The Middle Interscalene Block: Cadaver Study and Clinical Assessment

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Background and Objectives: A variety of brachial plexus block techniques via the interscalene approach have been proposed. We describe here a new middle interscalene perivascular approach to the brachial plexus. To verify its effectiveness, we studied 719 patients scheduled for shoulder arthroscopy. Furthermore, to verify the accuracy of the proposed bony landmarks to use in the case of inability to palpate the subclavian artery pulse, we simulated the block on 10 cadavers.

Methods: The aim of our technique is to cannulate the neurovascular bundle by inserting a 35-mm needle lateral to the subclavian arterial pulse near the midpoint of the upper edge of the clavicle in a horizontal or slightly cephalad direction while pointing toward the seventh cervical vertebra. If the pulse of the subclavian artery is not palpable, we localize the direction of the needle with reference to 3 bony landmarks (the middle point of the clavicle, the spinous process of C7, and the sternoclavicular joint). By connecting these 3 landmarks, we obtain an angle whose apex lies at the midpoint of the clavicle and its bisecting line points to the plexus. The needle is introduced in the transverse plane of C7.

Results: The block was performed successfully in 692 of 719 cases (96.2%). Horner's syndrome occurred in 93.5% of the cases, arterial puncture with hematoma occurred in <1%, phrenic nerve block without respiratory impairment in 60%, with transient respiratory failure in <1%, and laryngeal nerve block in <1%. The incidence of severe complications or permanent injuries was zero (upper limit 95% confidence interval = 0.4% or 1:250 patients). The technique performed on cadavers showed that the previously mentioned bony landmarks were reliable reference points in reaching the brachial plexus.

Conclusions: Our technique via a middle interscalene approach is easy to perform and provides a high success rate. Even in the absence of a subclavian artery pulse, the easily recognizable bony landmarks reliably guide us in the insertion of the needle. Furthermore, this technique appears to avoid complications that are theoretically possible in other supraclavicular perivascular approaches (pneumothorax) and paravertebral approaches (injection into the vertebral artery and subarachnoidal injection). However, further comparative studies will be required to assess the clinical relevance of the block. *Reg Anesth Pain Med 2006;31:563-568.*

Key Words: Interscalene brachial plexus block, Brachial plexus anesthesia.

More than 90 years have passed since Kulenkampff published his brachial plexus block technique. Among the 20 or more techniques proposed since, it is still debatable which is more effective than the others. Most of the proposed techniques have similar success rates and the development of new techniques is largely an attempt to reduce the incidence of complications.

See Editorial page 492

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The aim of the middle interscalene block (MIB) is to avoid the most serious complications that can occur with the paravertebral techniques[1-3] or with the supraclavicular caudad techniques. We had experienced 2 cases of pneumothorax (PTX) by using the Kulenkampff technique modified by Moore and 1 case of vertebral artery injection with the Winnie technique. This led us to search for an alternative method. We believe this new supraclavicular perivascular technique greatly reduces the possibility of reaching the subarachnoidal space or causing a PTX. We reasoned that it was best to direct a 35-mm needle toward the interscalene triangle in the transverse plane of C7. In other words, the needle approaches the brachial plexus encountering it at the level of the upper or sometimes the middle trunk. With the initially proposed technique,[4,5] the needle was directed toward the spinous process of C7 and then in a fanwise manner toward the vertebral arch and the pedicle in order to stay in the transverse plane of C7. In this manner, the first 2 directions were ineffective and the suprascapular nerve could also be stimulated, outside the neurovascular bundle, with the risk of a false twitch and an ineffective injection. Therefore, we altered our approach to point the needle directly toward the central area of the scalene triangle. The aim of this technique is to cannulate the neurovascular bundle by inserting the needle near the midpoint of the upper edge of the clavicle in a horizontal or slightly cephalad direction, lateral to the subclavian artery pulse and pointing toward C7.

To verify the technique's effectiveness, we conducted a prospective study of patients scheduled for shoulder arthroscopy. Furthermore, we simulated the block on 10 cadavers to verify the accuracy of the bony landmarks proposed and to perform the technique in the case of inability to palpate the subclavian artery pulse.

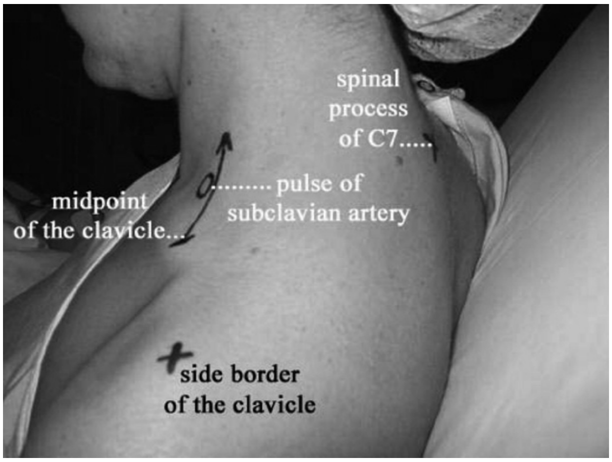

Fig 1. Patient position and landmarks. The midpoint of the clavicle, which is marked with a dot. The pulse of the subclavian artery, which is marked with an O. The spinal process of C7, which is marked with an X. The arrow represents only the cutaneous projection of the straight pathway of the needle, which moves along the transverse plane of C7.

Methods

Our institutional review board approved this study. Informed consent was obtained from 719 consecutive adult patients of either gender (Table 1), American Society of Anesthesiologists Physical Class 1-3, scheduled for shoulder arthroscopy. Patients with a history of central or peripheral neurologic disease, clinical evidence of pulmonary disease or a history of opioid dependence, and those who could not cooperate were excluded. Patients with allergy to amide local anesthetics were also excluded.

This study was performed during 2004 to 2005 by 4 of the 5 authors, whose learning curve had been completed by 2002. All patients were premedicated with 0.75 mg of oral alprazolam 1 hour before entering the operating room. A 23-gauge, 35-mm long Teflon-coated needle (Locoplex; Vygon, S.A., Ecouen, France) was connected to the negative lead of the nerve stimulator (Plexival; Medival, Padova, Italy). The stimulating current was initially set at 1 mA, the stimulus frequency at 2Hz, and the impulse duration at 50 milliseconds.

When the motor response was obtained (deltoid, biceps, or triceps response), the stimulating current was progressively decreased to 0.3 mA. Satisfactory positioning of the needle was obtained when stimulation by 0.3 mA elicited visible motor response. By using intermittent aspiration, the patients received an injection of ropivacaine 0.75% or levobupivacaine 0.75% (0.4 mL/kg). Epinephrine was not added. Patients received standard monitoring and were sedated with midazolam 1 to 2 mg intravenously before surgery. Patients were followed for 24 hours and monitored for the presence of complications and side effects.

Table 1. Demographic and Surgical Data of the Patients

Patients (ASA physical status I-III)	n = 719
Age (y)	Mean 57 y (range 20-78 y)
Body weight (kg)	71 ± 12
Height (cm)	166 ± 8
Male/female (%)	45/55
Type of surgery	Rotator cuff repair
Selection of anesthetic solution 0.4 mL/kg	Ropivacaine 7.5 mg/mL—60% of patients
	Levobupivacaine 7.5 mg/mL—40% of patients

Patient Position

The ideal position for the patient is the upright sitting position with a raised headrest (beach chair position), with the arm hanging off the side of the bed. In this manner, the shoulder is relaxed, the clavicle is rotated downward, and the neurovascular bundle becomes more superficial. The head is rotated 45° toward the opposite side. If the patient is unable to hold this position, the anesthetic block may also be performed in a supine position.

The landmarks (Fig 1) are as follows: (1) the pulse of the subclavian artery, which is marked with an O; (2) the midpoint of the clavicle, which is marked with a dot; and (3) the spinal process of C7, which is marked with an X.

Technique

After local anesthetic infiltration, a 22-gauge, 35-mm insulated needle was inserted 2 mm lateral to the subclavian artery pulse, following a straight line, which from the midpoint of the clavicle is the lateral tangent of the O (subclavian artery pulse), but lying deeper on the transverse plane of C7 (this is shown by the C7 spinous process). If no twitch is evoked, small adjustments are made in an anterior or posterior direction until a twitch of the deltoid, biceps, or triceps muscle is obtained with an intensity current of 0.3 mA. A local anesthetic solution (0.4 mL/kg) is then injected. We agree with the opinion of Silverstein et al.[6] in eliciting just 1 muscle twitch before injecting the entire anesthetic volume. If the pulse of the subclavian artery is not palpable, we refer to 3 bony landmarks to localize the path of the needle and the level on which it has to advance.[7] These are (1) the midpoint of the clavicle, (2) the spinous process of C7, and (3) the sternoclavicular joint. By drawing the skin lines connecting the midpoint of the clavicle to the spinous process of C7 and the sternoclavicular joint, we obtain an angle whose apex lies at the midpoint of the clavicle and whose bisecting line directs the needle toward the brachial plexus (Fig 2). An anesthetic skin wheal will be made on the bisecting line 1.5 cm from the midpoint of the upper edge of the clavicle. The needle is inserted following the bisecting line but along the transverse plane of C7 in a horizontal or slightly cephalad path.

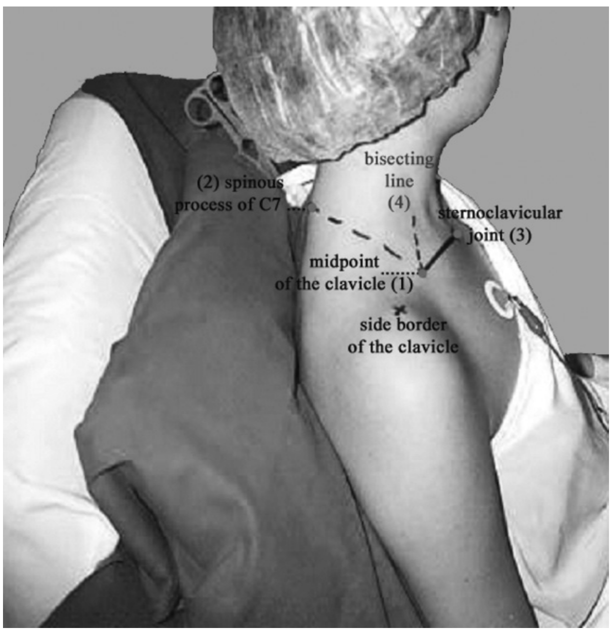

Fig 2. Variation of the technique if the subclavian artery pulse is absent: bony landmarks. (1) Midpoint of the clavicle, (2) the spinous process of C7, (3) the sternoclavicular joint, and (4) the bisecting line of the angle.

Cadaver Study

After having reported anatomic observation on a single cadaver,[7] we extended this research to 10 cadavers to verify the reliability of the bony landmarks. The demographic profile of the cadaver population was as follows: mean age 75 years (range, 69-81 years), mean height 163 ± 6 cm, and mean weight 69 ± 10 kg. On each cadaver, we marked the bony landmarks and drew the angle with its bisecting line. We introduced a spinal needle (Fig 3A) along the bisecting line in a horizontal direction according to the transverse plane of C7. After having introduced the needle, the skin and the fat of the supraclavicular region, the omohyoid muscle, and the cervical middle sheath were carefully removed; in this manner, the target reached by the needle was observable.

Results

We divided the 719 patients of the clinical study into 3 groups: (1) group 1: successful block without any intravenous injection analgesics (fentanyl) during surgery, (2) group 2: successful block but with an intravenous injection during surgery of fentanyl ≤0.1 mg, and (3) group 3: unsuccessful block because of insufficient analgesia, requiring >0.1 mg of fentanyl or general anesthesia to complete anesthesia.

The block was performed successfully on 692 cases (96.2%), divided into 508 cases (70.6%) without fentanyl (group 1) and 184 cases (25.6%) with the addition of small amounts of fentanyl (group 2). In 27 cases (3.8%), we considered the block unsuccessful (group 3). In the 27 cases of unsuccessful block, 12 patients suffered pain during placement of the posterior portal (C4 territory). Indeed, in the plexus called by Winnie "postfixed," the contribution of C4 is lacking and C4 is outside of the neurovascular bundle. Therefore, it is impossible to anesthetize it by injecting the anesthetic nearby the neurovascular bundle. The other 15 patients suffered pain during the use of the VAPR.

In group 1, the duration of sensory block was 11.2 ± 2.7 hours with ropivacaine and 13.1 ± 2.8 hours with levobupivacaine. Out of 692 patients treated, only 97 consented to chest x-rays, and 58 of these (60%) were diagnosed with hemidiaphragmatic paresis. A chest x-ray in our operating room was considered a simple procedure, even though less accurate than ultrasound or fluoros-

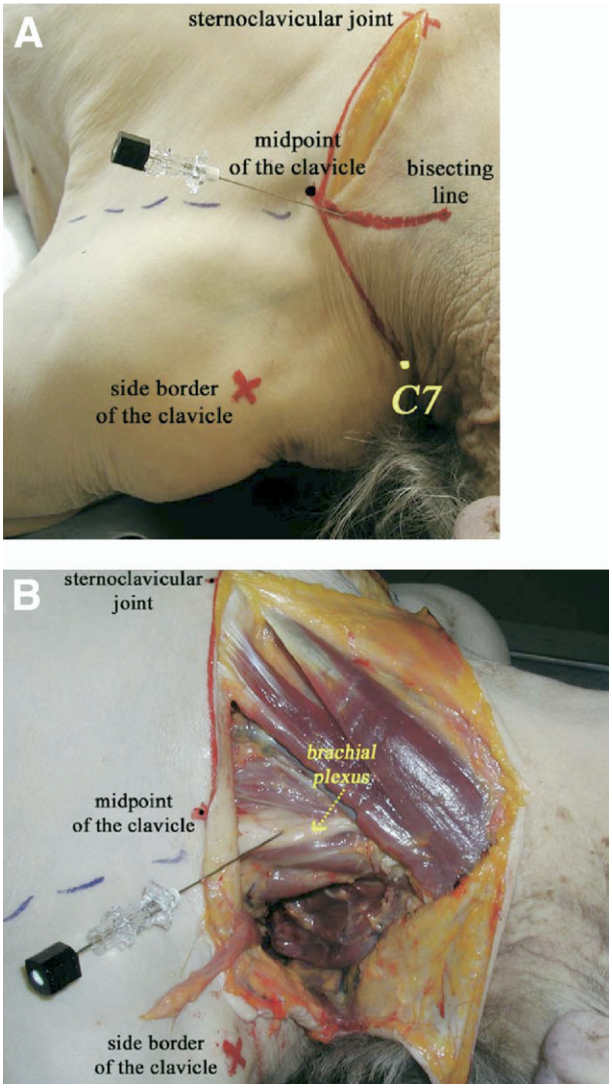

Fig 3. (A) The bisecting line became curved after the supraclavicular cutting. (B) Exact transfixion of the plexus.

copy for the diagnosis of hemidiaphragmatic paresis. We did not consider using plethysmography as a reliable tool to assess diaphragmatic paresis because an administration of oxygen by face mask is established by protocol in our clinical setting.

In the 692 cases successfully performed, we recorded the following complications: phrenic nerve block with dyspnea and an arterial oxygen saturation <90% in 4 patients (0.6%), arterial puncture and hematoma in 4 patients (0.6%), inferior laryngeal nerve block in 6 patients (0.9%), and Horner's syndrome in 647 patients (93.5%). There were no cases of pneumothorax or subarachnoid or vertebral artery injection (upper limit of 95% confidence interval = 0.4%). The mean onset time was 15 ± 3 minutes, whereas the mean completion time was 35 ± 8 minutes.

Cadaver Study

In 7 of 10 cadavers, the needle reached the brachial plexus either directly (3 cases) (Fig 3B) or between the middle scalenus muscle and the plexus (4 cases); in the remaining 3 cases, the needle entered into the middle scalenus muscle not far from the plexus. Despite some anatomic differences among the various cases or slight errors in drawing the angle or inserting the needle, the bisecting line always led the way to the plexus. Had we performed the procedure on patients we would likely have elicited the twitch in all cases after only small needle trajectory adjustments.

Discussion

Almost 20 different supraclavicular approaches to the brachial plexus have been described in the past 90 years. The importance lies not in the success rates of one or the other because these are more or less similar but in the effort to avoid the more serious complications. Over time, the paravertebral techniques have been preferred by some to the supraclavicular ones. We chose to search for another technique because of the complications we had experienced with the Moore or Winnie procedures.

In Brown's "plumb bob method," with the patient in a supine position, the needle is inserted at a right angle to the horizontal plane of the bed into the point in which the clavicular head of the sternocleidomastoid muscle meets the clavicle and attempts are made to locate the brachial plexus. If success is not achieved, the needle is redirected either in a cephalad or in a caudad direction up to 30° from the perpendicular.[8] It is an attractive technique that we have used with success, but because of its 30° caudad direction, it may have a low percentage of PTX.[8] Our technique differs from that of Pitkin for the following reasons: (1) in the Pitkin technique, the subclavian artery pulse is not used as a landmark; (2) the needle enters 1.5 inches above the clavicle, and therefore it is a lateral paravertebral approach (in our technique, the needle enters near to the superior border of the clavicle); and (3) the 2.5-inch needle is directed 3 times toward the roots of the brachial plexus (ie, C5, C6, and C7 where the anesthetic is injected after coming into contact with the bone). In our technique, the 35-mm needle, because of its point of entry and direction, reaches the brachial plexus at the level of the superior trunk without coming in contact with the vertebrae. The scalene muscles extend, with an

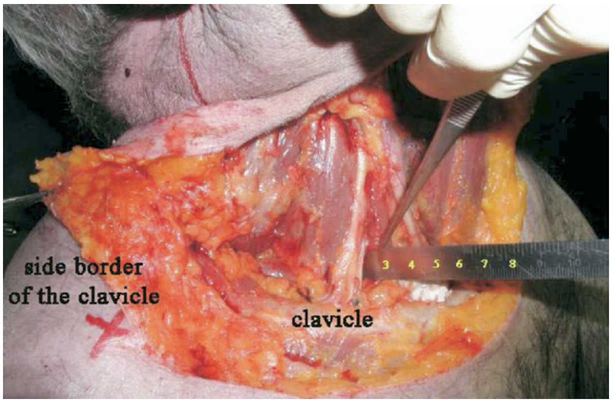

Fig 4. Distance of the spine from the central area of the interscalene triangle: 3 cm.

anterior-lateral direction, from the lateral processes of the cervical vertebrae to the first rib; the scalene triangle has its apex in a paravertebral position and the base far from it.

In the MIB, the needle reaches the scalene triangle in its central area. Because the base of this triangle lies on the anterolateral portion of the first rib, the central area should be far enough (3 cm) from the cervical spine (Fig 4) and above the pleura to reduce the risk of major complications.

Winnie's method is substantially different from the MIB because of its entry point at C6 level and for its needle direction "dorsad, mesiad, caudad." Lombard and Couper[9] noted that the minimum distance from the skin to the foramen of C6 was 23 mm, and the minimum distance from the medial edge of the scalenus medius to the spinal column was 35 mm.[9] In the cadaver study, we measured the distance from the point of entrance into the skin to the vertebral foramen of C7 and it was ≥5 cm. We also measured the distance from the scalene triangle to the vertebral foramen of C7, and this was 3 cm (Fig 4). This finding was similar to that described by Lombard and Couper. The difference in the distance from the cutaneous point of entrance to C7 rather than C6 is because of the fact that the neck widens near its base. In other words, we can compare the scalene triangle to a ladder whose base lies on the anterolateral portion of the first rib and whose apex leans against the cervical spine at the level of C6. In the MIB, the point of contact between the needle and the brachial plexus takes place at the midpoint of this ladder, a presumably safe area, 3 cm away from the cervical spine. The 35-mm needle, in order to reach the plexus, only passes through soft tissues and any bony contact should be avoided. If properly performed, the risk of pneumothorax is low but only if the needle is not directed inferiorly.

In a previous study,[10] the extent of the anesthesia 2 hours after induction was evaluated by using a pinprick test on the various topographic areas of the individual nerves. The percentages of nerve block achieved by the anesthetic block differed as follows: circumflex nerve 100%, musculocutaneous nerve 100%, radial nerve 100%, median nerve 88%, medial cutaneous nerve of forearm 73%, ulnar nerve 72%, cutaneous medial nerve of arm, and intercostobrachial nerve 50%. Thus, this approach, like other supraclavicular techniques, primarily blocks the upper dermatomes of the arm and misses the C8-T1 innervations.

Urmey et al.[11] found that diaphragmatic paralysis occurs with nearly 100% of interscalene blocks. In our experience, it occurs in 60%. Whether this lower incidence is because of a smaller volume of local anesthetic or the injection of anesthetic further away from where the phrenic nerve crosses the neurovascular bundle is unknown. Our results agree with Neal et al.,[12] who reported a 50% incidence of diaphragmatic paralysis after supraclavicular block using 30 mL of 1.5% lidocaine.

Surface landmark-guided techniques may be used less in the future with the advent of ultrasound-guided techniques or percutaneous electrode guidance.[13] But they will always remain a useful aid to needle placement. In the anatomic study, we deliberately used a spinal needle to better emphasize the direction and the risk that may occur with a longer needle. If a needle is ≥5 cm, it is possible to reach the vertebral foramen or the vertebral artery, but because we normally use a 35-mm needle and it is rarely necessary to introduce it completely in order to obtain a twitch, a 5-cm needle is only rarely used on more robust patients. However, a ≥5-cm needle could represent a risk if normally used in this technique.

To summarize, we have 2 methods to safely reach the brachial plexus. The first one makes use of the subclavian arterial pulse, which, if present, is the most important landmark. With this basic method, the needle is introduced in the transverse plane of C7 and follows a straight line toward C7 that corresponds to the straight skin line, which, starting from the middle point of the clavicle, is just laterally tangent to the skin projection of the subclavian artery pulse. If the desired twitch is not evoked, we redirect the needle backward with small adjustments, step by step up to 15°, or forward up to 15° from the straight line described. The second method, which is performed in the absence of a subclavian artery pulse, is based on the identification of 3 bony landmarks: the midpoint of the clavicle, the spinous process of C7, and the sternoclavicular joint. By connecting the first point to the others, we obtain an angle, whose bisecting line traces the way toward the brachial plexus. If we prolong this bisecting line, it will reach the axilla. It coincides with the "line of anesthesia" described by Bazy.[14]

We believe that our anatomic dissections confirm that the bony landmarks are reliable reference points. The technique is in agreement with the concept of anesthetic line also described by Grossi.[15] In our opinion, this technique as well as the other supraclavicular techniques are indicated for shoulder and arm operations, whereas more distal techniques are preferable for forearm and hand surgery. In the clinical setting, our block was effective in a high percentage of patients; it appears easy to perform. We recorded no major complications such as subarachnoidal injection, intravertebral artery injection, or pneumothorax. The only relevant complication was phrenic nerve block in patients already suffering from respiratory insufficiency.

Based on the limited number of patients studied, our technique appears safe. However, major complications may still be as frequent as 1 in 250 patients, based on the upper limit of the 95% confidence interval. In conclusion, we present our initial experience with the middle interscalene block. Based on 719 patients, this approach appears to be highly successful in producing anesthesia of the upper arm and shoulder. Safety of the MIB must be established by larger studies. Similarly, the advantages or disadvantages of the MIB, as compared with other approaches to the brachial plexus, can only be established with direct randomized comparative trials.

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