Is Nerve Stimulation for Dual Guidance REALLY necessary? ...

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INTRODUCTION

The first description of successful ultrasound use in 1989 by Ting and Sivagnanaratnam[1] for axillary brachial plexus block has since herald a new dawn in the expansion of global regional anaesthetic practice, supplanting nerve stimulator as the primary neuro-localization tool. However, central to this issue in question, current ultrasound technology is still unable to reliably delineate important nerve microstructures down to intra-fascicular level.[2] Although various prior studies have intimated that apparent intra-neural injection may be safe and do not result in persistent neurological symptoms, [2,3,4,5,6] inadvertent intra-fascicular impalement during needle advancement could predispose to a higher risk of post-operative neurological symptoms and needle trespass to these layers must be avoided at all cost. [7] Dual use of nerve stimulation, as an adjunct to ultrasound was intended to provide additional physiological information regarding estimation of needle-to-nerve proximity outside the anatomical realms that ultrasound is able to offer and has been recommended as an additional neuro-localization tool by various prominent regional anaesthesia societies since 2009.[8]

Dual Guidance, a technique combining both ultrasound and peripheral nerve stimulator has been advocated for a safe and more accurate practice of peripheral nerve block within the last decade. Although recommended by most authorities and theoretically thought to confer much benefit, there have been evidence to the contrary.[2,3,4] Review of publications in Regional Anesthesia and Pain Medicine journal from 2012 through 2014 revealed dwindling use of dual guidance technique in their study protocols, from 7 research papers in 2012 to 4 in 2013 and only 1 in the 2014.[9-20] Whether this reflects the general trend of practice by regional practitioners globally, or it is only institutionally based, is not known but improved clinical training with upgrades in ultrasound and needle tracking technology may obviate the need for nerve stimulation.

Despite prior studies showing promise in various areas surrounding the practice of dual guidance in peripheral nerve blocks, few key questions remain fully unanswered especially surrounding;

- Dual Guidance and block efficacy
- Dual Guidance and prevention of nerve injury

Use of nerve stimulation on block efficacy

There had not been any clear definition of 'block efficacy' previously and various characteristics have been utilized as such. Similarly lacking in clarity is what is deemed as 'block success', as motor and or sensory composite scoring, [21, 22, 23] need for supplementation, [23] surgical anaesthesia or conversion to general anaesthesia [24, 25] were few different alternative parameters that had been used as definitions in various studies. Based on these multitudes of different quantitative criteria, multiple single centre studies albeit with small sample sizes have looked at 'block success rates', 'block quality', 'performance times', 'needle passes' and 'complication rates' as surrogates of block efficacy. [21, 23, 24, 25, 26] These studies were however conducted on a heterogenous sample population, with a variety of block types, making it difficult to have systematic reviews or meta-analyses specifically powered to address the advantages of dual guidance with respect to block efficacy with a high level strength of evidence.

Beach in his study looked at 'surgical anaesthesia rates' in 94 consecutive patients who had surgery below the elbow with the use of nerve stimulation in ultrasound guided supraclavicular brachial plexus block, according to set criteria of 'well-defined image' and grouped the patients into 'with twitch' and 'without twitch'. He obtained similar surgical anaesthesia rates with both groups and found that in well-defined anatomy and needle position, the twitch monitor does not add any further useful information with respect to the ultimate success of the block and further concluded that a positive motor response to nerve stimulation does not increase the success rate of the block. In addition, it was also noted that nerve stimulation conferred a high false negative rate and suggested that these blocks are usually effective, even in the absence of a motor response.[25]

Chan similarly looked into ‘surgical anaesthesia rates’ in patients who underwent elective hand surgery under axillary brachial plexus blocks among three groups; between Ultrasound guided (US), dual guidance (US-NS) and nerve stimulation (NS). He found that US guided techniques, both yielded similar ‘surgical anaesthesia rates’ and ‘block quality’ which was significantly higher than NS group alone. They however failed to demonstrate a higher block success rate when nerve stimulation was added to ultrasound as a confirmatory tool. [21]

Gurkan added ‘block performance times’ as primary end point besides ‘block success rates’ based on their working definition in patients scheduled for distal upper limb surgery. Similarly, findings showed high success rates for both ultrasound-only and dual guidance groups (94.5% for both), with significantly shorter procedural times for ultrasound-only group. They concluded that ultrasound guided alone produces block success rate identical to dual guidance, yet with a shorter block performance time.[23]

Dingemans alternatively looked into ‘quality of block’ as surrogates for efficacy in patients with infra-clavicular ultrasound guided approach for below elbow surgery. It was found that ultrasound guided-only group had a higher proportion of patients achieving ‘block quality’ as defined by the group, with 86% achieved ‘complete blocks’ compared with 57% in dual guidance group, higher ‘surgical anaesthesia’ rates and lower ‘block supplementation rates’. Speed of execution in terms of procedural times was also found to be shorter in ultrasound-only group. They concluded that for infra-clavicular approach, visualization of local anaesthetic spread as the end point yields better success rates with shorter performance times. [24]

For femoral nerve blocks, Sites conducted comparisons between ultrasound-only and dual guidance groups on post block pre-operative ‘motor and sensory deficits at 40 minutes’ and looked at proportions of complete and partial block in 107 knee arthroplasty patients. They also looked at mean time to perform the blocks and numbers of needle redirections as their secondary end-points. Proportions of patients in each group with complete or partial block were slightly dissimilar but the difference was not statistically significant. The mean time for block performance was longer and number of needle redirections significantly higher for dual guidance group. They concluded that the addition of nerve stimulator to a US guided femoral nerve block did not change pre-operative block efficacy.[26]

Summary of findings of the above studies are shown in Table 1. Despite the findings and conclusions from these studies, only Dingemans described strict use of nerve stimulation as end-point for dual guidance group in their methodology, irrespective of the spread pattern visualized under ultrasound.[24] Chan, Gurkan and Sites used nerve stimulation as end-point for their dual guidance group, BUT adjusted spread pattern depending on distribution seen under real-time.[21,23,26] Chan did not compare ultrasound-only and dual guidance groups with regards to the tested parameters and no statistical testing was done to look at the differences between these groups. They only performed statistical analyses to compare between groups with and without ultrasound.[21] Gurkan’s work was only powered to detect a difference in performance time and NOT in success rates.[23] Pitfalls within their studies made interpretation and inference to their results and conclusions difficult with a high level of certainty.

Author	'Block Success'	Block Time	Needle pass	Complication
Beach 2006 (Supraclvicular) n=94	Overall 89% With twitch 89% Without twitch 92%	Not significant	Not as end point	No complications
Vincent 2007 (Axillary) n=188	US USNS PNS 82.2%* 80.7%* 62.9% Surgical anaesthesia 95%* 92%* 85.5%	US USNS PNS 9.3* 12.4* 11.2	Not as end point	No major complications
Dingemans 2007 (Infraclavicular) n=72	'Block quality' Complete blocks US USNS 86% 57%* Surgical anaesthesia 92% 72%* Supplement rate	3.1 v 5.2*	Not as end point	Vascular puncture 2 v 1 Paraesthesia>1/52 1 v 0 Shoulder pain <3/7 0 v 1
Sites 2009 (Femoral) n=107	Complete and partial at 40 mins US USNS 88.1%(69%+19.1%) 95.7%(71.7%+24%) 90.2% 89.1% (motor)	147.8s v 188.2s*	1.1 v 4.2*	No complications
Gurkan 2010 (Infraclavicular) n=110	US USNS 94.5% 94.5%	157s v 230s*	Not statistically significant	Vascular puncture in 2 (USNS)

Table 1 showing a summary of various studies comparing block efficacy.
* denotes comparisons which are statistically significant

Is nerve stimulation sensitive in detecting intra-neural injections?

Although there were no reports of neurological sequelae in various studies in which apparent intra-neural injections were detected, [5, 6] prevention of trans-epineurium trespass retains utmost priority as it hypothetically correlates to a lower at risk potential for intra-fascicular transgression.[7] With preponderance towards safety rather than location mode as current trend in neuro-stimulation, acquisition of specific motor responses at currents between 0.2 to 0.5 mA, which used to be the end point reflective of the needle to nerve distance estimates, are no longer necessary. The stimulator, has since evolved functionally from being a tool to specify neural structures, to a close-proximity sensor, as the set minimal current is now not indicative of distance estimates, but whether there is intra-neural trespass. Prior practice of purposely seeking muscle responses at low threshold currents may even in fact be partly the reason why our blocks works so well, and on the contrary, expose patients to the risk of post block neurological injury.

With regards to the use of nerve stimulation for prevention of neurological injury, there have been evidence to show that not all needle-nerve contacts result in stimulation and motor response or paraesthesia, [5,6,25] and insistence on specifically looking for absolute response may even be detrimental.[5, 6, 27]

Review of Tsai's animal study further laid credence to this findings. His work in looking at association of needle-to-nerve distance with stimulating current intensity, showed that specific muscle response to pig sciatic nerve stimulation were only obtained starting at a distance of 0.1 cm away and trans-epineurally with currents ranging from 0.24-1.48 mA at a distance 0.1 cm (in 70% of the attempts), and 0.15-1.4 mA on the epineurial surface (95%). When the needle was placed intra-neurally however, specific response was observed in 100% of attempts at stimulation with current intensity ranging from 0.08-1.80 mA. Importantly, of these 100% attempts of intra-neural stimulation, only 87.5% could be elicited with low current intensity from 0.08-0.4 mA. In 5 of total 40 attempts (12.5%), a specific response could only be attained with higher current intensity (0.8-1.8 mA). They concluded that although there is a correlation between nerve-to-needle distances with current intensity, currents of low intensity (<0.2 mA) is highly specific, but relatively insensitive of intra-neural needle placement. Dependence on nerve stimulation to decrease risk of an intra-neural injection may not be reliable. [28]

Intra-neural injections are in fact, a common occurrence than is originally thought and the intensity of stimulating current may not be a reliable indicator of transgress. Robards, using dual end-points in 24 patients for foot or ankle surgery, either apparent intra-neural location of needle tip on ultrasound or elicited motor response between 0.2 and 0.5 mA, found that motor response were acquired **ONLY** upon intra-neural entry as observed under real time in 83.3% (20/24). In 16.7% (4/24), no motor response was obtained with 1.5 mA even when intra-neural trespass occurred. They concluded that absence of motor response does not exclude intra-neural needle placement and additionally, low-current stimulation was associated with a high frequency of intra-neural trespass.[5] Similarly Siedel when conducting conventional technique nerve stimulation guided sciatic nerve blocks in 125 patients, learned that 70 out of 125 patients had intra-neural trespass when observed by a second physician using ultrasound imaging but blinded for the investigator who was performing nerve stimulation. No post block neurological sequelae was discovered during follow up in both studies. [5, 6]

Sadly, incidence of post block neurological injury with or without ultrasound guidance was not found to differ significantly.[1] Furthermore, no strong evidence exists in terms of risk reduction when dual guidance is used. Isolated case reports of nerve injury still emerge despite the use of this neuro-physiological monitor and strict adherence to standards in what is believed to be a procedural protocol when using nerve stimulator. [27] These reports highlight the issue of differences in, or the range of incidences of nerve injuries for different levels of nerve block approaches, highest being the interscalene.[29]

Should dual guidance be used for interscalene block exclusively? Sinha and colleagues showed in sixty one patients for outpatient shoulder surgery that successful anaesthesia can be achieved with ultrasound-guided needle placement regardless of motor stimulation threshold above or below 0.5 mA, suggesting that acceptance of ultrasound evidence should preside over specific motor responses as an end-point. They observed responses at current ranges from 0.14 to 1.7 mA, with 25 patients (42%) with stimulating current of less than 0.5 mA and 35 (58%) with more than 0.5 mA even though the needle tip was positioned appropriately in the interscalene groove. [30] Patients were followed up after surgery for complications but there was no mention of any post block neurological sequelae. The wide range in stimulating current thresholds in this study highlights the possibility of a false negative interpretation if the cut-off current threshold indicating intra-neural injection was set at an absolute value of 0.2 mA. Moreover, the review by Brull and colleagues was in the age where volumes of 30 ml or more of local anaesthetics and with vasopressors at times, were administered for interscalene blocks.[29] Acknowledging multifactorial aetiologies in the development and progression of post block nerve injuries, probable cause for increased incidence in interscalene approach may not be attributed to the block per se. Moayeri uncovered a probable anatomical reason for these differences which could be due to quantitative architectural ratio of neural to non-neural composition of different nerves and also within the same nerve at different locations. [31]

Sauter's work on the effect of tissue impedance on current threshold for nerve stimulation may partly hold the answer to the enigma that is the safe current threshold. His findings were that, different approaches or block locations for the same nerve may have different stimulating thresholds and they depend, and had an inverse relationship to tissue impedance at the particular site of stimulation. The group also noted that the threshold currents at variable sites of the same nerve were also different when different impulse durations were used. The results of their study indicate that current settings used for nerve stimulation may require adjustments based on surrounding tissue types and impedance.[32] Their conclusion further complicates and challenges our very understanding of what was fifty years ago the 'gold standard' technique in neuro-localization.

As we stand currently, a threshold stimulating current of **less than 0.2** mA **IS** intra-neural, **BUT** no response **OR** other stimulating current **up to 1.7 mA MAY be intra-neural**, depending on what is seen on ultrasound in real-time.[5, 6, 28] What nerve stimulation is able to show is that its use only reflects nerve-needle distance but is insensitive to intra-neural needle placement. [28] What is unnerving is that Sauter's discovery, shows current threshold depends on various parameters for its correct interpretation, which suggests the possibility that all these while, our application and clinical use of nerve stimulation principles based on **ABSOLUTE VALUES** may be wrong.[31] The use of a different mode of nerve stimulation; Sequential Electrical Nerve Stimulation (SENs) may be more sensitive than the current conventional mode in terms of fine tuning needle-nerve distance estimates, but in terms of preventing intra-neural injection, the likelihood of success is doubtful since similar application and principles of use still apply.[33]

CLick **A**ssociated **A**dequate **S**pread (**CLAAS**) technique; an alternative method?

CLAAS is a technique which utilizes combined appreciable tactile sensation of fascial click and direct real-time visualization of injectate deposition and spread pattern in relation to needle tip and the neural elements. A high degree estimate of a successful block utilizing the CLAAS technique would be predicted when all four pre-requisites are observed, which include;

i) **Tracking** of needle tip presentation, from insertion point to neural target
ii) appreciable **fascial click** as the needle is seen at an appropriate distance from the neural structure as interpreted by the operator as the para-neural sheath, **WITH**
iii) appropriate real-time test injectate **spread pattern** between needle tip (or the axis of the needle shaft) and the neural elements, **AND**
iv) **no nerve swelling** at the point of injectate deposition until completion of the delivered bolus

Although the practice of appreciating presence of fascial click is without much clinical evidence[2], when coupled with strict needle tracking and recognition of appropriate test injection spread pattern, are consistently found to provide valuable information to the experienced regional practitioner with regards to spatial orientation of the peri-neural structures. These precious multitudes of 'anatomical' real-time information may well obviate the need for nerve stimulators to function as a 'physiological indicator' given the low sensitivity of its needle-to-nerve distance estimates especially in prevention of intra-neural injection.[5,6,27,28]

Appropriate test injectate spread pattern **AFTER the click** depends on the angle of needle approach in relation to the neural structure. Three (3) patterns of spread are usually recognizable and are associated with high degree of predicted successful blocks. Test injectate is targeted to occupy the space **between the needle axis or the needle tip**, to the neural structure, **simultaneously displacing** it away from the needle.

I) If the needle approach angle is **tangential (parallel) to the fascia** that surrounds the particular nerve, the **spread** of local anaesthetic administered should be **directed upwards or downwards <u>FROM THE AXIS</u> of the needle** while propelling the neural structures away**.**

II) If the needle approach angle is **perpendicular to the fascia** of the neural tissue, appropriate **spread** is deemed to occur if the injectate spreads **<u>ALONG THE AXIS</u> of the needle, or diverging away from the needle tip**, directed towards, while pushing the neural structure away.

III) Further suggestions of adequate spread can be alluded if **injectate is seen to circumvent** the neural structure in real-time while the titrated injection bolus is being administered.

To the best of our knowledge, none have attempted to describe what is considered as an 'adequate spread', beyond 'circumferential' distribution [11,20,21, 22, 26] 'halo surrounding the nerve' [9] or 'donut sign' [26] which implies observation of appearance **AFTER** a pre-determined volume had been administered. CLAAS technique attempts to provide description of real-time local anaesthetic spread pattern from initial test injection, until its completion by observing relationship of the needle-nerve-local anaesthetic dynamics.

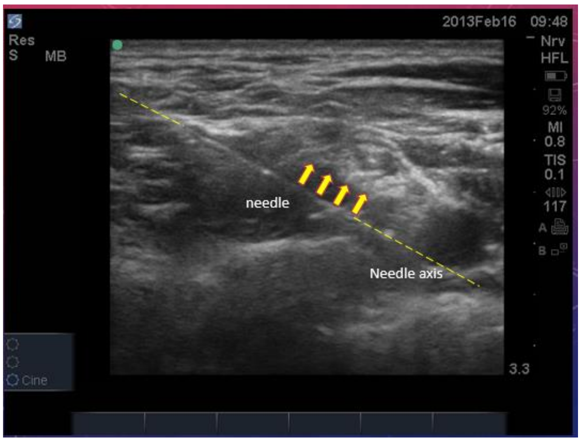

Figure 1 showing supraclavicular brachial plexus block being performed using CLAAS technique with the needle approach angle being tangential to the fascia. Note the local anaesthetic is being deposited between needle axis and the neural elements while simultaneously displacing them away.

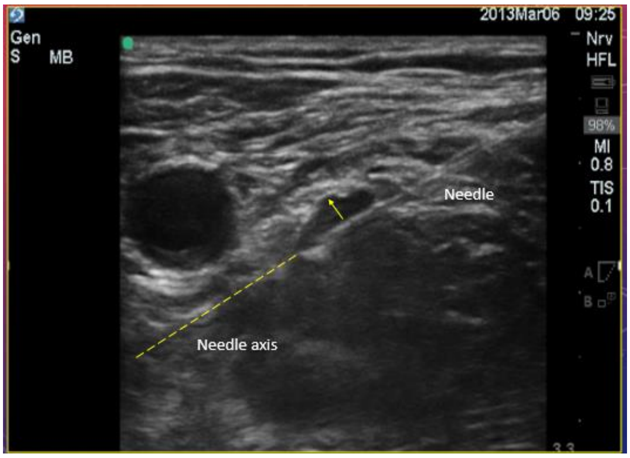

Figure 2 showing femoral nerve block performed using CLAAS technique, with needle approach angle being tangential to fascia iliaca. Note that the local anaesthetic is being deposited and the femoral nerve is simultaneously being pushed upwards and away from a plane between the needle axis and neural elements.

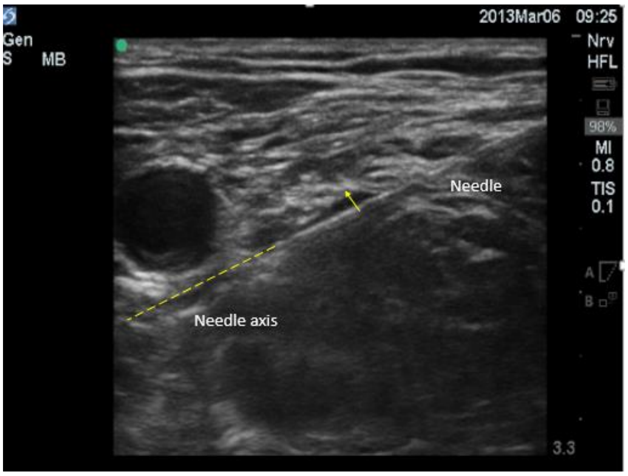

Figure 3 showing femoral nerve block performed using CLAAS technique, with the needle approach angle being tangential to fascia iliaca. Note the local anaesthetic spread is upwards in the space between needle axis and the neural elements, pushing it away from the axis.

CONCLUSION

Currently, evidence within the literature on the clear benefits of dual guidance is lacking at best. At the moment, **conventional nerve stimulation** mode **adds no value** with regards to; 'block success', predicting safe peri-neural placement of needle tip and avoidance of persistent neurological symptoms through prevention of apparent 'intra-neural' needle misadventure. There has been **no** evidence however on the use of SENS mode for dual guidance technique. Advocating routine use of nerve stimulation with ultrasound guidance is probably not warranted for every block, all the time but always be mindful of the role of nerve stimulation in addition to ultrasonography in deep or difficult blocks or where images of nerves or needles are degraded.

Continued experience and improved understanding in the use of ultrasound and image interpretation, together with various enhancements in equipment technology may improve overall efficacy of regional anaesthetic practices in the near future in terms of optimizing success rates and eliminate, if possible, the incidence of neural complications. Whenever dual guidance is used, understanding the limitations and advantages of either and both techniques will further enhance understanding on the effective use of the available tools for accurate and safe delivery of regional anaesthetic practice.

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