

Does Interscalene Catheter Placement with Stimulating Catheters Improve Postoperative Pain or Functional Outcome After Shoulder Surgery? A Prospective, Randomized and Double-Blinded Trial

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BACKGROUND: In this prospective, randomized, double-blind trial we investigated the use of stimulating catheters in patients during and after shoulder surgery; functional improvement being the primary outcome measurement.

METHODS: After eliciting an adequate muscular twitch at ≤ 0.5 mA nerve stimulation output, the perineural catheter was advanced either blindly (conventional catheter = CC group, $n = 20$) or guided by stimulation via the catheter (stimulating catheter = SC group, $n = 20$). A bolus of 40 mL prilocaine 1% and 10 mL ropivacaine 0.75% was injected, followed by a patient-controlled infusion of ropivacaine 0.2% (8 mL/h infusion rate, bolus 2 mL, lockout time 20 min).

RESULTS: Onset of motor block was faster in the SC group, whereas sensory block did not differ between groups. Median pain scores on two postoperative days were equal. Improvement of the objective shoulder function score (Constant Murley Score) 6 wk postoperatively was enhanced to a clinically relevant extent in the SC group compared to the CC group ($P < 0.01$).

CONCLUSIONS: We conclude that the use of a stimulating catheter results in a faster onset of motor block, unaltered postoperative pain, and a significantly improved functional outcome 6 wk after shoulder surgery.

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Regional anesthesia not only reduces postoperative pain, but also facilitates functional recovery after orthopedic surgery (1-3). A major problem of peripheral nerve block catheters is that although a sufficient block can be achieved by initial bolus injection via the cannula, postoperative analgesia through the catheter is insufficient in up to 75% of patients (4,5). The secondary failure rate seems to be highest with interscalene catheters (4,5). Consequently, the interscalene block is theoretically the peripheral nerve block which might benefit most by use of a stimulating catheter.

Stimulating catheters have been developed to precisely control catheter placement (6). No previous study has evaluated the effects of stimulating catheters during and after blocks of the upper extremity. Furthermore, there are no studies evaluating the long-term effect of

stimulating catheters on the functional outcome after surgery.

Hence, we investigated patients undergoing elective shoulder surgery. In these patients postoperative function and outcome are presumably dependent on the ability to perform physiotherapy (7). We hypothesized that a stimulating catheter, by producing superior analgesia, enhances functional recovery 6 wk after surgery.

METHODS

This prospective, randomized, double-blind trial was approved by our local ethics committee and written informed consent was obtained from each patient. Patients scheduled for elective surgery of the shoulder were included. Exclusion criteria were pregnancy, lactation, infection or prior surgery at the site of catheter insertion, age < 18 yr, coagulopathies, clinically apparent neuropathy, lack of patient consent for regional anesthesia, inability to locate the plexus with the needle (current ≤ 0.5 mA) within 20 min, and withdrawal of patient consent. Forty-three patients undergoing shoulder surgery under a combination of interscalene block and general anesthesia received a continuous interscalene block performed by one anesthesiologist with considerable experience in peripheral nerve blocks. Patients received 7.5 mg midazolam orally on the day of surgery.

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The interscalene blocks were performed after infiltration of the skin with 3 mL lidocaine 1% and sedation with 1–2 mg of alfentanil. The interscalene plexus was approached longitudinally using a landmark technique (8,9). In both groups, the same stimulating catheter set (StimuCath®, Arrow, Erding, Germany) with a 17-gauge isolated Tuohy needle and a 19-gauge catheter was used. Starting with a current of 1 mA (frequency: 2 Hz; stimulus width: 0.1 ms; Stimuplex® HNS 11; Braun, Melsungen, Germany), the needle was advanced until contraction of the deltoid or biceps muscles was detected and the current was reduced to levels ≤ 0.5 mA. The needle was relocated if required. Patients were randomized when a motor response was elicited with a current ≤ 0.5 mA through the needle within 20 min. If this goal could not be achieved within 20 min, the patient was excluded from the study. The patient, as well as the anesthesiologist performing the general anesthesia and evaluating onset of block, postoperative analgesia, and shoulder function, was unaware of the randomization. In the conventional catheter group (CC group) the catheter was blindly advanced 1–2 cm through the needle without stimulation of the catheter. In the stimulating catheter group (SC group), the catheter was advanced until a motor response with a current of ≤ 0.5 mA could be elicited. If no motor response could be elicited with the same current, the catheter or needle was redirected until a motor response was evoked. The needle was carefully withdrawn and the catheter sutured to the skin. Thereafter, correct catheter placement was rechecked by stimulation.

In both groups, the duration of catheter placement from skin infiltration to suturing the catheter to the skin was noted. Thereafter, 40 mL of prilocaine 1% and 10 mL of ropivacaine 0.75% were injected as a bolus through the catheter within 3 min. After data collection for onset time of block, general anesthesia was induced with 2 mg/kg propofol, 0.5 mg alfentanil, muscle relaxation by rocuronium 0.6 mg/kg, and a continuous propofol infusion was started (10 mg/kg \cdot h⁻¹ for the first 20 min and 5–8 mg/kg \cdot h⁻¹ thereafter). Nitrous oxide was not used. The trachea was intubated and the patient positioned semirecumbent without traction to the shoulder. When depth of anesthesia was considered insufficient, a remifentanil infusion (0.2 μ g/kg/min) was started. Two hours after bolus administration of the local anesthetics, a continuous infusion of 8 mL/h of ropivacaine 0.2% was injected through the interscalene catheter. Postoperatively, a patient-controlled analgesia pump (PEGA® plus, Pegasus, Kiel, Germany) was started (8 mL/h ropivacaine 0.2% with a bolus of 2 mL and a log-out time of 20 min). All patients received the same postoperative physiotherapy during their hospital stay.

Analgesia

After insertion of the catheter, the patients were asked to rate their discomfort on a number rating

Table 1. Demographic Data, Preoperative Functional Scores

	Conventional catheter group (n = 20)	Stimulation catheter group (n = 20)
Age (yr)	48 (35/57.25)	49 (40/53.75)
Sex ratio (male/female)	7/13	8/12
Body mass index (kg/m ²)	25.2 (22.1/27.1)	25.7 (23.1/30.3)
ASA	2 (1/2)	2 (1/2)
Surgery (n)		
Calcified tendopathy	11	12
AC arthropathy	5	5
Impingement	3	1
Biceps tendinitis	1	2
Duration of surgery (min)	69.5 (54/98)	55 (43/75)
CMS preoperatively*	43.0 (26.5/58.5)	30.0 (18.5/34.0)
DASH Score preoperatively	51.6 (34.8/63.0)	52.9 (38.7/66.9)

AC = acromioclavicular; DASH Score = Disability of Arm, Shoulder, and Hand Score (0–100 points); CMS = Constant Murley Score (0–100 points).

Data are presented as median (25th/75th percentile) or *n*.

* *P* = 0.04.

scale. Starting at the end of the local anesthetic injection, sensory changes and motor strength were measured every 5 min for 30 min. Pinprick sensation was evaluated by a needle wheel and motor strength of the axillary, musculocutaneous, and radial nerve was tested on a three-point scale (normal, diminished, plegic). Complete loss of pinprick sensation and complete motor block were the predefined end points to analyze the onset of block.

The pain score was evaluated by means of a numeric rating scale (0–10) for pain at rest and pain on mobilization (10° abduction) of the shoulder at discharge from the postoperative care unit, 12, 24, and 48 h after injection of the bolus dose of local anesthetic. The number of boluses delivered through the interscalene catheter was documented by the infusion pump. If the patient was still experiencing severe pain a rescue medication of 1 g metamizol (a nonsteroidal antiinflammatory drug) was administered by mouth. In case of insufficient analgesia, 7.5 mg piritramide (a synthetic opioid) was injected subcutaneously. The number of local anesthetic boluses and rescue medications were summed within 48 h after the first injection of local anesthetics. The postoperative pain therapy through the catheter was continued as long as needed. After withdrawal of the catheter, the patient was asked to judge the quality of analgesia on a numeric rating scale, and the intention to choose an interscalene catheter in a future operation was documented.

Functional Outcome

Preoperatively and 6 wk postoperatively, the subjective disabilities of the shoulder of each patient were assessed by the Disability of Arm, Shoulder, Hand (DASH) Score questionnaire and the functional abilities were investigated by the Constant Murley Score (CMS) (10–12).

Table 2. Characteristics of Catheter Placement*

	Conventional catheter group (n = 20)	Stimulation catheter group (n = 20)
Catheter placement time (min)	6.5 (5/9.5)	9 (6.5/14.5)
Lowest stimulation (mA)	0.4 (0.3/0.5)	0.4 (0.3/0.5)
Ratio of patients (n) with predominant biceps/deltoid muscle stimulation	9/11	12/8
Catheter depth (cm)	9.5 (9/10)	8 (7/10)
Patient satisfaction with catheter placement	2 (1/2)	2 (1/3)
Number of vessel punctures (n)	4	4

Patients rated their satisfaction with catheter placement on a scale from 1 to 6: 1 representing very well, 6 representing very unpleasant. Data are presented as median (25th/75th percentile) or n.

* There were no significant differences between groups.

Table 3. Onset of Sensory and Motor Block (Axillary, Muculocutaneous, and Radial Nerve)

Quality	Conventional catheter group (n = 20)	Stimulation catheter group (n = 20)
Overall nerve blocks		
Pinprick sensation	20 (10/30)	20 (10/45)
Light touch sensation	20 (10/45)	20 (10/45)
Motor block*	20 (10/41.25)	10 (5/20)

Time in minutes to complete sensory (pinprick and light touch sensation) and motor block. Data are presented as median (25th/75th percentile).

* $P = 0.02$.

The CMS is the official score of the European Society of Shoulder and Elbow Surgery and the German Society of Shoulder and Elbow Surgery for scientific evaluation of shoulder function. The CMS is a 100-point functional shoulder assessment tool in which higher scores reflect increased function (12). It combines four separate subscales: subjective pain (15 points), function (20 points), objective clinical assessment of range of motion (40 points), and strength (25 points). The CMS system is used internationally as a means of establishing normal levels of shoulder function appropriate for different age groups and to establish what constitutes disability in normal individuals (12). It has also been used to establish differential rates of progress after injury or treatment and a high reliability has been reported (12,13). Thus, an increase in CMS by 30 is considered as an enhanced range of pain-free movement and strength as well as less pain during rest and daily activities.

The American Academy of Orthopedic Surgeons' outcome research committee developed and validated a functional outcome questionnaire for disabilities of the upper extremity (DASH). The DASH score evaluates symptoms and upper extremity functional status to determine the relative impact of disorders. The DASH is a 30-item questionnaire with a 5-item response option for each item, e.g., 1 item rates the ability of a patient to turn a key on a 5-point scale from 1 representing no difficulty to 5 representing the inability to turn a key with the disabled arm. The DASH score is calculated by the formula [(sum of all values)/30 - 1] × 25. The test has a maximum score of

100 and a greater disability is reflected by higher scores. It can be used to determine change over time (14). Discriminative validity has also been determined, indicating that patients who were currently able to work with their condition or who were able to complete activities of daily living to their satisfaction recorded statistically significant differences in DASH scores, versus those who were unable to work or complete daily functions (14). Although it is a subjective questionnaire, a good correlation with the more objective CMS has been validated (15).

Six weeks after the operation, patients were seen in clinics to evaluate DASH and CMS scores and to examine for neurologic dysfunction of the arm.

Statistical Analysis

A functional improvement of 30 points in CMS by use of stimulation-guided catheter placement was considered clinically relevant. To demonstrate a difference of 30 points between groups with distribution-free statistics, the study had a proposed total sample size of 40 ($\alpha = 0.05$; two-tailed; power of 0.9) to yield a significant result. All data are presented as median (25%/75% percentiles). Calculations were made with the SPSS program 12.0 (SPSS, Chicago, IL). Comparisons between groups in onset time, postoperative pain score (numeric rating scale, area under the curve), number of self-administered local anesthetic boluses, number of systemic rescue medications as well as improvement of shoulder function scores (DASH and CMS) were made by unpaired two-sided Mann-Whitney *U*-test. Numeric values (e.g., number of vessel punctures, number of patients receiving intraoperative analgesics) between groups were compared by Fisher's exact test. A value of $P < 0.05$ was considered significant. The *P* values of the primary outcome measurements (the two functional scores) were corrected by Bonferroni-Holmes adjustments for multiple comparisons.

RESULTS

Forty-three patients were scheduled for inclusion into the study. Three patients were not randomized, because a motor response with a current ≤ 0.5 mA through the needle could not be achieved within 20

Table 4. Postoperative Pain Scores and Analgesic Therapies*

	Conventional catheter group (n = 20)	Stimulation catheter group (n = 20)
Patients receiving intraoperative analgesics (n)	4	3
NRS-AUC resting	0.3 (0/1.3)	0 (0/1.6)
NRS-AUC mobilization	1.5 (0.3/2.9)	1.2 (0.4/2.4)
Ropivacaine boluses	2.5 (1/19)	9.5 (1/16)
Rescue medications	0 (0/4)	1 (1/2)
Duration of therapy over the interscalene catheter (h)	53 (50/77)	50 (35/74)
Patients rating of analgesic quality (1 = very good, 6 = very bad)	1 (1/1.25)	1 (1/2)
Patients choosing an interscalene catheter in an future operation (n)	19	19

NRS-AUC = area under the curve of the numeric rating scale during the first 48 postoperative hours. Data are presented as median (25th/75th percentile) or n.

* There were no significant differences between groups.

Table 5. Functional Outcome

	Conventional catheter group (n = 20)	Stimulation catheter group (n = 18)
Functional improvement		
DASH Score	-10.3 (-35.0/12.4)	-29.4 (-39.4/-4.2)
CMS*	4.0 (-15.8/19.5)	34.5 (8.5/51.5)

Note: A negative change in DASH Score means a functional improvement, whereas a functional improvement in CMS results in positive values.

DASH Score = disability of arm, shoulder, and hand score (0-100 points); CMS = constant Murley score (0-100 points).

Data are presented as median (25th/75th percentile).

* $P < 0.01$.

min. In four patients, the catheter was dislocated within the first postoperative day (three in the SC group, one in the CC group). They were included in an intention-to-treat analysis. Postoperatively, one patient fell on the operated shoulder 4 wk after surgery and one patient was lost to follow-up. Both patients were in the SC group. These patients were not included in the analysis of the shoulder function tests 6 wk after surgery.

There were no significant differences between the groups' in patient demographics or characteristics of catheter placement except for preoperative CMS (Tables 1 and 2).

Median onset of complete motor block was 10 min faster in the SC group, whereas onset of sensory block was not significantly different between groups (Table 3).

The mean postoperative pain scores at rest and during mobilization, the number of self-administered ropivacaine boluses and the number of rescue medications were not significantly different between groups during the first 48 postoperative hours (Table 4). Duration of therapy over the interscalene catheter was equal (Table 4). The shoulder function scores of the SC group improved 6 wk postoperatively more in the SC than in the CC group (Table 5), as assessed by CMS. However, there was no difference in functional outcome using the DASH criteria.

One patient (SC group) had paresthesias in the small finger, which gradually resolved within 4 mo. Two patients (one in each group) developed severe

pain in the shoulder and arm postoperatively, which lasted 4 mo. One patient (CC group) reported severe pain in the complete arm after withdrawal of the catheter. All four patients underwent neurologic and neurophysiologic evaluation. The patient who reported pain after withdrawal of the catheter had a positive Tinnel sign at the Erb's point, a clinical sign of damage, and regeneration of a peripheral nerve. Despite extensive investigations in no case could a clear etiology of these deficits be identified. Also, no patient had objective signs of nerve damage (anesthesia, weakness, alteration of nerve conduction).

DISCUSSION

The use of the stimulating catheter improved onset of motor nerve block, but did not reduce postoperative pain, local anesthetic and analgesic requirements. Nevertheless, shoulder function scores improved significantly more in patients with a stimulating catheter.

This is the first trial evaluating the effects of stimulating catheters in upper extremity blocks. Studies evaluating the use of stimulating catheters of the lower extremity have produced contradictory results. A trial of femoral nerve blocks in volunteers showed a tendency towards increased success rates and significantly improved sensory and motor block (16), whereas in one retrospective survey no differences in postoperative pain or medication could be observed when switching from nonstimulating to stimulating catheters (17). A randomized, observer-blinded trial did not find any difference in onset time, postoperative pain, or analgesic consumption in patients undergoing major knee surgery with the aid of a femoral nerve catheter (18). Our study had the advantage that all nerves innervating the shoulder can be blocked by the interscalene catheter, whereas the study cited above may have been biased by the unblocked sciatic and obturator nerves. Casati et al. (19) investigated stimulating catheter placement during distal sciatic nerve block for foot surgery and demonstrated a reduced onset time of block. We also observed a shortened onset of motor block. Casati et al. also observed a 25% reduction of local anesthetic requirement, but no difference in postoperative pain scores (19). In contrast, the most recent study

investigating the stimulating catheter in patients undergoing hallux valgus surgery under sciatic nerve block reported a reduced pain score with the aid of a stimulating catheter (20). In the latter study, the patients received a comparatively low basal rate of local anesthetics (3 mL/h levobupivacaine 0.125%) compared with our rate (8 mL/h ropivacaine 0.2%). This may have been why these authors could demonstrate an advantage of the stimulating catheters, whereas we and others using higher doses of local anesthetics could not (18,19). Our overall low pain score is certainly related to the good postoperative pain regime with a high continuous rate and the possibility to self-administered boluses of local anesthetic, as shown by others (21–23). However, none of these studies evaluated long-term functional outcome.

The main finding of our study is that stimulating catheters improved functional scores 6 wk postoperatively, although no significant difference in postoperative pain control was observed. The objective CMS were significantly improved (by 30 points) which is considered to be clinically relevant (7,12,14). Although the patients were randomized, the patients in the SC group had lower preoperative CMS values, representing a higher degree of shoulder disability. This disparity may have influenced the functional improvement observed in the SC group.

The advantage of regional anesthesia on long-term postoperative recovery has been shown in many studies (1–3,24). These studies compared the effect of regional anesthesia to systemic administration in regard to short- and long-term recovery of orthopedic patients. To our knowledge, there is no study that could demonstrate a significantly improved outcome between different regional anesthetic techniques. Therefore, our results suggest that the use of a stimulating catheter may improve postoperative outcome, but further research is needed to confirm our evidence.

One may argue that the pain elicited by this type of surgery was too low to justify the use of a catheter technique. This assumption could be supported by the generally low postoperative pain scores. Nevertheless, functional improvement differed significantly between groups, which cannot be related to different durations of local anesthetic infusion. It may be speculated that the patients in the SC group had less pain and a wider range of movement during physiotherapy, leading to increased functional improvement.

The relatively high complication rate of 10% of patients with long-term postoperative pain is similar to that in a recent study (25) after interscalene brachial plexus blockade with an incidence of postoperative neurologic symptoms of 9.3%–10.1%. Borgeat et al. (26) reported a complication rate after interscalene block of 14% after 10 days, 7.9% after 1 mo, and 3.9% after 3 mo. Likewise, it is always difficult to distinguish among symptoms related to positioning during surgery, surgery itself, or anesthetic technique (27). Several case reports described

idiopathic brachial plexus neuritis after general anesthesia with and without interscalene block (28–30). Additional studies are needed to determine the relative risks and benefits of this technique.

In conclusion, the stimulating catheter improved functional outcome of the shoulder 6 wk postoperatively, but could not significantly improve postoperative pain control. The stimulating catheter may be a valuable tool to improve long-term functional recovery in orthopedic patients undergoing surgery to the shoulder using continuous interscalene analgesia.

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