Case series: ultrasound-guided supraclavicular block using a curvilinear probe in 104 day-case hand surgery patients

Série de cas: bloc supraclaviculaire échoguidé avec une sonde curvilinéaire chez 104 patients pour une chirurgie d'un jour de la main

Ban C. H. Tsui, MD · Kathleen Doyle, MD ·
Kinny Chu, BSc · Jennifer Pillay, BSc ·
Derek Dillane, MB

Received: 5 June 2008 / Revised: 21 October 2008 / Accepted: 30 October 2008 / Published online: 20 December 2008
© Canadian Anesthesiologists' Society 2008

Abstract

Purpose To report our experiences regarding the implementation of a combined ultrasound and nerve stimulation guidance technique for supraclavicular blockade in day-case hand surgery patients at our institution.

Clinical features We retrospectively reviewed 104 patient charts from the first 6 months of our clinical practice of using this block approach for upper extremity surgery. Block success, completion and recovery time, post-block analgesia requirement, acute complication rate, and duration of hospital stay were evaluated and categorized based on the practitioner who performed the block (fellow/staff anesthesiologists and residents), as well as the body mass index of the patient (when available). During the performance of each block, the brachial plexus was viewed using a curvilinear probe, and the needle was advanced in-plane in an anterolateral-to-posteromedial direction. The plexus, needle, and spread of local anesthetic could be clearly visualized in each case. Surgical regional anesthesia was achieved in 94.2% of blocks. The block was the sole method of postoperative analgesia in 85.6% of patients, and the overall block completion time was 20.2 ± 9.2 min. There were no occurrences of clinical pneumothorax during the study period.

Conclusions We report our successful experience using ultrasound guidance and nerve stimulation during supraclavicular blockade. The curvilinear probe enables a large field of view, adequate resolution in larger patients, and excellent needle visibility that allows access to the plexus while avoiding the pleura and subclavian artery.

Résumé

Objectif Rapporter nos expériences au sujet de la mise en œuvre d'une technique combinée de guidage par ultrason et stimulation nerveuse pour un bloc supraclaviculaire chez des patients de chirurgie d'un jour de la main dans notre centre.

Éléments cliniques Nous avons révisé rétrospectivement les dossiers de 104 patients ayant subi une chirurgie d'un membre supérieur au cours des six premiers mois d'utilisation de cette technique de bloc dans notre pratique clinique. La réussite du bloc, le temps d'installation et de récupération, les besoins analgésiques post-bloc, le taux de complications aiguës et la durée du séjour à l'hôpital ont été évalués et catégorisés sur la base du médecin ayant réalisé le bloc (anesthésiologistes, résidents et fellows), ainsi que selon l'indice de masse corporelle du patient (lorsque les données étaient disponibles). Pendant la réalisation de chaque bloc, le plexus brachial a été visionné à l'aide d'une sonde curvilinéaire, et l'aiguille a été insérée longitudinalement dans une direction antéro-latérale à postéro-médiale. Le plexus, l'aiguille et la diffusion de l'anesthésique local étaient clairement visibles dans chaque cas. Une anesthésie régionale chirurgicale a été réalisée dans 94.2 % des blocs. Le bloc a constitué l'unique méthode utilisée en analgésie postopératoire chez

B. C. H. Tsui, MD (✉) · K. Doyle, MD · K. Chu, BSc ·
J. Pillay, BSc · D. Dillane, MB
Department of Anesthesiology and Pain Medicine, University
of Alberta Hospitals, 8-120 Clinical Sciences Building,
Edmonton, AB, Canada T6G 2G3
e-mail: btsui@ualberta.ca
URL: www.EdmARA.ca

85.6 % des patients, et le temps d'installation global du bloc était de 20.2 ± 9.2 min. Il n'y a pas eu de pneumothorax pendant la période de l'étude.

Conclusion Nous rapportons ici notre expérience réussie d'utilisation de l'échoguidage et de la stimulation nerveuse lors d'un bloc supraclaviculaire. La sonde curvilinéaire permet d'obtenir une visualisation très large, une résolution adéquate chez les patients plus gros ainsi qu'une excellente visibilité de l'aiguille, ce qui donne accès au plexus tout en évitant la plèvre et l'artère sous-clavière.

Major advances have been made regarding the use of peripheral nerve blocks for ambulatory surgery. Nevertheless, transforming the standard daily practice of any major centre, from one that exclusively uses general anesthesia to one that regularly uses regional anesthesia, can be extremely challenging. At our institution, one of the major barriers to change is the fear of block failure.

Plastic surgery for the distal upper extremity is one of several common ambulatory surgical disciplines amenable to regional anesthesia. Supraclavicular brachial plexus blocks are beneficial because of their rapid onset time and predictable anesthesia. Yet, whether the blocks are ultrasound-guided (85–95%)^{1–4} or nerve stimulation-located (72–97%),^{5–7} current evidence indicates variable success rates. These blocks have also been associated with pneumothorax^{8,9} and procedural difficulty in patients where landmark-based techniques can be inadequate [e.g., high body mass index (BMI) or anatomical variation].⁶ These factors introduce a degree of uncertainty when considering suitability of supraclavicular brachial plexus blocks for day-case surgical patients. As a result, in order to improve the success and safety of these blocks, the combined ultrasound and nerve stimulation-guided (USNSG) technique using a curvilinear probe for supraclavicular blockade was selected at our institution.

The objective of this retrospective analysis was to demonstrate that USNSG supraclavicular brachial plexus blockade is effective and safe in patients undergoing day-case hand surgery.

Methods

Review of clinical series

After Institutional Ethics Board approval (University of Alberta, Edmonton), patient charts were retrospectively reviewed from the first 6 months of our practice of using this block approach for elective hand surgery. Light sedation (generally midazolam 2–5 mg *iv* with maintenance of verbal contact) was given at the outset of each procedure.

No other sedation was provided until after assessment of the block. Local anesthetic solutions generally consisted of a 20–30 ml volume of a mixed lidocaine (1.5%) and bupivacaine (0.125%) solution.

The blocks were performed by a supervised resident (postgraduate years 2, 3, 4, or 5), an anesthesia fellow, or a staff anesthesiologist. All staff received a brief introduction to scanning and needling methods, including practice on a gel phantom, prior to performing the blocks for the first time, and they were verbally instructed during all procedures. The staff anesthesiologist assumed control of the procedure in cases where a trainee was having difficulty finding the plexus or locating the needle.

Sensory deficit, prior to and after surgery, was measured using response to pinprick in the distribution of the major terminal nerves (musculocutaneous, radial, median, and ulnar). Complete block onset was defined as anesthesia (no sensation to touch) of all terminal nerves and was indicative of readiness for surgery. Motor block was assessed by the inability of patients to move their fingers and wrist on the operative side. The postoperative analgesia standard at our institution is a visual analogue scale of $\leq 3/10$; therefore, a score of 3 or less was considered as adequate analgesia.

For our analysis, a successful block was defined as that which did not necessitate conversion to general anesthesia. Supplemental regional anesthesia may have been performed, but was calculated as part of the block completion time and was still considered a successful block. Block completion time included the time from probe placement to the time of complete block onset. The number of needle passes/attempts was not recorded, as the reporting of this information was incomplete. The incidence of inadvertent arterial puncture, signs of local anesthetic toxicity suggesting intravascular injection, and clinically overt pneumothorax were documented. Length of stay in the post anesthetic recovery room (PARR) and time spent on the recovery unit until discharge were recorded. Feasibility of using the USNSG technique for day-case upper extremity surgery was characterized as discharge within the same day of surgery. Body mass index [(weight(kg)/height² (m)²] was recorded when available, and the patients were then classified as morbidly obese (≥ 40 kg m⁻²), obese (30–39.9 kg m⁻²), overweight (25–29.9 kg m⁻²), or normal weight (≤ 24.9 kg m⁻²).¹ The success rate and block completion times were compared between groups of patients based on BMI and on experience level of block performer. All patients were discharged with a patient care pamphlet and were instructed to report any breathing

¹ World Health Organization. Obesity: preventing and managing the global epidemic: report of the WHO consultation of obesity. Geneva (Switzerland): World Health Organization; 1997; 9.

difficulties and/or prolonged anesthesia by calling a 24 h contact number.

Combined USNSG supraclavicular block

The needle was ultimately aligned in-plane to a low-frequency curved array probe using a portable ultrasound machine [e.g., TITAN or MicroMaxx machine (SonoSite Inc., Bothell, WA, USA) with C11e, 11 mm footprint, 8–5 MHz probe], with the needle directed in an anterolateral-to-posteromedial direction (Fig. 1). For localizing the trunks/divisions of the brachial plexus, the probe was initially placed above the clavicle at its lateral aspect and then moved in a medial direction until the pulsatile anechoic subclavian artery was identified (using colour Doppler when required). The plexus was then visualized as several (3–4) hypoechoic nodules surrounded by a hyperechoic perineural connective tissue immediately posterolateral to the artery, where both nerves and artery are superior to the pleura (Fig. 2, top). The probe was then moved laterally, so that the plexus and artery were placed at the centre or inner aspect of the ultrasound screen to ensure adequate room for viewing the block needle (Fig. 2, middle). Finally, by rotating or tilting the probe, the resolution of the nerves was enhanced by optimizing the incidence of the ultrasound beam at a 90° angle relative to the transverse (short) axis of the nerves. The needle was advanced incrementally during which the needle shaft and tip were viewed at all times. To maintain sterility and to minimize image distortion, the probe was covered with a transparent dressing (Tegaderm, 3 M Health Care, St. Paul, MN, USA), as previously reported (Fig. 1).¹⁰ The primary endpoint for local anesthetic injection was visibility of the needle tip in close approximation to at least one plexus

Fig. 1 In-plane needle alignment and insertion directed in an anterolateral-to-posteromedial direction. The probe is covered with a sterile dressing which we have found most suitable for the curved probe and for obtaining good colour Doppler effect

Supraclavicular Brachial Plexus Block

Identify plexus trunks/divisions superolateral to subclavian artery (SA)

Insert needle in an anterolateral-to posteromedial direction while viewing shaft and tip (arrowhead)

Inject local anesthetic and view its circumferential spread

Fig. 2 Procedure for ultrasound-guided supraclavicular block. The needle is viewed at all times to enhance safety, and the local anesthetic spread is important for assessing block performance. Dotted line = plexus trunks/divisions; arrowheads: needle tip; SA = subclavian artery

trunk/division, followed by observation of adequate injectate spread (dextrose 5% in water, D5W) between the nerve structures and artery. Injection of 1–2 ml of D5W confirms spread of solution, while maintaining the motor response during a nerve stimulation technique.¹ Nerve stimulation responses (hand or wrist movement at a current threshold of 0.5 mA) were used for confirmation of the nerve structure. Ultrasonographic visibility of close needle-plexus proximity and appropriate spread of solution (Fig. 2, bottom) were always attained.

Results

One hundred four patients had USNSG supraclavicular blocks performed during the 6 month timeframe. During all blocks, sonographic visibility of the needle, plexus, subclavian artery, and local anesthetic spread was achieved (Table 1).

Table 1 Patient demographics

	Successful regional blocks (<i>n</i> = 98)	Conversion to general anesthesia (<i>n</i> = 6)
Age	32.85 ± 12.60	36.16 ± 14.12
Sex (M/F)	76/22	3/3
BMI (<i>n</i> = 64) (kg m ⁻²)	25.72 ± 4.44	25.92 ± 5.40
<i>Block completion time (min)</i>		
Fellow/staff anesthesiologists	19.1 ± 7.9	43.67 ± 31.94
Residents	21.8 ± 11.3	15.33 ± 8.08
<i>Block completion time (min)</i>		
Normal weight	18.64 ± 8.44	N/A
Overweight	17.9 ± 8.17	
Obese	27 ± 9.41	
Morbidly obese	15*	
PARR (min)	34.7 ± 5.6	48.5 ± 28.03

Note: Values are mean ± SD

BMI body mass index, PARR post anesthetic recovery room

N/A = incomplete data collection

* Indicates *n* = 1

Surgical regional anesthesia was achieved in 94.2% of blocks, with an overall block completion time of 20.2 ± 9.2 min. The need for supplemental local anesthetic was not consistently recorded; however, 14.4% required supplemental analgesia in the form of morphine (2.5 mg), meperidine (25 mg), or acetaminophen (325 mg) with codeine (30 mg) intraoperatively and/or in PARR. Five patients complained of postoperative nausea and were each given 25 mg of dimenhydrinate. Mean stay in the PARR was 34.7 ± 5.6 min, and mean stay in the day surgery ward before discharge was 120.5 ± 34.1 min. The majority of patients were discharged on the same day (91/104), with two patients requiring overnight stays for anesthesia-related issues (one for extensive motor block and one for uncontrolled pain) and 11 patients staying behind for other medical or social reasons. No concerns were reported in the follow-up phone calls to all patients within 1–2 days of discharge. There was no documented incidence of pneumothorax or intra-arterial injection.

Block completion times for fellow/staff anesthesiologists and residents were 19.1 ± 7.9 min and 21.8 ± 11.3 min, respectively. Block completion times for normal weight (*n* = 28), overweight (*n* = 26), obese (*n* = 9), and morbidly obese (*n* = 1) patients were 18.64 ± 8.4, 17.9 ± 8.17, 27 ± 9.4, and 15 min, respectively. The success rates were 96.4%, 96.2%, 88.8%, and 100%, correspondingly. Only 64 patient charts had both height and weights recorded for BMI calculations. The range of BMI was 18.62 kg m⁻² to 40.47 kg m⁻².

Discussion

This case series demonstrates that USNSG supraclavicular blocks, as performed by staff or supervised trainees with limited skills in ultrasound-guidance, are feasible for day-case hand surgery. The described block technique allowed good visibility of all block-related structures at various anatomical depths, without compromising needle placement as may occur with the use of larger footprint probes.

Both ultrasound-guidance and nerve stimulation are two of the most commonly employed techniques for nerve localization. The nerve stimulation technique has been the established modality in anesthesiology for nerve localization. However, it is prone to physiological variability as well as being dependent on the needle–tissue interface.^{11,12} The use of real-time ultrasound guidance allows visualization of the target nerve structure with its anatomical surroundings, but the image is subject to the skill and interpretation of the operator.¹³ Moreover, the quality of the acquired image may be influenced by patient habitus. At the time when the USNSG technique was implemented at our hospital, the use of ultrasound in regional anesthesia was still in its infancy, and the methods were not as well established as they are today. Furthermore, we did not have an in-house expert regarding the various ultrasound techniques applicable to regional anesthesia. In order to minimize this weakness, we devoted ample time to studying and understanding the relevant anatomy as well as practising needling on a gel phantom prior to block performance.

We believe ultrasound and nerve stimulation have their respective limitations; however, in combination, they may compensate for each other's weaknesses. Ultrasound-guidance allows for visualization of the penetrating needle and nerve as well as a reasonable estimate of the spread of local anesthetic. Yet, the exact identity of the nerve can occasionally be uncertain. By electrically stimulating that target structure, one can objectively determine its identity.¹³ Furthermore, nerve stimulation can be an important indicator of needle–nerve proximity. This case series has demonstrated the complimentary nature of ultrasound and nerve stimulation as modalities for nerve and needle location. We believe that, in combination, both are important for obtaining a block success rate of 100%,¹³ especially when the block is performed by an anesthesiologist with little clinical ultrasound experience.

Another issue that has the potential to limit success and safety with ultrasound-guided supraclavicular blocks is the use of large footprint probes.^{1,2} The use of a displaced needle puncture point, with a strict lateral-to-medial needle direction in such a compact anatomical region, inherently increases the risk of pneumothorax.^{14,15} Thus, we have modified this technique with the use of small footprint

probes, allowing needle insertion closer to the target with a more anteroposterior needle direction. The curvilinear probe enables a larger field of view which, in turn, allows for visualization of the structures under the clavicle, provides adequate beam penetration for use with varying patient habitus, and facilitates needle visibility in order to approach the plexus while avoiding the pleura and subclavian artery. The use of small footprint curved probes has been described for infraclavicular^{16,17} and sciatic nerve blocks¹⁸ for providing continuous visualization of needle location as well as a large field of view to capture all relevant anatomical structures. The small footprint is useful at the compact supraclavicular location, where loss of full contact between the skin and probe faceplate, i.e., tangential contact with air as an interface, is common and may lead to image dropout.¹⁹ Obtaining an ultrasound plane, with an incidence angle of 90° that provides ideal specular reflection, is optimal for providing clear visibility without producing artifactual images (e.g., reverberation and scattering) or dorsal shadowing, as seen with beam refraction. When the needle is inserted at a clinically relevant (e.g., 35–45°) angle, the ultrasound beam provided by the linear array probe can lead to poor detection and distinction of the needle from the surrounding media.²⁰ In contrast, the beams of the curved array are more likely to interact with the needle at a resulting 90° angle, thereby providing a better view of the needle shaft when the needle is inserted at a clinically relevant angle. Additionally, the curved array may improve imaging at this location by minimizing acoustic shadowing from the clavicle and first rib.¹⁹ With this modified technique, there was no incidence of clinical pneumothorax within our case series of 104 patients. Since no clinical pneumothorax was observed, the upper risk limit of this complication occurring as a result of this modified technique is estimated to be 3% or less (95% confidence interval).²¹

Our success rate of 94.2% is comparable to other studies using a combination of ultrasound and nerve stimulation techniques.^{1,2,22} However, despite the high success rate, we did have over a 5% failure rate for complete surgical block attainment. We suspect that many factors could have contributed to these failures, such as inadequate local anesthetic spread, patient body habitus, and local anesthetic soakage time. In spite of this, we cannot definitively define the exact cause, due to the small sample size. The average block completion time obtained in this case series was 20.2 ± 9.2 min, substantially lower than the block completion time reported in a previous study.² This is the first reported series to consider the effect of an USNSG technique on the length of stay in the recovery room and surgical ward before discharge. In the past, we could not achieve a consistently successful surgical block that would

convince our surgical and nursing colleagues that regional anesthesia is a reliable and safe anesthetic technique. After the introduction of the USNSG technique, regional anesthesia has been accepted by both the surgical and nursing teams at our institution as a routine way of performing anesthesia on patients undergoing hand surgery.

This clinical series is limited by its retrospective nature and, as a result, several measurements were not recorded on a consistent basis (e.g., weight, height, needle attempts, and time for image acquisition). Retrospectively, there was no standard protocol for the administration of sedation or performance of a rescue block (e.g., supplemental local infiltration). This was the rationale for defining a successful block i.e. that which did not require conversion to general anesthesia, rather than assessing success by the degree of sedation required. We are currently developing a comprehensive database to record all relevant block-related parameters. Additionally, the incidence of non-overt pneumothorax was not evaluated (there was no radiological study in patients without overt signs). In an effort to detect such unwanted effects, prior to discharge, all patients are provided with a detailed pamphlet that contains in-depth instructions, should they experience shortness of breath, dyspnea, or unresolved upper limb anesthesia that lasts over 24 h. As Table 1 shows, the regional blocks performed using the USNSG technique can achieve consistent patient recovery times and postoperative analgesia. As a result of the implementation of this technique at our institution, all patients with a successful regional block can now return immediately to the day surgery unit and bypass PARR monitoring.

Ideally, a prospective trial should be performed to confirm our findings. However, due to our current extensive experience with the modality, it would now be impossible to reproduce and conduct a prospective trial to reflect our historical inexperience of using ultrasound for regional anesthesia. Nevertheless, we believe that this retrospective analysis illustrates that USNSG supraclavicular brachial plexus blockade can be successfully performed by anesthesiologists with limited ultrasound experience, who are equipped with an adequate knowledge of anatomy while understanding the respective limitations of both ultrasound and nerve stimulation. As ultrasound training opportunities become more readily available, anesthesiologists should seek to improve their skills by attending lectures, participating in workshops, and performing nerve blocks under the direct supervision of experienced practitioners.

Acknowledgements This work was supported in part by an Education and Research Fund, Department of Anesthesiology and Pain Medicine, University of Alberta Hospitals, Edmonton, Canada, and Clinical Investigatorship Award, Alberta Heritage Foundation for Medical Research, Alberta, Canada.

Conflicts of interest The authors have no conflicts of interest regarding this case series.

References

1. Beach ML, Sites BD, Gallagher JD. Use of a nerve stimulator does not improve the efficacy of ultrasound-guided supraclavicular nerve blocks. *J Clin Anesth* 2006; 18: 580–4.
2. Chan VW, Perlas A, Rawson R, Odukoya O. Ultrasound-guided supraclavicular brachial plexus block. *Anesth Analg* 2003; 97: 1514–7.
3. Kapral S, Krafft P, Eibenberger K, Fitzgerald R, Gosch M, Weinstabl C. Ultrasound-guided supraclavicular approach for regional anesthesia of the brachial plexus. *Anesth Analg* 1994; 78: 507–13.
4. Williams SR, Chouinard P, Arcand G, et al. Ultrasound guidance speeds execution and improves the quality of supraclavicular block. *Anesth Analg* 2003; 97: 1518–23.
5. Baranowski AP, Pither CE. A comparison of three methods of axillary brachial plexus anaesthesia. *Anaesthesia* 1990; 45: 362–5.
6. Franco CD, Gloss FJ, Voronov G, Tyler SG, Stojiljkovic LS. Supraclavicular block in the obese population: an analysis of 2020 blocks. *Anesth Analg* 2006; 102: 1252–4.
7. Franco CD, Vieira ZE. 1,001 subclavian perivascular brachial plexus blocks: success with a nerve stimulator. *Reg Anesth Pain Med* 2000; 25: 41–6.
8. Brown DL, Cahill DR, Bridenbaugh LD. Supraclavicular nerve block: anatomic analysis of a method to prevent pneumothorax. *Anesth Analg* 1993; 76: 530–4.
9. Finucane BT, Tsui BC. Complications of brachial plexus anesthesia. In: Finucane BT, editor. *Complications of Regional Anesthesia*. 2nd ed. New York: Springer; 2007. p. 121–48.
10. Tsui BC, Twomey C, Finucane BT. Visualization of the brachial plexus in the supraclavicular region using a curved ultrasound probe with a sterile transparent dressing. *Reg Anesth Pain Med* 2006; 31: 182–4.
11. Tsui BC, Wagner A, Finucane B. Electrophysiologic effect of injectates on peripheral nerve stimulation. *Reg Anesth Pain Med* 2004; 29: 189–93.
12. De Andres J, Sala-Blanch X. Peripheral nerve stimulation in the practice of brachial plexus anesthesia: a review. *Reg Anesth Pain Med* 2001; 26: 478–83.
13. Tsui B. Ultrasound-guidance and nerve stimulation: implications for the future practice of regional anesthesia. *Can J Anesth* 2007; 54: 165–70.
14. Collins AB, Gray AT, Kessler J. Ultrasound-guided supraclavicular brachial plexus block: a modified Plumb-Bob technique. *Reg Anesth Pain Med* 2006; 31: 591–2.
15. Gray AT, Schaffhalter-Zoppoth I. A concerning direction. *Anesthesiology* 2004; 100: 1325.
16. Bigeleisen P, Wilson M. A comparison of two techniques for ultrasound guided infraclavicular block. *Br J Anaesth* 2006; 96: 502–7.
17. Sandhu NS, Manne JS, Medabalmi PK, Capan LM. Sonographically guided infraclavicular brachial plexus block in adults: a retrospective analysis of 1146 cases. *J Ultrasound Med* 2006; 25: 1555–61.
18. Chan VW, Nova H, Abbas S, McCartney CJ, Perlas A, Xu DQ. Ultrasound examination and localization of the sciatic nerve: a volunteer study. *Anesthesiology* 2006; 104: 309–14.
19. Sites BD, Brull R, Chan VW, et al. Artifacts and pitfall errors associated with ultrasound-guided regional anesthesia. Part II: a pictorial approach to understanding and avoidance. *Reg Anesth Pain Med* 2007; 32: 419–33.
20. Maecken T, Zenz M, Grau T. Ultrasound characteristics of needles for regional anesthesia. *Reg Anesth Pain Med* 2007; 32: 440–7.
21. Hanley JA, Lippman-Hand A. If nothing goes wrong, is everything all right? Interpreting zero numerators. *JAMA* 1983; 249: 1743–5.
22. Perlas A, Chan VW, Simons M. Brachial plexus examination and localization using ultrasound and electrical stimulation: a volunteer study. *Anesthesiology* 2003; 99: 429–35.