiate between ISB-related complications, needle trauma, intraneural injection, toxicity of the local anesthetic,[20] or nonrelated stretching or compression of the plexus.

Complications dealing with the use of the interscalene perineural catheter are rare. There is one report in the literature on plexus irritation caused by the catheter.[21] This study demonstrated that interscalene catheter placement as well as the prolonged administration of 0.2% ropivacaine does not increase the rate of complications. Fifteen patients complained of some transient pain radiating on the dorsal part of the scapula during catheter placement. This pain rapidly disappeared and never recurred.

In conclusion, this prospective study demonstrates that the performance of ISB with a standardized technique and drug application is associated with a very high success rate, and, although there was a high incidence of transient problems with paresthesias, dysesthesias, or

pain not clearly related to surgery (14% at 10 days postoperatively), very few patients experienced long-term complications (0.4%). Moreover, no association between complications with or without catheters was observed. The diagnosis of sulcus ulnaris syndrome, carpal tunnel syndrome, or CPRS must be excluded in case of persistence of paresthesia, dysesthesia, or pain not related to surgery after ISB, because specific treatment may be necessary to treat these medical problems.

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