The Optimal Motor Response for Infraclavicular Brachial Plexus Block

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BACKGROUND: In this prospective study we compared the success of the infraclavicular brachial plexus block using double-stimulation in regard to the second nerve response elicited with neurostimulation.
METHODS: Six-hundred-twenty-eight patients undergoing emergency upper limb surgery using infraclavicular brachial plexus block were included in this study. The musculocutaneous nerve was initially blocked and the groups were then evaluated according to the second nerve located, which was radial in 54%, median in 35%, and ulnar in 11% of patients. Blocks were performed using lidocaine 1.5% with 1/400,000 epinephrine 40 mL in all cases. The block was assessed every 5 min for 30 min after completion of the block.
RESULTS: The success rate was 96% for the radial response group, 89% for the median response group, and 90% for the ulnar response group ($P < 0.05$). Time to perform the block and the onset time were not significantly different among groups. No serious complications were observed.
CONCLUSION: We conclude that having initially located and blocked the musculocutaneous nerve, subsequent injection on a radial response resulted in a slightly more reliable success rate than injection with an ulnar or median response.
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A renewed interest in the infraclavicular brachial plexus block (ICB) technique has emerged and several technical modifications have been recently described. Most of the modern techniques use the coracoid process as the main landmark (1–3). The advantages of these techniques include the ability to perform the block regardless of the patient's arm position, avoidance of neurovascular structures of the neck, low risk of pneumothorax, and adequate block efficacy (3). ICB is also more comfortable than axillary block (4), and than humeral block, particularly in trauma patients (5). Finally, a double-stimulation technique provides more successful blockade compared with a single-injection technique (6,7). Therefore, the ICB with a double-stimulation technique (with localization of the musculocutaneous and one other nerve) is routinely used on our orthopedic anesthesia service. Although easy to perform and efficient, no data regarding the optimal second nerve response (radial, median, or ulnar) and the relative success rate in this regional anesthesia technique are available.

The aim of this study, therefore, was to investigate the optimum second nerve response (radial, ulnar, or median) in the ICB double-stimulation technique using block success (complete anesthesia) as a primary outcome measure.

METHODS

After approval by our local ethical committee, all patients provided informed consent. This prospective study was conducted over a period of 14 mo in a single university hospital. Inclusion criteria were all patients undergoing surgery from the inferior third of the humerus to the hand. Exclusion criteria were any contraindication to regional anesthesia, bilateral surgery, a history of pneumonectomy, pregnancy, dementia, or allergy to local anesthetics.

All blocks were performed in a high capacity induction area to improve operating room turnover. Sufentanil (0.1 μg/kg) was given IV 5 min before the procedure. All blocks were performed by staff or resident anesthesiologists using a nerve stimulator (Braun® Stimuplex® HNS 11) and an insulated needle (Braun Stimuplex, 50 mm and 22-guage Mesungen, Germany). The nerve stimulator was set at 100 μs, 1.4

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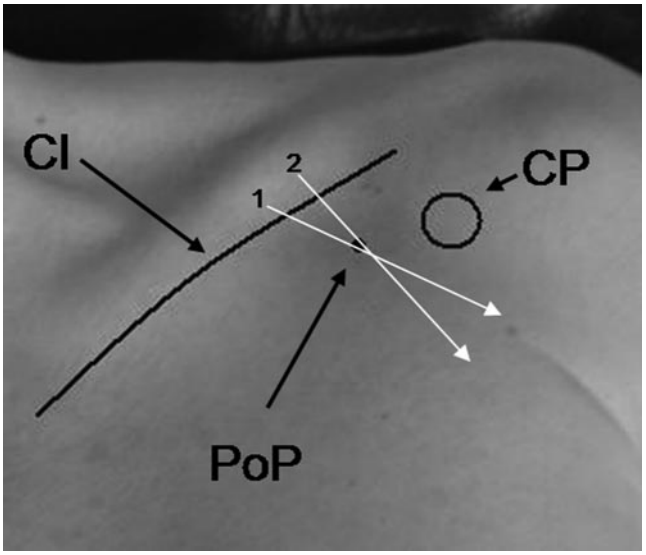

Figure 1. Landmarks and site of puncture of the infraclavicular brachial plexus block. 1) First needle direction (white arrow): the needle is directed toward the axillary fossa. 2) Second needle direction (white arrow): the needle is directed medially and posteriorly. Abbreviations: Cl, clavicle; CP, coracoid process; PoP, point of puncture.

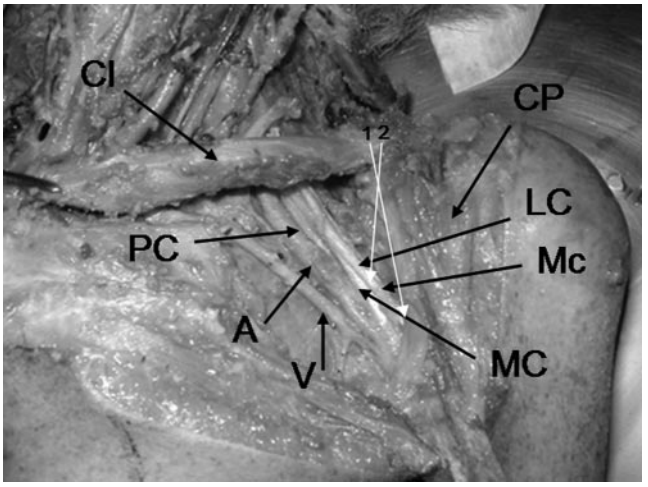

Figure 2. Infraclavicular dissection. 1) First needle direction (white arrow): the needle is directed toward the musculocutaneous nerve. 2) Second needle direction (white arrow): the needle is directed toward the main trunks of the brachial plexus. Abbreviations: PC, posterior cord; MC, median cord; LC, lateral cord; M, median nerve; Mc, musculocutaneous nerve; Cl, clavicle; CP, coracoid process; A, axillary artery; V, axillary vein.

mA, and 2 Hz. A distinct distal motor response at the level of the hand or wrist at a current output ranging between 0.3 and 0.5 mA was obtained in all patients. Blocks were performed using lidocaine 1.5% with 1/400,000 epinephrine in all cases.

Patients were placed supine, with the head turned away from the arm to be anesthetized as previously described (3). The forearm was placed on the abdomen. The puncture site was located 1 cm under the clavicle and 1 cm medially to the coracoid process (Fig. 1). After antiseptic preparation of the area, the insulated needle was inserted toward the top of the axillary fossa (in relation to the axillary artery) with an angle of 45°–60° to the skin. In all cases the first response was the musculocutaneous nerve and 10 mL of the above solution was injected with repeated aspiration. The needle was then withdrawn 1 or 2 cm and redirected medially and posteriorly (Figs. 1 and 2). We sought a distal and clear motor response in the hand or the wrist. The first distal nerve response found was considered to be an adequate end point. Third finger flexion was accepted as a median nerve stimulated response, fifth finger flexion as an ulnar-stimulated response, and finger or wrist extension as radial nerve-stimulated response. Thirty milliliters of the same local anesthetic solution in fractionated doses was then slowly injected with frequent aspiration. The procedure duration was measured from needle insertion to withdrawal.

The sensory block onset (from 0 = no sensation to 2 = normal sensation) was assessed every 5 min by an anesthesiologist blinded to the block technique. A successful block was defined as the absence of cold (alcohol soaked swab) and pinprick (needle wheel) response (score = 0) in the four major nerve distributions: radial (posterior wrist and first three fingers), medial (anterior wrist and first three fingers), ulnar (medial part of wrist and hand), and musculocutaneous (lateral part of forearm). The medial brachial and antebrachial cutaneous (medial part of the arm and forearm) nerve distributions were tested as well as the shoulder area for incidental axillary nerve block. Assessment was performed within 30 min after the injection and compared with the same stimulation on the contralateral arm. If one or two nerves were not blocked, selective supplementation at the humeral canal was performed using a nerve stimulator. If >2 nerves remained unblocked, general anesthesia was performed.

Immediate and late complications (venous puncture, arterial puncture, vascular absorption of the local anesthetic, overdose, recurrent laryngeal or phrenic nerve block, residual paresthesia, Horner's syndrome, and pneumothorax) were noted. Patient satisfaction with anesthetic technique was assessed after arrival in the postanesthesia care unit using a 5-point scale (from 0 = dissatisfied to 5 = very satisfied). Each patient was followed-up by the surgeon postoperatively and late complications recorded (pain, paresthesia, hematoma, infection, bad experience retrospectively).

Before the trial and based on our previous study (3), a power calculation for a 12% difference in the success rate with a probability level α of 0.05 and power of 0.80 ($1-\beta$) yielded a sample size of 113 patients for each group. We anticipated that all groups would be equal, and thus we enrolled 628 patients to allow for comparisons even if one group size was smaller than the others. Statistical analysis was performed using the Statview software (version 5.0 CA, USA). Data are presented as mean ± SD, ratio or percent. χ^2 test, Student's *t*-test or ANOVA was performed when appropriate. $P < 0.05$ was considered statistically significant.

Table 1. Demographic and Surgical Data

	Radial (n = 338)	Median (n = 222)	Ulnar (n = 68)
Sex (M/F)	196/142	107/115	43/25
ASA (I/II/III)	233/88/17	155/58/9	54/13/1
Age (yr)	46 ± 20	48 ± 20	42 ± 20
Weight (kg)	70 ± 13	71 ± 14	69 ± 14
Height (cm)	171 ± 9	170 ± 9	172 ± 9
Stimulating current (mA)	0.37 ± 0.08	0.34 ± 0.09	0.34 ± 0.08
Tourniquet (n)	317	198	65
Surgical duration (min)	43 ± 35	47 ± 20	50 ± 29
Tourniquet duration (min)	27 ± 18	27 ± 20	30 ± 20
Surgical site (n)			
Elbow	54 (16)	33 (15)	13 (19)
Forearm	54(16)	36 (16)	8 (13)
Wrist	166 (49)	113 (51)	33 (48)
Hand	64 (19)	40 (18)	14 (20)

Data are expressed as ratios, percentages, or as means ± SD. Values in parentheses indicate percentage values. No difference was found among groups in regard to demographic and surgical data.

RESULTS

Six-hundred-twenty-eight patients were consecutively enrolled in this prospective study. No difference was found among groups in regard to demographic and surgical data (Table 1). The second response was a radial response in 54% of cases, median response in 35% of cases, and ulnar response in 11% of cases. The success rate was 96% for a radial response, 89% for a median response, and 90% for an ulnar response (Fig. 3). Fourteen patients in the radial group (4%), 20 patients in the median group (9%), and 7 patients in the ulnar group (10%) needed supplementation (NS). General anesthesia was performed in four patients in the median group (0.008). Incidental axillary nerve block was noted in 74% of patients in the radial Group 62% in the median group and 43% in the ulnar group ($P < 0.0001$).

Time taken to perform the block and onset time were similar among the three groups. In this trial, we showed that readiness for surgery is around 35 min, including the block performance and onset time. Stimulating current of each nerve and success rate did not differ significantly among groups (Table 1). There was no difference in the satisfaction rate. Venous puncture was observed in one patient in each group, but none had any clinical consequence. No other clinical complications, including vascular absorption of the local anesthetic, overdose, recurrent laryngeal or phrenic nerve block, residual paresthesia, Horner's syndrome, and pneumothorax were observed.

DISCUSSION

This study showed that using double stimulation, having initially located and blocked the musculocutaneous nerve, subsequent injection from a radial response resulted in a better success rate with ICB than injection from an ulnar or median response. These results might be explained by a better spread of the local anesthetic solution (8). Using ultrasound guidance during ICB, Porter et al. (9) reported that separate injections anteriorly and posteriorly to the axillary artery improved the block success rate, speculating that posterior spread of injectate is associated with a more successful block. This could explain why no difference was found between the ulnar and the median injection, whereas a significant difference was found with injection from the radial response compared with either median or ulnar response. However, these results are observational and can only be definitively established by further research under more controlled conditions. A recent study (10) using single-injection infraclavicular block found the same results; that is to say, improvement of the success rate with a posterior injection.

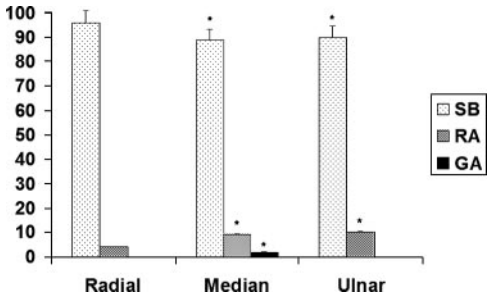

Figure 3. Percentage success rate according to the second nerve stimulated, having initially blocked the musculocutaneous nerve in all cases. RA denotes the need for selective local anesthetic supplementation and GA the need for general anesthesia in each group. Radial response is associated with a better success rate than median or ulnar response. No difference was found between ulnar and median nerve. *$P < 0.05$ compared with Radial.

In 54% of patients the second nerve response was radial. This is explained by the posterior and medial redirection of the needle after the musculocutaneous was located. This corresponds, anatomically, to the radial nerve position compared with the musculocutaneous. Conversely, the ulnar nerve was less easily identified (11%) as it is more medial to the artery. Moreover, it is in a region that can be considered (incorrectly) by the anesthesiologist as a potentially dangerous region. Although it is the nearest cord to the ribs, it is still far from the lung, and therefore far from the risk of pneumothorax. Even if a radial response results in a statistically higher success rate, we do not know whether deliberately seeking the radial response results in a significantly longer time for block performance or a higher rate of complications from needle reinsertion (vascular puncture, nerve transfixion, and pneumothorax).

This study has several limitations. First, these findings may not be extrapolated to other techniques of ICB, particularly single injection. Second, the study was not blinded and randomized. Some anesthesiologists involved in this study knowing that radial response can lead to a better success rate, searched specifically for it. This possibility cannot be discounted and future studies

will have to allow for this within their methodologies and study design. Finally, although the sample size was large enough to provide comparative groups of equal size, the ulnar group was the smallest.

In conclusion, injection of local anesthetic solution on the radial, median, and ulnar nerve provides a high success rate and is associated with similar block performance and onset time. Nevertheless, a second injection on the radial nerve provides a higher success rate than an injection on the median or ulnar nerve when performing ICB with the double-stimulation technique. However, we do not know whether deliberately seeking the radial response would increase the time for block performance, the rate of complications from needle reinsertion, or patient discomfort.

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