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SHORT COMMUNICATION

Electrostimulation with or without ultrasound-guidance in interscalene brachial plexus block for shoulder surgery

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Abstract In a prospective controlled trial to compare conventional interscalene brachial plexus block (ISBPB) using anatomic landmarks and electro-stimulation with a combined technique of ultrasound guidance followed by nerve stimulation, 60 patients were randomized into 2 matched equal groups: Group A using nerve stimulation (NS) alone and Group B using the combination of ultrasound and NS. The time to detect the plexus (3.9 ± 4 min in Group A and 3.3 ± 1.4 min in Group B) was not significantly different. We needed to reposition the needle once ($n = 13$) or twice ($n = 4$) in Group B. First-shot motor response was achieved in all but one patient in Group A; here we were only able to locate the plexus by use of ultrasound. None of the patients needed general anaesthesia. There were no significant differences between postoperative pain, motor power, or patient's satisfaction. ISBPB seems similarly effective using electro-stimulation and ultrasound if performed by experienced anesthesiologists.

Keywords Ultrasound · Nerve stimulation · Interscalene brachial plexus block

Interscalene brachial plexus block (ISBPB), first described by Winnie [1], is a well established, highly successful technique for shoulder surgery [2, 3]. Conventional methods used for locating the plexus, e.g. nerve stimulation and patient-reported paraesthesia rely on surface landmark identification in a semi-blind manner. The success of these depends on individual and anatomic variations and on equipment accuracy [4]. Epidural puncture, pneumothorax, intravascular injection, and time-consuming trial and error attempts have been reported [2–5]. Ultrasound (US) guidance has recently improved the success and reduced the incidence of complications in regional anaesthesia [3, 4, 6–12]. Satisfactory results have been obtained with US in supraclavicular and axillary blocks [5, 9, 10].

To compare conventional and US-guided brachial plexus block in the less studied interscalene approach, 60 consecutive patients scheduled for shoulder surgery were randomized into 2 groups, 30 patients each, after Ethics Committee approval and obtaining a written informed consent: Group A for which ISBPB was performed using nerve stimulator (NS) alone and Group B guided by 2-dimensional US, with use of NS after securing correct needle position. Exclusion criteria were hypersensitivity to local anaesthetics, neurologic deficits, bleeding tendency, respiratory failure, local infection, incompliance, refusal to participate in the study or request for general anaesthesia. Group A included 14 males and 16 females who ranged in age between 36 and 82 (median 60.5) years. Group B included 19 males and 11 females, 30–75 (median 56.5) years old. There were no significant differences between the groups as regards their ASA physical status ($p = 0.79$) and the body mass index ($p = 0.06$). The most common procedure was arthroscopic subacromial decompression ($n = 38$), equally divided between both groups. Mean operative time was 45 (±17) min in Group A and 48 (±19) min in Group B.

ISBPB was performed in the induction room. Two anaesthetists (consultants with over 10 years experience)

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performed all blocks. We used the anterior approach according to Meier et al. [13]. A Stimuplex® D 55 mm 15° bevel, 22 G insulated needle connected to Stimuplex® HNS 12 (B. Braun Melsungen, Germany) NS, with a current of 1 mA, pulse duration of 0.1 ms, and frequency of 2 Hz, and to a 5-ml syringe with NaCl 0.9% through the injection line was then inserted in a caudal, slightly lateral, and discrete dorsal orientation. After 3–4 cm, the upper trunk or portions of the lateral sheath are reached causing biceps contractions. We then reduced the current incrementally until the threshold of 0.2–0.3 mA was reached. If response was still triggered <0.2 mA, the needle was retracted slightly. If contraction continued, we performed a negative aspiration test and slowly injected the local anaesthetic. We then turned the current back up to 1.0 mA after the first 10 ml were injected. To avoid intraneural injection we avoided injection when stimulation was obtained at an intensity of <0.2 mA.

In the US group, the roots of the brachial plexus were sought between the anterior and middle scalene muscles in an axial oblique plane. Deeper than this plane, the vertebral vessels were seen next to the vertebral transverse process. The carotid artery and internal jugular vein lie medially. After sonographic plexus identification, we injected glucose 5% to scan the fluid around the plexus; then we fixed the needle. Nerve stimulation was then switched on looking for muscle contractions as in Group A.

After needle placement in both groups; 30 ml prilocaine 1% was injected and a catheter was fixed 2 cm beyond the needle. Sensory block was assessed using cold alcohol spray on the shoulder. Motor block was assessed by using shoulder movement, elbow and wrist extension (radial nerve), elbow flexion (musculocutaneous nerve), and wrist flexion (median nerve). The effect of the resulting ISBPB was graded as follows:

0: No success. Change to general anaesthesia
1: Complete sensory and motor block.
2: Block requires supplementary analgesia (fentanyl >50 µg and/or ketamine).
3: Another attempt is needed or shift to another technique

Patients received a sedating dose of propofol at a rate of 2 mg/kg/h unless they asked to stay fully awake. For additional sedation, 1–3 mg midazolam was used. To minimize bleeding, intravenous clonidine (50–150 µg) was given intraoperatively to hypertensive patients undergoing arthroscopy. Two hours after ISBPB, patient-controlled analgesia was started with 0.2% ropivacaine (3 ml/h infusion rate, 5 ml bolus, 20 min lockout time). Patients were assessed regularly for pain by use of a 100 mm linear visual analogue scale (VAS; 0 mm = no pain, 100 mm = worst pain imaginable), motor power, and side effects. A questionnaire with 6 points was completed describing the patient's satisfaction at the time of block, and during and after the operation, and whether he wishes this technique to be used in future operations. Statistical analysis was performed using SAS software version 9.1.3 (Cary, NC, USA). Differences were analysed by Fisher's exact test and Mann–Whitney *U* test.

The mean time spent detecting the brachial plexus and injecting the local anaesthetic (primary outcome measure) did not vary significantly between both groups ($p = 0.32$): 3.9 ± 4 min (median 2.5, range 1–21 min) in Group A and 3.3 ± 1.4 min (median 3, range 1–8 min) in Group B (Fig. 1).

For twenty-nine patients in Group A a successful response was obtained from the first trial whereas 3 trials were conducted for the last patient after which we failed to get any response after 18 min, necessitating US guidance (Fig. 2). In Group B, we changed the needle position once in 13 patients and twice in 4 patients. These were blocks in which NS alone failed to elicit any motor response.

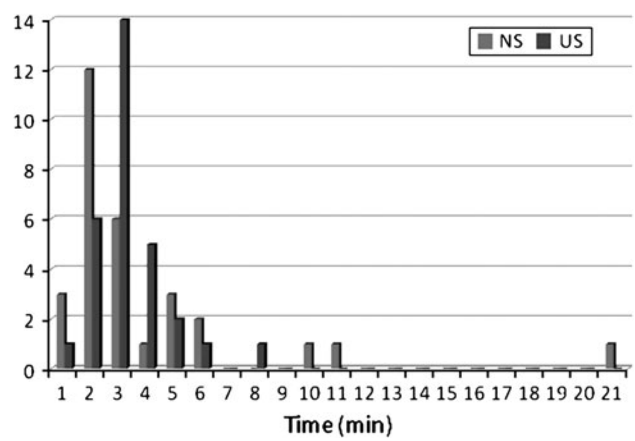

Fig. 1 Time needed for location of the brachial plexus (*NS* nerve stimulator, *US* ultrasound)

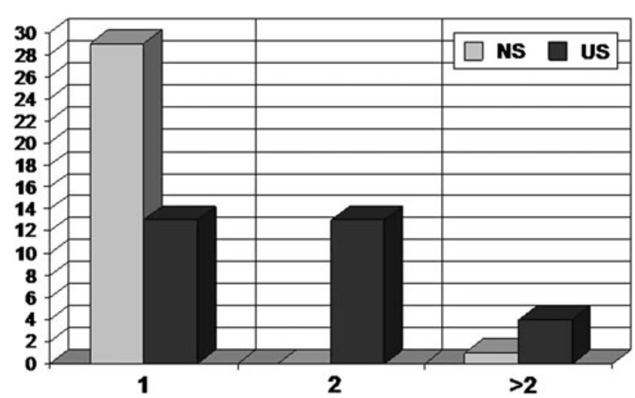

Fig. 2 Number of trials to reach the brachial plexus (*NS* nerve stimulator, *US* ultrasound)

For 23 patients in Group A we obtained a biceps response, in 3 a deltoid response, in another 3 a triceps response, and no response in one patient. In Group B, the biceps was the muscle of response in 18 patients, in 4 patients we obtained a deltoid response, in 1 a triceps response, and in 7 patients we failed to obtain any response although we increased electro-stimulation to 1.5 mA; we were, however, able to see the plexus and injected the local anaesthetic around it ($p = 0.02$).

There was no significant difference ($p = 0.21$) regarding onset time of ISBPB between Group A (median 4.5, range 1–25 min) and Group B (median 5, range 2–12 min). As regards block success, 27 patients in Group A had a complete block, 2 required additional analgesia, and in one we shifted to US. In Group B, 28 cases had a complete block and 2 needed additional analgesia. Likewise, there was no significant difference in pain perception after 6 ($p = 0.56$) and 24 h ($p = 0.17$). Regain of motor power was also not statistically significant after 6 ($p = 0.29$) and 24 h ($p = 0.55$).

Complications were equally divided between both groups ($p = 0.52$). A bloody tap was seen in one patient (Group A). Four patients in Group A and five in Group B had transient neurological dysfunction (Horner's syndrome, recurrent laryngeal nerve palsy, phrenic nerve stimulation or paraesthesia); all resolved in the early postoperative period. No difference in patient satisfaction was observed ($p = 0.65$).

In recent years, there has been a growing interest in regional techniques and, in particular, peripheral nerve blocks [3]. One of the main challenges is the unreliability of conventional methods for nerve location. On the other hand, US enables safe and accurate nerve imaging. It is non-invasive, portable, generates no radiation, and requires little preparation for immediate use. Perhaps its most significant advantage is the ability to examine the plexus in real-time [3]. It is, therefore, particularly helpful for obese patients with a short neck or after previous neck surgery [7, 8].

In contrast with studies showing the superiority of US over NS in many plexus approaches [3, 9], we could not show these advantages in our study, because both anaesthetists were experienced in both techniques. Likewise, Casati et al. [10] showed that in experienced hands, both techniques provide similar results. Similarly, 2 recent trials revealed no significant differences between both methods in ISBPB as regards postoperative analgesia [11] and neurologic symptoms [12].

An interesting finding in this study is the inconsistency of muscle contraction with a current up to 1.5 mA, despite clear US evidence of nerve contact in 24% of cases in Group B. This lends support to Choyce et al. [14] and Urmey and Stanton [15]. If US was not present, we would have advanced the needle further in search of contraction not realizing it had already reached the target.

US guidance is operator-dependent, with a long learning process for anatomic recognition and hand–eye coordination. Furthermore, it is relatively expensive. On the other hand, nerve stimulation has its own limitations. It relies on physiological response that is affected by the interplay of injectates, physiologic solutions, and disease.

In conclusion, ISBPB is highly effective using nerve stimulation with or without US guidance. No advantage could be attributed to either technique if block is performed by anaesthetists experienced in both techniques. In some cases, however, nerve location may be achieved only by use of US. It is also an important technique for trainees first learning ISBPB.

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