*Acta Anaesthesiol Scand 2006; **50**: 112–116*
Printed in UK. All rights reserved

ACTA ANAESTHESIOLOGICA SCANDINAVICA
doi: 10.1111/j.1399-6576.2005.00874.x

Transarterial block as an addition to a conventional catheter technique improves the axillary block

T. KJELSTRUP
Department of Anaesthesiology, Rikshospitalet University Hospital, Oslo, Norway

Background: We have had favourable experience with a triple injection technique, combining an axillary catheter technique with a transarterial axillary block. This method has been used successfully for routine surgery and re-implantation of fingers, hand or forearm. We hypothesized that with this technique, block onset time and effectiveness are better than with a conventional catheter technique, and designed a study comparing this new technique with a conventional single injection through a catheter.

Methods: Fifty-one adult patients were included in a prospective study. In all patients, a short axillary plexus catheter was positioned close to the median nerve. All patients had an injection through the catheter, while 26 of the patients had an additional injection behind, and in front of, the axillary artery. Sensory and motor block were tested continuously every minute for 29 min. Block success was recorded as onset time to analgesia, anaesthesia and complete motor block in the first 29 min. At 30 and 50 min, an analgesia block score was recorded.

Results: The transarterial injection plus catheter method was more effective, with a higher success rate and faster onset, than the catheter method. Readiness for surgery with analgesia in the median, radial and ulnar nerves was achieved in the catheter group in 13 patients (52%) at a mean time of 20.8 min, and in the combined group in 21 patients (81%) at a mean time of 13.3 min ($P < 0.05$, $P < 0.05$). At 50 min the situation was 17 (68%) and 24 (92%), respectively ($P < 0.05$).

Conclusion: The combined triple injection is faster and more effective than the catheter method alone.

Accepted for publication 18 June 2005

Key words: brachial plexus; axillary block; transarterial; catheter technique.

We favour a brachial plexus block with a short axillary catheter for hand and forearm surgery. An alternative triple injection technique, developed by the author and now first published, combines the short catheter method with a transarterial block. Transarterial axillary plexus anaesthesia is a well-known method (1–5), but this method prevents post-operative pain treatment with regional anaesthesia. A conventional catheter may solve this problem, but the initial block can fail. The aim of the present study was to compare the efficacy of a conventional catheter technique with a catheter combined with a transarterial block. We also looked for differences in block development from 30 to 50 min.

Methods

Fifty-one elective patients ASA physical status I–II were included in the study without randomization. Patients developing a haematoma after venous or arterial puncture using the axillary catheter were excluded. The author performed and evaluated all blocks. The study was in accordance with the Helsinki II declaration and approved by the Regional Ethics Committee. Informed consent was obtained from all patients prior to inclusion in the study.

Each patient received a total of 0.75 ml/kg of a 50/50 mixture of lidocaine 20 mg/ml with 12.5 μg epinephrine/ml and bupivacaine 5.0 mg/ml, giving a concentration of bupivacaine 2.5 mg/ml, lidocaine 10 mg/ml and epinephrine 6.25 mg/ml.

The 25 patients in the catheter group (Cath group) received a single injection block via an axillary 18-gauge (1.3 × 45 mm) catheter (Contiplex®, B. Braun, Melsungen, Germany). The same type of axillary catheter was inserted in the 26 patients in the catheter and transarterial group (C + TAB group) and then a transarterial block was performed, with injections behind, and in front of, the artery. A third injection in the C + TAB group was given through the catheter after the transarterial block.

In performing the block, local anaesthesic was injected subcutaneously close to the lateral border of the pectoralis major muscle with a 0.5 × 25 mm needle. The point of needle insertion was close to the upper, superior wall of the axillary artery. The Contiplex cannula was first inserted 1 cm subcutaneously, and then raised perpendicularly to the skin and the neurovascular bundle. Using a nerve stimulator (Stimuplex®DIG/HNS11, B. Braun), the cannula was advanced through the fascia. After a 'fascial click', or contact with a nerve, the cannula was lowered tangentially to the skin and advanced parallel to the artery in a proximal direction until stimulation of the median nerve caused muscle contractions. The complete length of the cannula was inserted along the median nerve with a continuous motor response. The final position was confirmed with maximally 0.4 mA with an impulse width of 0.1 ms. The stylet was then withdrawn and the catheter left in position. The local anaesthetic was then injected as a single bolus in the catheter only group. The injection rate was, in both groups, 20 ml in 30 s.

In the C + TAB group, a Contiplex catheter was first positioned as in the Cath group. A transarterial puncture was performed with a 0.5 × 25 mm needle filled with saline, by inserting it perpendicularly to the artery approximately 0.5 cm below the catheter insertion point, and advancing it until retrograde blood flow stopped, indicating that the needle had penetrated the back wall of the artery. In this position, a syringe with a 10-cm extension tube was connected. Half of the local anaesthetic dose was injected close to the back wall of the artery (Fig. 1), and a quarter of the total dose was injected close to, and in front of, the artery. The axillary artery was compressed for 2 min thereafter. After finishing the transarterial procedure, the last quarter of the total dose was then injected through the catheter as the third injection in the C + TAB group.

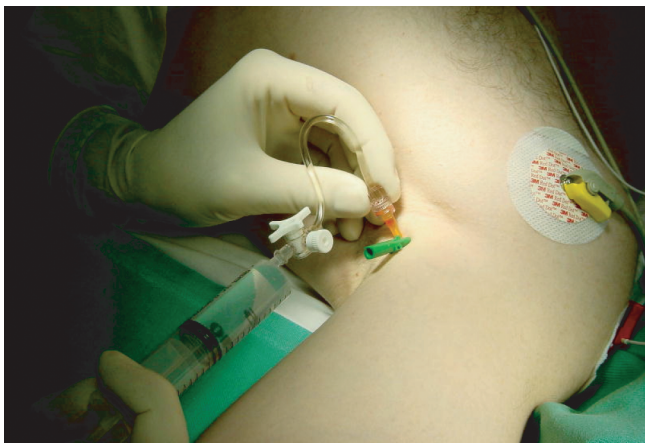

Fig. 1. Transarterial injection below a Contiplex catheter placed close to the median nerve. Left shoulder with the arm abducted 90°.

Ice-cubes placed directly on the skin were used for testing sensory block every minute during the first 29 min. The time in minutes until the onset of analgesia, anaesthesia or complete motor block was recorded for each of the five nerves (the axillary, median, musculocutaneus, radial and ulnar). The areas used for testing the sensory status were identical to those used in another study (6). Analgesia was defined as a sensation of touch from the ice-cube, but no sensation of cold. Anaesthesia was defined as no sensory perception at all. The motor block was assessed manually. All blocks were compared with the other arm.

An analgesia block score was recorded at 30 and 50 min. The score was 0 for normal function and 1.0 for complete blockade. For example, if the perception of ice was reduced by 40% compared with the other arm which had normal sensation (100%), the recorded block score was 0.4. The patient estimated the score subjectively.

If analgesia had not been achieved in the median, radial and ulnar nerves at 50 min (7), the block was then supplemented with a peripheral block in the elbow using a nerve stimulator. We used 10 ml per nerve of the same local anaesthetic mixture as before. 'Ready for surgery' was given when analgesia was established in the three nerves (8).

Data were tested for normal distribution, and presented as mean values and standard deviations. The groups were compared with independent sample *t*-tests, Pearson's χ^2 test and Fischer's exact test to compare variables.

P-values less than 0.05 were considered statistically significant. The SPSS 12.0 (SPSS Inc., Chicago, IL) program was used.

Results

The demographic data and ASA categories were not statistically different between the groups (Table 1).

Four patients out of the 51 included developed a haematoma after venous or arterial contact with the Contiplex cannula. They were excluded and replaced.

Onset of block during the first 29 min (Table 2)

After testing every minute during the first 29 min, we found readiness for surgery, with analgesia of the median, radial and ulnar nerves, in the Cath group in 13 patients (52%) at a mean time of

Table 1

Baseline characteristics

	Group	*n*	mean	SD
Age	Cath	25	42	13.2
	C ± TAB	26	42.3	16.9
Height (cm)	Cath	25	176.7	6.8
	C ± TAB	26	174.5	10.3
Weight (kg)	Cath	25	78.1	14.4
	C ± TAB	26	80.5	15.7
Male/female	Cath	18/7		
	C ± TAB	14/12		
ASA I/II	Cath	22/3		
	C ± TAB	22/4		

n, number of patients. There were no significant differences between the groups.

20.8 min, and in the C + TAB in 21 patients (81%) at a mean time of 13.3 min ($P < 0.05$, respectively). Analgesia was more often present, and with a shorter onset time, in the C + TAB group for all nerves compared with the Cath group. There were significant differences in onset time for the median, musculocutaneus and radial nerves.

Anaesthesia was more often present and with a shorter onset time in the C + TAB group compared with the Cath group. The radial nerve was anaesthetized in only 4 (16%) patients in the Cath group compared with 17 (65%) in the other group ($P < 0.05$).

Complete motor block of the radial nerve occurred in only five out of 25 (25%) patients in the Cath group compared with 21 out of 26 (80%) patients in the C + TAB group ($P < 0.05$). The ulnar nerve was more often paralysed in the C + TAB group than in the Cath group ($P < 0.05$). The time to motor block onset was significantly shorter in the C + TAB group than in the Cath group for the musculocutaneus, radial and ulnar nerves. For the median nerve, we found an equal motor block in both groups.

Analgesia block score at 30 and 50 min (Table 3)

The C + TAB group had a higher analgesia score than the Cath group at 30 and at 50 min. The Cath group improved from 30 to 50 min, but had a higher need for supplementary injections. Seventeen out of 25 (68%) patients in the Cath group and 24 out of 26 (92%) patients in the C + TAB group ($P < 0.05$) had analgesia in the median, radial and ulnar nerves at 50 min and were ready for surgery. At 30 min, the situation was 13 (52%) and 21 (81%), respectively ($P < 0.05$).

Table 2

Onset of block during the first 29 min

	Analgesia = no coldness but touch							Anaesthesia = no coldness and no touch							Motor block = paralysis						
	Cath 25 patients			C + TAB 26 patients			*P*-value	Cath 25 patients			C + TAB 26 patients			*P*-value	Cath 25 patients			C + TAB 26 patients			*P*-value
Nerves:	*n*	min	SD	*n*	min	SD	min	*n*	min	SD	*n*	min	SD	min	*n*	min	SD	*n*	min	SD	min
Axillary	2	21	2.8	3	6.7	5.5	0.32	0	–	–	1	17	–	–	3	23.3	5.6	1	27	–	–
Median	19	13.9	6.3	24	7.5	6.8	<0.05	11	18.5	5.1	19	12.1	6.9	<0.05	18	14.4	6.2	21	13	5.8	0.46
Musculocut.	16	15.3	8.4	21	7.3	6.5	<0.05	10	19.5	5.9	18	10.6	5.9	<0.05	15	19.7	5.4	18	10.4	6.6	0.49
Radial	12	17.7	6.9	22	8.6	5.7	<0.05	4	18.8	6.9	17	14.7	7.9	<0.05	5	22	3	21	11.8	7.7	<0.05
Ulnar	19	12.2	5.6	24	9.4	7.9	0.11	17	17.2	7.1	21	13.1	5.4	0.3	16	14.2	6.3	23	9.9	6.3	<0.05

Cath, catheter group, single injection. C + TAB, triple injection group via catheter and transarterial technique. *n*, number of patients with analgesia, anaesthesia or motor block; min, mean time in minutes until analgesia, anaesthesia or motor block was observed. SD, standard deviation in minutes; *P*-value *n*: Pearson's χ^2-test; *P*-value min: *t*-test for equality of means, two-tailed significance.

Table 3

Analgesia block score						
Time	30 min			50 min		
Group	Cath	C + TAB		Cath	C + TAB	
Patient no.	25	26		25	26	
Nerves			*P*-value			*P*-value
Axillary	0.35	0.41	NS	0.5	0.53	NS
Median	0.95	0.98	NS	0.96	1.0	NS
Musculocut.	0.81	0.95	<0.05	0.89	0.99	NS
Radial	0.76	0.99	<0.05	0.9	0.99	<0.05
Ulnar	0.98	0.99	NS	0.98	1.0	NS

Analgesia, score 1.0. Normal function, score 0. Cath, catheter group, single injection. C + TAB, triple injection group via catheter and transarterial technique. *P*-value, *t*-test for equality of means, two-tailed significance. All values as mean.

Supplementary injections

To obtain analgesia in the hands of all patients, eight (32%) patients in the Cath group and two (8%) in the C + TAB group were given a supplementary block at the elbow at 50 min ($P < 0.05$). Eight radial, three median, and two ulnar nerve blocks were administered in the Cath group. In the C + TAB group, one radial (patient with analgesia score 0.9) and one ulnar nerve (patient with analgesia score 0.95) were given supplementary blocks. Readiness for surgery came within few minutes.

The need for supplementation at 30 min was necessary in 12 patients (48%) in the Cath group and in 4 patients (19%) in the C + TAB group.

The Contiplex cannula in the C + TAB group had a position closer to the median nerve, with a mean stimulus current of 0.21 mA compared with 0.28 mA in the Cath group ($P < 0.05$).

One patient in the C + TAB group had discomfort during performance of the block and was successfully treated with 0.1 mg of fentanyl and 1.5 mg of midazolam intravenously (i.v.). After the injection, another patient in the same group developed symptoms of local anaesthetic CNS intoxication. This patient received 2.5 mg of diazepam i.v. and the symptoms disappeared after a few minutes. One patient in the Cath group, and three patients in the C + TAB group, had venous or arterial puncture with the Contiplex cannula without developing a haematoma. One patient in the transarterial group (4%) had paraesthesia in the median nerve for 1 day.

Discussion

That surgery could start without supplementation more often in the C + TAB group compared with the Cath group, confirmed our hypothesis that the triple injection method is more effective. Eighty-one per cent of the patients in the C + TAB group were ready for surgery at a mean time of 13.3 min and 92% at 50 min. Two nerves in the C + TAB group were given supplementary blocks at 50 min, with analgesia scores close to 1.0. These results are acceptable, and legitimize the use of this new combined method.

The conventional catheter method is inadequate for a rapid start of surgery, and the radial nerve should be selectively blocked at the start of the procedure.

Detailed differentiation between the two groups is possible because of recording the time to onset of block for the different nerves. The analgesia score is a method in daily use. Most of the patients have few problems comparing the blocked side with the other, and expressing the difference as a per cent.

The lack of randomization is shortcoming of this study. In addition, the author performed and evaluated all of the blocks, providing another source of potential bias, although there was often an independent observer. On the other hand, the procedures were more standardized with one person performing all the blocks. Also, the positioning of the catheter close to the median nerve was more standardized than in other studies (7).

The superiority of the axillary multi-injection technique over a single injection has been shown in several studies (1,8,9). Turkan et al. reported that a triple injection method including a transarterial technique, but without the use of a catheter, was more effective than a single injection or a transarterial method alone (4). In order to improve the effect of a catheter method, the present study confirms that this can be achieved by combining the catheter technique with a transarterial double injection. The

results of the Cath group are comparable with Selander's original study, where he found surgical analgesia in 79.6% of the patients after a single injection through a catheter (10). Selander used the catheter for additional injections to improve incomplete blocks. A partly incomplete block can be improved by injection through the catheter after 40 min, but complete failure at 20 min should be supplemented with another technique (11).

The median nerve was blocked more frequently and faster (Table 2) in the C + TAB group compared with the Cath group. The additional transarterial deposit in front of the artery is close to the median nerve, and may be the reason for the higher efficacy on the median nerve. The catheters in the C + TAB group had a lower minimal current for motor response and were probably closer to the median nerve, but all catheters were positioned by a stimulus of no more than 0.4 mA which is usually accepted to indicate successful placement. In the Cath group, the total volume was injected on the median nerve, compared with 50% of the total volume injected through the catheter and in front of the artery in the C + TAB group, but in the C + TAB group the median nerve still was better blocked.

The musculocutaneus nerve was remarkably better blocked in the C + TAB group than in the C group. Sia (9) demonstrated an improved effect on this nerve after a selective block using a triple deposit compared with a double deposit method not seeking this nerve. The analgesia score for the musculocutaneus nerve was 0.89 in the Cath group at 50 min. This nerve should therefore also have been given a supplementary block even if the surgery did not affect this nerve.

The transarterial method is considered to have a low risk of nerve injury. Stan et al. (3) reported an incidence of 0.2% with nerve affection in 1000 patients. The number of patients in our study is too small to assess the method's risk of neuropathy. The frequency of disturbing haematomas (4 of 51 patients, 8%) from the Contiplex cannula seems high. Other equipment may reduce this problem, but the indication for use of a catheter technique should consider this risk.

In conclusion, the combined catheter and transarterial method demonstrated a faster onset and more extensive block than the single injection technique.

Acknowledgements

I thank my colleagues Øivind Klaastad and Harald Breivik for constructive discussions of the manuscript and Geir Aamodt for the statistical analyses.

References

1. Koscielniak-Nielsen ZJ, Nielsen PR, Nielsen SL, Gardi T, Hermann C. Comparison of transarterial and multiple nerve stimulation techniques for axillary block using a high dose of mepivacaine with adrenaline. *Acta Anaesthesiol Scand* 1999; **43**: 398–404.
2. Pere P, Pitkanen M, Tuominen M, Edgren J, Rosenberg PH. Clinical and radiological comparison of perivascular and transarterial techniques of axillary brachial plexus block. *Br J Anaesth* 1993; **70**: 276–9.
3. Stan TC, Krantz MA, Solomon DL, Poulos JG, Chaouki K. The incidence of neurovascular complications following axillary brachial plexus block using a transarterial approach. A prospective study of 1,000 consecutive patients. *Reg Anesth* 1995; **20**: 486–92.
4. Turkan H, Baykal B, Ozisik T. Axillary brachial plexus blockade: an evaluation of three techniques. *Mil Med* 2002; **167**: 723–5.
5. Winnie AP. Does the transarterial technique of axillary block provide a higher success rate and a lower complication rate than a paresthesia technique? New evidence and old. *Reg Anesthesia* 1995; **20**: 482–5.
6. Klaastad O, Smedby O, Thompson GE, Tillung T, Hol PK, Rotnes JS, et al. Distribution of local anesthetic in axillary brachial plexus block: a clinical and magnetic resonance imaging study. *Anesthesiology* 2002; **96**: 1315–24.
7. Raeder JC, Drosdahl S, Klaastad O, Kvalsvik O, Isaksen B, Stromskag KE, et al. Axillary brachial plexus block with ropivacaine 7.5 mg/ml. A comparative study with bupivacaine 5 mg/ml. *Acta Anaesthesiol Scand* 1999; **43**: 794–8.
8. Koscielniak-Nielsen ZJ, Stens-Pedersen HL, Lippert FK. Readiness for surgery after axillary block: single or multiple injection techniques. *Eur J Anaesthesiol* 1997; **14**: 164–71.
9. Sia S, Lepri A, Ponzecchi P. Axillary brachial plexus block using a peripheral nerve stimulator: a comparison between double- and triple-injection techniques. *Reg Anesth Pain Med* 2001; **26**: 499–503.
10. Selander D. Catheter technique in axillary plexus block. Presentation of a new method. *Acta Anaesthesiol Scand* 1977; **21**: 324–9.
11. Vester-Andersen T, Husum B, Zaric D, Eriksen C. Perivascular axillary block VII: the effect of a supplementary dose of 20 ml mepivacaine 1% with adrenaline to patients with incomplete sensory blockade. *Acta Anaesthesiol Scand* 1986; **30**: 231–4.

Address:
Overlege Trygve Kjelstrup
Rikshospitalet Universitetsklinikk
Anestesiavdelingen
Sognsvannsveien 20
N 0027 Oslo
Norway
e-mail: trygve.kjelstrup@rikshospitalet.no