

Evaluation of the Lateral Modified Approach for Continuous Interscalene Block after Shoulder Surgery

Alain Borgeat, M.D.,* Alexander Dullenkopf, M.D.,† Georgios Ekatodramis, M.D.,‡ Ladislav Nagy, M.D.§

Background: Continuous interscalene block is the technique of choice for postoperative pain relief treatment after shoulder surgery. The authors prospectively evaluated the modified lateral approach for the performance of the interscalene catheter block and monitored 700 patients for clinical efficacy and complications during the first 6 months after placement of the catheter.

Methods: A total of 700 adults scheduled to undergo elective shoulder surgery performed with an interscalene brachial plexus block through an interscalene catheter were included in this study. The interscalene brachial plexus block procedure was standardized for all patients. Difficulties in placement of the catheter, clinical efficacy of anesthesia and analgesia, patient satisfaction, and acute and chronic complications were recorded. Patients were observed daily for 5 days for any complications and were evaluated at 1, 3, and 6 months after surgery. Persistence of neurologic complication was investigated by electroneuromyography.

Results: A total of 700 adults completed the study. Easy placement of the catheter (one attempt) was achieved in 86% of the patients. Resistance to thread the catheter was encountered in 6%; no major complications were observed during injection of the initial bolus. The success rate for anesthesia was 97%. Postoperative analgesia was efficient in 99%. The concentration and the rate of infusion of ropivacaine had to be increased in 31 patients (6%). In five patients (0.7%), signs of local infection around the puncture point were noted; in one patient (0.1%), a collection of pus was surgically drained. Patient satisfaction was 9.6 on a scale of 0–10. Minor neurologic complications (paresthesias, dysesthesias, pain not related to surgery) were observed in 2.4%, 0.3%, and 0% at 1, 3, and 6 months, respectively. At 1 month, three sulcus ulnaris syndromes, one carpal tunnel syndrome, and one complex regional pain syndrome were diagnosed. Two patients (0.2%) had sensory-motor deficit, which necessitated 19 and 28 weeks to recover. Electromyography was suggestive of partial axonotmesis.

Conclusion: The lateral modified approach provides good conditions for placement of the interscalene catheter. Anesthesia and analgesia performed through the catheter are efficient. The rates of infection and neurologic complications are low, and patient satisfaction is high.

CONTINUOUS perineural blocks have been shown to promote better postoperative analgesia, increase patient satisfaction, and have a positive influence on the surgical outcome compared to intravenous opioids for both the upper^{1–3} and lower extremities.^{4,5}

Continuous interscalene brachial plexus block (ISB) has become an accepted method for anesthesia and analgesia in shoulder surgery.^{2,6} However, interscalene

catheter insertion is technically challenging, and failure rates up to 25% have been reported.⁷ Reports on clinical assessment and complications associated with this technique are still rare.^{8,9} Recently, clinical reports^{8–10} have demonstrated the benefits of the use of the modified lateral approach, compared to the traditional Winnie's approach to perform this block. This prospective study was conducted to evaluate the clinical efficacy of anesthesia and postoperative analgesia of this approach for the interscalene catheter.

Methods

After obtaining institutional approval (Gesundheitsdirektion des Kantons Zürich, Kantonale Ethik-Kommission) and verbal patient consent, 700 consecutive adult patients of both sexes (American Society of Anesthesiologists physical status class I–III, age 18–75 yr, weight 45–110 kg) who were scheduled to undergo elective open or arthroscopic shoulder or upper arm surgery and were suitable for ISB with placement of a perineural catheter were included in the study. Exclusion criteria were severe bronchopulmonary disease, known allergy to 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. They were premedicated with 0.1 mg/kg oral midazolam 1 h before surgery. The ISB was performed in all patients through the catheter according to the modified lateral technique as described elsewhere¹⁰ (Appendix; fig. 1), before sedation or induction of general anesthesia, when indicated according to patient's or surgeon's wish. Formal sterile technique was used. 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; B. Braun Melsungen AG). The bevel of the needle was directed upward. Placement of the needle was considered successful when a contraction of the triceps muscle or, as second choice, contraction of the deltoid muscle was obtained with a current output of less than 0.5 mA with an impulse duration of 0.1 ms. The insertion of the perineural catheter was performed using the cannula-over-needle technique with a plastic cannula (Polymedic[®], Polymyx N-50T, 20-gauge external diameter; te me na, Bondy, France). A catheter (Polymedic[®], Polymyx N-50, 23-gauge with stylet) was introduced distally between

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

Received from the Orthopedic University Clinic Zurich/Balgrist, Switzerland. Submitted for publication January 21, 2003. Accepted for publication April 9, 2003. Support was provided solely by departmental sources.

Address for reprint requests to Dr. Borgeat: Orthopedic University Clinic Zurich/Balgrist, Forchstrasse 340, CH-8008 Zurich/Switzerland. Address electronic mail to: aborgeat@balgrist.unizh.ch. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

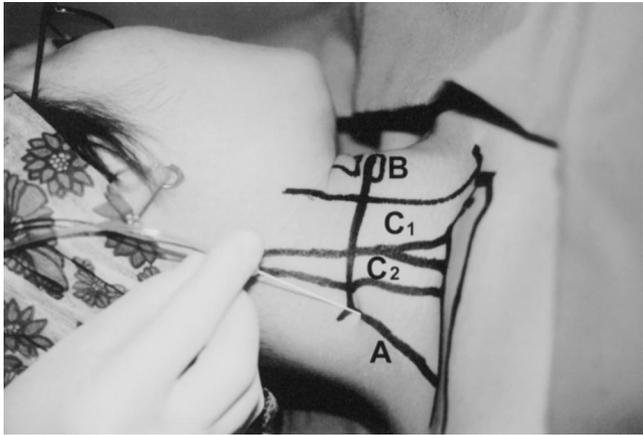


Fig. 1. The lateral modified technique. The needle is inserted toward the plane of the interscalene space (A) at an angle of between 45 and 60°. The point of puncture lies approximately 0.5 cm under the level of the cricoid (B). CI = sternal head of the sternomastoid muscle; C2 = clavicular head of the sternomastoid muscle.

the anterior and middle scalene muscle up to 2–3 cm. The catheter was subcutaneously tunneled for 4–5 cm through an 18-gauge intravenous cannula and was fixed to the skin with adhesive tape.¹¹ ISB was performed with 30 or 40 ml ropivacaine 0.5% for patients weighing less than 60 kg and 40 or 50 ml ropivacaine, 0.5%, for those weighing more than 60 kg. General anesthesia was performed with propofol by means of a target-controlled infusion (Diprifusor® TCI module; AstraZeneca Pharmaceuticals, Macclesfield, United Kingdom). The initial target was set at 4 µg/ml, and maintenance was targeted at twice the concentration at the effect site necessary for loss of consciousness. Fentanyl, 1.5 µg/kg, was given 3 min before intubation and vecuronium, 0.6 mg/kg, was given for facilitating tracheal intubation. Rocuronium, 0.15 mg/kg, was repeated if necessary. Supplementary fentanyl was given if blood pressure or heart rate increased more than 20% as compared to preinduction (pre-ISB) values. Postoperative analgesia was provided by patient-controlled interscalene analgesia (PCIA; Pain Management Provider; Abbott Laboratories, North Chicago, IL) with a continuous infusion of 0.2% ropivacaine at a rate of 5 ml/h plus a bolus dose of 4 ml with a lockout time of 20 min, which was started 6 h after the initial block and continued until pain and rehabilitation could be adequately performed without the need of the catheter.

A block was considered successful when a sensory (inability to recognize cold temperature, pins and needles-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 administration of local anesthetic. All of the catheter placements were performed by an anesthesiologist, who had performed more than 80 interscalene catheter placements. Performance and evaluation of the block were performed by the same anesthesiologist.

The block was considered to have failed when patients who only received local anesthetics needed general anesthesia because of pain during surgery. The need for added sedation because of pain in other joints or in the back or discomfort because of prolonged surgery were not classified as failure. The ISB in patients undergoing general anesthesia was considered a failure if the patient needed supplementary fentanyl during surgery or if the patient reported pain (visual analog scale score > 30) between awakening (end of surgery) and beginning of the perineural infusion of ropivacaine. Postoperatively, all patients received paracetamol (4 × 2 g intravenously; the first dose given 6 h after the initial ISB and then every 6 h) and rofecoxib (50 mg orally; the first dose given the morning after surgery) in addition to the local anesthetic infusion through the interscalene catheter. In case of pain over 20 at rest or over 30 during movement (visual analog scale from 0 = no pain to 100 = worst pain imaginable), the concentration of ropivacaine was increased to 0.3%, and if insufficient, the rate of the background infusion was increased to 8 ml/h. If these measures were insufficient, analgesia provided by the interscalene catheter was considered a failure. Monitoring of sensory and motor block was performed by nurses according to a standardized protocol in force for the past 8 yr in our department.

The number of punctures and technical difficulties during insertion of the catheter were recorded. Easy placement of the catheter was considered when only one attempt was necessary. Signs of local anesthetic toxicity, spinal or epidural extension, blood aspiration, hematoma, and pneumothorax were classified as short-term complications. The insertion site was checked once a day by a research nurse for local signs of infection or blood through the catheter. All surgical patients received intravenous cefazolin, 1 g/6 h, for 24 h. In case of signs of local inflammation or pus, ultrasonography was performed, the catheter was removed, and 3 cm of the distal portion was cut and sent to the laboratory for culture. Twenty-four hours after withdrawal of the catheter, patients were asked by the research nurse to rate their pain management on a scale from 0 = totally dissatisfied to 10 = completely satisfied.

All patients were monitored during a 6-month period after ISB (longer with occurrence of long-lasting complications) for 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 provoked; and the presence of pain unrelated to surgery. Pain unrelated to surgery was defined as 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, and 6 months, the patient was examined and questioned independently by one of the anesthesiology staff and the surgeon (L. N.). 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 department and one member of the surgery staff (L. N.), separately.

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 with 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 selected for electroneuromyography at 1 month were those who had either an increase in severity of any one of the complications (as compared to the first assessment and therefore classified one step higher on the severity scale) or spreading of the localization (larger nerve 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 months by one member of the anesthesiology staff and the surgeon (L. N.). Spontaneous resolution was defined as the disappearance of the symptoms and the inability to provoke them during examination of the patient.

Complications lasting more than 6 months were considered to be long-term, and those with some sensory-motor deficit impairing normal daily activities were considered severe.

Descriptive statistics were used. Results are presented as mean \pm SD unless otherwise specified.

Results

A total of 700 patients were included in the study over a 15-month period. The demographic and surgical data are summarized in table 1. Anesthetic procedures in the open surgery group are reported in table 2. In this

Table 1. Demographic and Surgical Data

	Surgery	
	Open	Arthroscopic
n	529	171
Sex, M/F	321/208	104/67
Age, yr	51 \pm 15	42 \pm 13
Weight, kg	77 \pm 19	81 \pm 21
Surgical time, min	146 \pm 32	68 \pm 17
Shoulder arthroplasty, No.	149	—
Rotator cuff repair, No.	258	58
Bankart operation, No.	101	15
Acromioplasty, No.	—	31
Capsulotomy, No.	—	61
Other, No.	21	6

group, five patients of 127 scheduled to have only an interscalene block with or without sedation had to receive general anesthesia because of pain during surgery (3.9%). Among patients who had interscalene block and general anesthesia, four of 402 (1%) had insufficient postoperative analgesia—two patients required reinsertion of the catheter, and the other two needed a continuous infusion of morphine. Supplementary perioperative boli of fentanyl were needed in these four patients. No other patients required perioperative opioids. Unplanned sedation during surgery was required for 15 patients. Remifentanyl (10 patients), because of pain in the back or other joints not involved by surgery, or propofol (five patients), because of anxiety or discomfort, was used for sedation. The concentration of ropivacaine for postoperative analgesia was increased to 0.3% in 31 patients (6%), and a concomitant increase of the background infusion of ropivacaine 0.3% up to 8 ml/h was needed in 14 of these patients. The pain was successfully controlled with these measures in all of these patients. Anesthetic procedures in the arthroscopic group are summarized in table 3. In this group, one patient out of 160 (0.6%) needed general anesthesia because of pain during surgery, and another asked postoperatively for a continuous infusion of morphine (0.5%). Ten patients of 106 (9%) needed sedation for discomfort or anxiety with remifentanyl or propofol (in 6 and 4 patients, respectively). Median patient satisfaction regarding pain management was 9.6 (range, 7.5–10).

The interscalene catheter was easy to insert (one attempt) in 603 patients (86%). Two, three, and four attempts were needed in 72 (10.4%), 23 (3.3%), and 2

Table 2. Anesthetic Procedures in the Open Surgery Group

No.	529
Planned combined ISC + general anesthesia	402
Planned ISC	93
Planned ISC + sedation	34
Unplanned general anesthesia	5
Unplanned sedation	15
Postoperative insufficient analgesia	4

ISC = interscalene catheter.

Table 3. Anesthetic Procedures in the Arthroscopic Group

No.	171
Planned ISC	106
Planned ISC + sedation	54
Planned ISC + general anesthesia	11
Unplanned general anesthesia	1
Added sedation	10
Postoperative insufficient analgesia	1

ISC = interscalene catheter.

(0.3%), respectively. In one patient (0.1%), it was not possible to elicit a muscular response; this patient was therefore excluded from the study. Technical data for placement of the interscalene catheter are reported in table 4. Isolated triceps or deltoid response was elicited in 73 and 6.5%, respectively. Inappropriate response that necessitated correction of the placement of the tip of the needle was found in 14 (phrenicus) and 19 (suprascapularis) patients, respectively. Among the patients who needed general anesthesia, five had an isolated deltoid and one had a mixed triceps deltoid response. Among those who had insufficient analgesia, three had a deltoid response, and one each had a triceps and mixed triceps-biceps response, respectively. Complications occurring during placement of the interscalene catheter are reported in table 5. The placement of the needle was changed in all patients who reported paresthesias, and the procedure could have been continued smoothly. Resistance during the catheter threading was encountered in 42 patients (6%) requiring a new puncture point.

Complications associated with the application of the initial bolus of 0.5% ropivacaine, early signs of central nervous system toxicity, were observed in five patients (0.7%)—tinnitus in three and metallic taste in two patients. These patients received a bolus of propofol of either 10 or 20 mg. No one developed subsequent signs of central nervous system toxicity. No cardiac toxicity or pneumothorax, spinal, or epidural anesthesia was observed. Among the side effects, Horner syndrome was detected in 6%, hoarseness was detected in 0.9%, and hematoma at the puncture point was detected in 0.2%. No catheter was dislodged in this study.

Signs and symptoms of infections were observed in six patients (0.8%). In five patients, local pain, redness, and

Table 4. Technical Data of the Interscalene Catheter Placement

Lowest current, median (range)	0.34 (1.8–4.9) mA
Isolated triceps response, No.	612
Isolated deltoid response, No.	46
Mixed triceps–deltoid, No.	61
Mixed triceps–biceps, No.	81
Diaphragmatic response, No.	14
Supraspinatus response, No.	19
Depth of nerve, median (range)	3.4 (1.6–5) cm
Duration of catheter, median (range)	3.2 (1.5–5) days

Table 5. Complications during Placement of the Interscalene Catheter

	No.
Paresthesias during puncture	6
Blood during puncture	12
Difficulties during catheter placement	
Transient pain in the shoulder	25
Paresthesias	2
Resistance during catheter threading	42
Blood within the catheter	5
Local dysesthesias during injection	11
Distal dysesthesias during injection	2

induration were noted in one after 3 days and in four patients after 4 days. Ultrasonography did not reveal the presence of a collection of pus. The tips of the catheters were sent for bacteriologic examination; two were positive for coagulase-negative *Staphylococcus*—one for *Staphylococcus aureus*—and two remained noncolonized. All patients were successfully treated with antibiotics. In one diabetic patient, a collection was evidenced by ultrasonography after 5 days. Surgical drainage was performed, followed by administration of antibiotics. The culture of the catheter tip was positive for coagulase-negative *Staphylococcus*. Hemocultures remained negative. Complete recovery was observed after 10 days of treatment.

Neurologic complications are summarized in table 6. All symptoms appeared within the first 19 days after the ISB. No patient had symptoms that recurred during the course of the study. Two patients underwent brachial plexus ultrasonography and electroneuromyography 2 days after the interscalene catheter was withdrawn because of persistence of sensory–motor block. The results of these investigations were unremarkable in both cases.

On the tenth day, 56 patients (8%) reported the presence of paresthesia, dysesthesia, or pain apparently not related to surgery. For all of these patients, the symptoms were mild, and no further investigation was undertaken. Two patients still had complete sensory–motor blockade of the upper extremity.

At 1 month, 17 patients (2.4%) had persistence of paresthesia, dysesthesia, or pain apparently not related to surgery. Among these, 0.3% had the first appearance

Table 6. Time of Diagnosis of the Nonacute Complication and Spontaneous Resolution of Symptoms

	10 Days	1 Months	3 Months	6 Months
Symptomatic patients	56	17	2	—
Spontaneous resolution	39	12	2	—
SUS	—	3	—	—
CTS	—	1	—	—
CRPS	—	1	—	—
Prolonged sensory–motor deficit	2	2	2	1

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

of paresthesias–dysesthesias on the fourteenth and nineteenth days. Ten underwent electroneuromyography because of worsening of the symptoms. Sulcus ulnaris ($n = 3$), carpal tunnel syndrome ($n = 1$), and complex regional pain syndrome ($n = 1$) were diagnosed. The other 5 were unremarkable. Thirty-nine patients had spontaneous resolution of symptoms between the tenth postoperative day and the first month. Electromyography of the two patients with sensory–motor deficit showed diffuse brachial plexus damage involving the middle and inferior trunks in particular.

At 3 months, two patients (0.3%) still had some symptoms. Electroneuromyography was normal in both. Twelve patients had spontaneous resolution of their symptoms between the first and third postoperative month (table 6). Electromyography of the two patients with sensory–motor deficit showed early signs of regeneration consisting of fasciculation potentials and large and complex potentials. Clinically, both could perform wrist and finger flexion. Finger extension was hardly perceptible. Neuropathic pain had appeared in the involved arm of both patients, which was treated with gabapentin and paracetamol.

At 6 months, no patient was symptomatic. Two patients had spontaneous resolution of their symptoms (table 6). One of the patients with sensory–motor deficit had completely recovered after 19 weeks. Her electroneuromyograph was normal. The only symptom was persistence of light paresthesia in the thumb. The other one showed partial recovery of strength. She still had sensory dysfunction (hypesthesia and dysesthesia) in the territory of the radial and ulnar nerves. Her electroneuromyograph had almost completely returned to normal. The presence of large and complex potentials were still noted on the middle trunk. Complete recovery occurred after 28 weeks.

After returning home, no patient, except the two with sensory–motor deficit, needed supplementary analgesics other than those prescribed by the surgeon for pain related to surgery. Rehabilitation and return to work or usual activity was not delayed, except for the patients with sensory–motor deficit, sulcus ulnaris syndrome, complex regional pain syndrome, and carpal tunnel syndrome, who had specific surgical or medical treatments.

Discussion

This prospective study shows that the use of the modified lateral approach for placement of a perineural catheter within the interscalene space by experienced anesthesiologists, following a standardized technique, use of material, and drug application is associated with a high success rate of effective anesthesia and postoperative analgesia and a low rate of acute and chronic complications.

The interscalene catheter has become the technique of choice for the management of postoperative pain management after shoulder surgery.^{2,5} To date, most of the studies dealing with this topic have used Winnie's approach, with various degree of success (for anesthesia, from 80% to 87%; for postoperative analgesia,¹² from 83%¹³ to 87%¹⁴). Our success rate (97%) is higher and is comparable to the 94% obtained by Meier *et al.*,⁸ who used an approach similar to ours. Our results may be explained by the anatomical approach.¹⁰ The placement of the interscalene catheter is challenging to perform because the catheter has to be placed in a “sandwich-like” manner between the two scalene muscles, whose shape, thickness, direction, and spatial orientation differ greatly between individuals. Winnie's approach does not take into account all these factors and may explain the relative high rate of catheter placement failure, whereas the success rate of the single shot is high by using the same approach.¹⁵ One may argue that our results may be biased because only experienced anesthetists, each having performed more than 80 interscalene catheter blocks, were involved in this trial. We chose this to have coherent and applicable results, avoiding the issue of mixed results from inexperienced and experienced anesthetists.

The modified lateral approach (fig. 1) takes into account the three-dimensional image of the interscalene space, and the needle is directed caudally and slightly laterally or medially, according to the plane of the interscalene space. The puncture point is just below Winnie's point to avoid piercing of the scalene muscles. The tangential approach of the plexus offers good conditions for placing the catheter. Meier *et al.*⁸ use the same approach, but their puncture point is more cephalad, increasing the chances to hit the scalene muscles.

Difficulties to insert the catheter, when reported, had been encountered by Singelyn *et al.*⁶ in 66% and Tuominen *et al.*⁷ in up to 25% when dislocation was considered; both used Winnie's approach. We had difficulties in threading the catheter in 6%; anatomic reasons as described above may explain our lower incidence.

Acute complications associated with the interscalene catheter have still not been extensively investigated. Serious complications such as total spinal anesthesia,¹⁶ epidural anesthesia,¹⁷ and injection in the spinal cord¹⁸ reported with Winnie's techniques have not been observed in any of our patients. The occurrence of these complications may be decreased by the modified lateral approach because the needle is directed away from the cervical spine toward the interscalene space. These results confirmed those found in our previous study.⁹ Aspiration of blood was encountered in 0.7%; the needle was directed and the ISB was performed without any other complications. Local and distal dysesthesias during injection of the initial bolus occurred in 1.8%; in all cases, drug administration was stopped, the needle was

slightly displaced, and the injection could be continued uneventfully. Minor side effects such as Horner syndrome or recurrent laryngeal nerve blockade were encountered in 6% and 0.9%, respectively. Using Winnie's technique and a single shot, Jochum *et al.*¹⁹ noticed an incidence of Horner syndrome of 71% and an incidence of recurrent laryngeal nerve blockade of 3%, similar to the incidences reported by Vester-Andersen *et al.*²⁰ using the same approach. Horner syndrome was present in 13% in the study of Meier *et al.*,⁸ an incidence close to that in our study. This can be explained by the more distal administration of the drug through the catheter within the interscalene diffusion space, making the preganglionic sympathetic fibers going to the stellate ganglion less exposed to the spreading of the local anesthetic.

Perineural catheter infection is an issue that has received little attention to date. Cuvillon *et al.*²¹ were the first to prospectively document the incidence of colonization and infection of a perineural catheter. They found that the femoral catheter was colonized in 57% and in 1.5% with bacteremia after 48 h. In a multicenter study involving 1,416 perineural catheters of different anatomic locations, Bernard *et al.*²² disclosed a rate of colonization of 28%; 3% had signs of local inflammation, and infection was found in 0.07%, which is similar to our findings. In their study, the coagulase-negative *Staphylococcus* was frequently isolated from the interscalene catheter, which is in accordance with our results. The absence of antibioprophyllaxis, the duration of the catheter, and transfer from the intensive care unit to the ward were identified as risk factors for the development of perineural catheter colonization. If strict aseptic surgical conditions are respected, preliminary results indicate that the incidence of infection of perineural catheter is low. However, further studies taking the location of each catheter into consideration are needed because the first studies pointed out that the incidences and the bacteria found in the femoral or the interscalene perineural catheter are not similar.

Neurologic damage is a major issue dealing with perineural catheters because it is accepted that neurotoxicity of a local anesthetic depends on its neurotoxic potency, its concentration, and how long the nerve tissue is exposed to the agent.^{23,24} The frequency of peripheral nerve complications reported after single-shot peripheral nerve blockade varies from 0 to more than 5%.²⁵ One case of plexus irritation, caused by an interscalene catheter, has been reported.²⁶ In a previous study, Borgeat *et al.*⁹ found an incidence of neurologic complications, mostly minor, of 6, 2.6, and 0.4% at 1, 3, and 6 months, respectively, in patients after an interscalene catheter. In the current study, we observed a lower incidence of "minor" neurologic complications of 2.4, 0.3, and 0% at 1, 3, and 6 months, respectively.

We had two patients who had a severe and prolonged

sensory-motor deficit involving the middle and lower trunks in particular, who needed 19 and 28 weeks, respectively, to recover. In both patients, the placement of the catheter was uneventful, and both received 0.2% ropivacaine at standard infusion rate (ground infusion 5 ml/h, bolus 4 ml, lockout time 10 min) for postoperative analgesia. These two patients had many similarities: both were female, their ages were similar (64 and 68 yr), their body mass indexes were relatively low (20 and 22), and both underwent shoulder arthroplasty and had sensory-motor deficit involving the middle and lower cords, which was present early postoperatively. In both cases, the continuous infusion of ropivacaine was stopped after 36 h because of the absence of any sensory-motor recovery in the territory of the radial and ulnar nerves. Although one cannot completely exclude the link between the block and the sensory-motor deficit, it seems unlikely to be directly involved in this complication. An intraneural injection can be ruled out, a plexus compression due to a hematoma was excluded by ultrasonography, and electromyographic investigations were suggestive of partial axonotmesis, a lesion most frequently encountered after plexus damage due to malpositioning or stretching. The occurrence of postoperative neuropathy (0.21%) found by Capdevila *et al.*²⁷ in a multicenter study including 1,416 patients is comparable to the occurrence (0.2%) observed in our study. An incidence of new postoperative neurologic deficits was observed in 1% by Berman *et al.*²⁸ in a retrospective evaluation of 405 continuous axillary catheters. The incidence of nerve injuries after shoulder arthroplasty is reported to occur in 1–4%²⁹ (2 of 149 [1.3%] in the current study). Lynch *et al.*³⁰ reported on 13 brachial plexus damages with neurologic deficit out of 417 shoulder arthroplasties, with spontaneous good recovery in 90% of the cases. The authors found the deltopectoral approach and the use of methotrexate to have a significant correlation. There was no significant correlation with interscalene block. Traction was the most likely explanation for neurologic complication that occurred.

Overall, the experience with interscalene block anesthesia has shown this modality to offer a safe and effective means of providing perioperative analgesia.^{31–33} However, the possibility of a link between older, thin women having an interscalene block for shoulder arthroplasty and the apparition of postoperative neurologic deficit remains open, and further studies focusing on these aspects will be welcomed.

In conclusion, this prospective study shows that the modified lateral approach for performing ISB fulfills the modern criteria for this block, which are, first, reducing the occurrence of severe complications and, second, offering good conditions for the placement of a perineural catheter, the technique of choice for the postoperative pain treatment after shoulder surgery. Moreover, this study demonstrates that the interscalene catheter in

trained hands does not seem to increase the incidence of acute or chronic neurologic complications. The incidence of infection is low, but strict aseptic conditions have to be respected during the procedure. Finally, patient acceptance of the interscalene catheter and patient satisfaction with pain control are high.

The authors thank Volker Dietz, M.D., F.R.C.P. (Head of the Paraplegic Center and Chairman), and Armin Curt, M.D. (Assistant Professor), both from the Swiss Paraplegic Center, University Hospital Balgrist, Zurich, Switzerland, for performing and interpreting the electromyographs.

References

- Enneking FK, Wedel DJ: The art and science of peripheral nerve blocks. *Anesth Analg* 2000; 90:1-2
- Borgeat A, Schättli B, Biasca N, Gerber C: Patient-controlled analgesia after major shoulder surgery. *ANESTHESIOLOGY* 1997; 87:1343-7
- Mezzatesta JP, Scott DA, Schweitzer SA, Selander DE: Continuous axillary brachial plexus block for postoperative pain relief: Intermittent bolus versus continuous infusion. *Reg Anesth* 1997; 22:357-62
- Capdevila X, Barthelet Y, Biboulet P, Ryckwaert Y, Rubenovitch J, D'Athis F: Effects of perioperative analgesic technique on the surgical outcome and duration of rehabilitation after major knee surgery. *ANESTHESIOLOGY* 1999; 91:8-15
- Singelyn FJ, Deyaert M, Joris D, Pendeville E, Gouverneur JM: Effects of intravenous patient-controlled analgesia with morphine, continuous epidural analgesia, and continuous three-in-one block on postoperative pain and knee rehabilitation after unilateral total knee arthroplasty. *Anesth Analg* 1998; 87:88-92
- Singelyn FJ, Seguy S, Gouverneur JM: Interscalene brachial plexus analgesia after open shoulder surgery: Continuous versus patient-controlled infusion. *Anesth Analg* 1999; 89:1216-20
- Tuominen M, Haasio J, Hekali R, Rosenberg PH: Continuous interscalene brachial plexus block: Clinical efficacy, technical problems and bupivacaine plasma concentration. *Acta Anaesthesiol Scand* 1989; 33:84-8
- Meier G, Bauereis C, Heinrich C: Interscalene brachial plexus catheter for anesthesia and postoperative pain therapy: Experience with a modified technique. *Anaesthesist* 1997; 46:715-9
- Borgeat A, EkatoDRAMIS G, Kalberer F, Benz C: Acute and nonacute complications associated with interscalene block and shoulder surgery. *ANESTHESIOLOGY* 2001; 95:875-80
- Borgeat A, EkatoDRAMIS G: Anaesthesia for shoulder surgery. *Best Pract Res Clin Anaesthesiol* 2002; 16:211-25
- EkatoDRAMIS G, Borgeat A: Subcutaneous tunneling of the interscalene catheter: A simple and effective method to prevent interscalene catheter dislocation. *Can J Anaesth* 2000; 47:716-7
- Haasio J, Tuominen M, Rosenberg PH: Continuous interscalene brachial plexus block during and after shoulder surgery. *Ann Chir Gynaecol* 1990; 79:103-7
- Cohen NP, Levine WN, Marra G, Pollock RG, Flatow EL, Brown AR, Bigliani LU: Indwelling interscalene catheter anesthesia in the surgical management of stiff shoulder: A report of 100 consecutive cases. *J Shoulder Elbow Surg* 2000; 9:268-74
- Pere P: The effect of continuous interscalene brachial plexus block with 0.125% bupivacaine plus fentanyl on diaphragmatic motility and ventilatory function. *Reg Anesth* 1993; 18:93-7
- Urban MK, Urquhart B: Evaluation of brachial plexus anesthesia for upper extremity surgery. *Reg Anesth* 1994; 19:175-82
- Dutton RP, Eckhardt WF III, Sunder N: Total spinal anesthesia as a complication of interscalene block of the brachial plexus. *ANESTHESIOLOGY* 1994; 80:939-41
- Scammell SJ: Inadvertent epidural anaesthesia as a complication of interscalene brachial plexus block. *Anaesth Intensive Care* 1979; 7:56-7
- Benumof JL: Permanent loss of cervical spinal cord function associated with interscalene block performed under general anesthesia. *ANESTHESIOLOGY* 2000; 93:1541-4
- Jochum D, Roedel R, Gleyze P, Balliet JM: Bloc interscalénique et chirurgie de l'épaule: Etude prospective d'une série continue de 167 patients. *Ann Fr Anesth Reanim* 1997; 16:114-9
- Vester-Andersen T, Christiansen C, Hansen A, Sorensen M, Meisler C: Interscalene brachial plexus block: Area of analgesia, complications and blood concentrations of local anesthetics. *Acta Anaesthesiol Scand* 1981; 25:81-4
- Cuvillon P, Ripart J, Lalourcey L, Veyrat E, L'Hermite J, Boisson Ch, Thouabtia E, Eledjam JJ: The continuous femoral nerve block catheter for post-operative analgesia: Bacterial colonization, infectious rate and adverse effects. *Anesth Analg* 2001; 93:1045-9
- Bernard N, Pirat P, Branchereau S, Gaertner E, Capdevila X: Continuous peripheral nerve blocks in 1416 patients: A prospective multicenter study measuring incidences and characteristics of infectious adverse events (abstract). *ANESTHESIOLOGY* 2002; 96:A882
- Selander D: Neurotoxicity of local anesthetics: Animal data. *Reg Anesth* 1993; 18:461-8
- Bainton CR, Strichartz GR: Concentration dependence of lidocaine-induced irreversible conduction loss in frog nerve. *ANESTHESIOLOGY* 1994; 81:657-67
- Selander D: Nerve toxicity of local anaesthetics, *Local Anaesthesia and Regional Blockade*, 1st edition. Edited by Löfström JB, Sjöstrand U. Amsterdam, Elsevier Science, 1988, p 77
- Ribeiro FC, Georgousis H, Bertram R, Scheiber G: Plexus irritation caused by interscalene brachial plexus catheter for shoulder surgery. *Anesth Analg* 1996; 82:870-2
- Capdevila X, Pirat P, Branchereau S, Gaertner E, Bernard N: Continuous peripheral nerve blocks in 1416 patients: A prospective multicenter descriptive study measuring incidences and characteristics of non infectious adverse events (abstract). *ANESTHESIOLOGY* 2002; 96:A881
- Bergman BD, Hebl JR, Kent J, Horlocker TT: Neurologic complications of 405 consecutive continuous axillary catheters. *Anesth Analg* 2003; 96:247-52
- Boardman ND III, Cofield RH: Neurologic complications of shoulder surgery. *Clin Orthop* 1999; 368:44-53
- Lynch NM, Cofield RH, Silbert PL, Hermann RC: Neurologic complications after total shoulder arthroplasty. *J Shoulder Elbow Surg* 1996; 5:53-61
- Arciero RA, Taylor DC, Harrison SA, Snyder RJ, Leahy KE, Uhorchak JM: Interscalene anesthesia for shoulder arthroscopy in a community-sized military hospital. *Arthroscopy* 1996; 12:715-9
- Conn RA, Cofield RH, Byer DE, Linstromberg JW: Interscalene block anesthesia for shoulder surgery. *Clin Orthop* 1987; 216:94-8
- Kinnard P, Truchon R, St-Pierre A, Montreuil J: Interscalene block for pain relief after shoulder surgery: A prospective randomized study. *Clin Orthop* 1994; 304:22-4

Appendix: The Modified Lateral Technique

The patient lies supine, turning the head slightly away from the side to be blocked. Then, he or she is asked to elevate the head slightly to bring the clavicular head of the sternomastoid muscle into prominence. A right-handed anesthetist should place the index and middle fingers of the left hand immediately behind the lateral edge of the sternomastoid muscle and instruct the patient to relax so that the palpating fingers move medially behind this muscle and finally lie on the belly of the anterior scalene muscle. They are then rolled laterally across the belly of this muscle until the interscalene groove is palpated. After exact palpation a line is drawn on the skin along the interscalene groove. This is crucial because it gives information about its shape, depth, and course and helps the anesthetist to gain a three-dimensional image of the interscalene space. The point of needle insertion lies 0.5 cm below the level of the cricoid. The needle is inserted with regard to the configuration of the interscalene space at an angle of between 45 and 60°, depending of the anatomical characteristics of the patient's interscalene groove (fig. 1).