Β3.Δ. REGIONAL ANAESTHESIA WITHOUT ULTRASOUND USE: IS IT FEASIBLE?

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Regional Anaesthesia (RA) has experienced a tremendous increase in technical innovations, like only few other anaesthesia techniques over the previous years. The introduction of Ultrasound (U/S) visualization of nerves and surrounding structures is considered the driving force behind this development and has revolutionized RA, particularly peripheral nerve blockade. Peripheral nerve localization by U/S use has already started to replace nerve localization by electrical neurostimulation (N/S). The U/S utilization has led to a paradigm change in daily routine for anaesthesiologists undergoing training, as well as experienced RA practitioners. Nerves and sensitive structures are now more than a mental projection; they are visible objects corresponding to anatomical knowledge. This new technology has triggered curiosity and motivation in beginners and experienced RA physicians alike to further optimize and develop RA. Blocks previously associated with an increased risk (eg TAP Block, Supraclavicular Blocks) became popular, as vulnerable structures can now be identified and avoided. In addition, U/S has the potential for a more accurate placement of local anaesthetics around peripheral nerves, minimizing intravascular injection. However inadvertent intraneural injection continues to occur despite the widespread use of U/S during RA and more specifically Peripheral Nerve Blocks (PNBs) performance. Additionally, N/S continues to be used by many anaesthesiologists, alone or in combination with U/S. In this context, one would wonder: Is RA without U/S use still feasible or acceptable? And, is there still a place for the use of N/S during nerve localization? Or Does N/S confer any additional benefit when used in conjunction with U/S guided RA? The answer is not easy and can be positive, taking into account a list of specific questions and issues.

1. **The role of N/S for detecting intraneural injection**

If the use of N/S consistently leads to prolonged block times and less successful outcomes, can we not justify its disavowal? This might be entirely appropriate if U/S imaging becomes an unfailing and dependable indicator of intraneural injection of local anaesthetic. This phenomenon has traditionally been associated with the development of neurologic injury (incidence of late neurologic deficit of 0.4 per 1000 PNBs, defined as persistence of symptoms for longer than 6 months after onset). However, this potentially catastrophic occurrence is such a rarity that it precludes statistical substantiation by comparative RCTs between various nerve localization methods. N/S, and latterly, U/S guidance provide a margin of safety through elucidation of nerve–needle proximity. A number of recent studies suggest that intraneural injection of local anaesthetic may occur with a greater frequency than previously thought, without inevitably leading to neurologic complications.

Paradoxically, U/S imaging, while having enhanced our understanding of the needle–nerve relationship, has created ambivalence regarding the principles of N/S.

Many newer studies have led to a new understanding of the distance between needle tip and nerve tissue when using electrical N/S. Nevertheless, questions arose as to the minimum required threshold current for successful stimulation of nerve tissue. How safe is N/S really? Is it needed at all? Or should both techniques be combined when identifying nerve structures? U/S also led to new explorative approaches. Where should local anaesthetic agents be injected, intraneurally or extraneurally? Does local anaesthesia require the patient to be awake or is it safe to perform a block with the patient under general anesthesia? Practitioners try to find answers to these questions in the daily routine. These topics have fuelled controversial debates. To date, there is only little data and studies concerning the mentioned topics on which to develop evidence – based guidelines and here are not even any recommendations reflecting the mentioned questions available.

The distillation of human and animal studies into clinically useful guidelines suggests that N/S has higher specificity than sensitivity for detecting intraneural needle placement. With an intraneural needle tip location, a high stimulating current may be required to generate a motor response. Current evidence suggests that a minimum stimulating current of 0.2 mA always signifies an intraneural position.

2. Is the use of nerve stimulation injurious?

Over the past decade, there has been a profusion of RCTs comparing U/S with peripheral N/S. These have largely demonstrated the superiority of U/S guidance using a variety of outcomes including block performance time, reduced volume of local anaesthetic, and block efficacy. Although there is no evidence that reduced doses of local anaesthetic will decrease the incidence of systemic toxicity, it would still seem prudent to use the lowest possible dose. U/S technology allows the provider to use these lower doses. A longer block performance time may be required when N/S is used with U/S guidance if anatomic and neurophysiologic endpoints are desired. However, it is possible that the procedure time may be shortened by using N/S for the sole purpose of excluding intraneural needle placement rather than fastidiously seeking a nerve – specific motor response.

There has been a growing body of RCTs over the past decade comparing U/S guided RA (UGRA) with other forms of nerve localization techniques. In particular, many investigators have attempted to demonstrate thesuperiority of UGRA over N/S. In the light of these developments, the role of electrical N/S must be reassessed, and the question whether U/S has been superannuated by a safer and more effective technique needs to be answered. A preponderance of evidence suggests that the pendulum of favor is swinging toward UGRA.

This is provided by a heterogeneous collection of RCTs with modest numbers and disparate endpoints. In meta-analysis of RCTs of UGRA compared with N/S, many authors concluded that U/S guided blocks were associated with higher success rates, shorter procedure and onset times and longer block duration. Owing to the infrequent occurrence of complications associated with RA, there was not enough evidence to confer any superiority of safety on UGRA over N/S. This largely concurs with the American Society of Regional Anesthesia Evidence-Based Medicine Assessment that

found UGRA to be superior or equal to N/S in most studies and also found no evidence to suggest that UGRA reduces complications.

3. Tips and Tricks when Using N/S

A threshold current below 0.5 mA (0.1 ms) may frequently result in an intraneural needle placement in patients with otherwise healthy nerve tissue. Therefore, stimulation below 0.5 mA at 0.1 ms impulse duration should not be attempted. This lower limit needs to be tested, i.e. the current is reduced until the desired reaction to the stimulus disappears.

Good block results can be achieved using a current up to 1.0 mA/0.1 ms. Damaged nerve tissue, as frequently encountered in patients with polyneuropathy due to diabetes and/or renal insufficiency, can have an influence on nerve response to electrical stimulation. If a reduced susceptibility to electrical stimulation is expected, increased threshold currents (0.5–1.5 mA) should be used. Increasing the impulse duration (0.3–1 ms) to achieve the desired nerve proximity can be used alternatively to an increased current in patients with neuropathy.

An impulse duration of 0.1 ms duration can be considered the standard parameter for patients with healthy nerves. If the target is a solely sensory nerve, a longer impulse duration (0.3–1.0 ms) or an increased current should be selected. The practitioner should be aware of the stimulator's set pulse duration. The current should always be seen in context to the pulse duration. With the position of the needle unchanged, the electrical current has to be tripled when using a short pulse (0.1 ms) to elicit the same response compared to using a long pulse of 1.0 ms.

The tissue resistance which modern stimulators will display, can also be of clinical use. Due to the high electrical resistance of the perineurium a sudden increase in impedance could indicate an intraneural positioning of the cannula. Likewise, an absent increase in impedance after injection of the glucose 5% solution, due to its poor conduction, can indicate an intravascular position. The needle should be slowly advanced while applying the current with a high frequency (2 Hz). Triggering painful neurological symptoms is a risk factor for nerve damage, the block or injection should therefore be aborted and the position corrected, regardless of nerve stimulation status. Paresthesia synchronous to impulse without a muscle reaction in the target area should be considered a positive response to nerve stimulation.

The location of the neutral electrode is irrelevant but should not result in current passing through sensitive material (e.g. pacemaker or implantable cardioverter defibrillator). Even though the product notice may exclude nerve stimulation, using the technique should be possible after careful risk-benefit consideration. The current delivered by the stimulator may not only be registered as a cardiac current by the monitoring equipment but also by a pacemaker and trigger an asystole. For this reason, registration of the peripheral pulse using a pulse oximeter is recommended. The current should be delivered with a short impulse (<0.5 ms) with as much distance to the pacemaker as reasonable. A defibrillator should be deactivated with a magnet and the device functionality should be verified after the procedure.

Stimulation of the nerve is not possible after injection of conducting liquid. Glucose 5% as a test dose allows for further stimulation, although the interpretation of a stimulation response should be critically evaluated. Techniques requiring multiple

injections should be performed using ultrasound. It should be noted that localizing nerves using stimulation without ultrasound is still perfectly acceptable and within the guidelines of good clinical practice.

Further issues of note: The actual current delivered should be shown. The practitioner should be aware of a discrepancy between set and delivered current by setting alarms accordingly. The initial current should be set significantly higher than the targeted lower threshold current (e.g. begin with 2.0 mA with an expected threshold current of 0.5–1.0 mA with a pulse duration of 0.1 ms in patients with healthy nerves). The expected stimulus response must be known. When the first muscle reaction occurs, do not advance the needle any further. Avoid changes to the current while advancing the needle. A maximum test dose of 2.0 ml should be injected after aspiration as soon as the stimulus response disappears after reaching the targeted current. Observe for signs of intraneural injection, i.e. pain radiating into the extremity, painful neurological symptoms and/or injection requiring large amounts of pressure. If stimulus response persists, check for intravascular positioning of the cannula through aspiration and/or ultrasound.

4. Combining ultrasound and electrical nerve stimulation

Combining both techniques is another possibility to achieve successful PNBs. Clinical investigations revealed a frequent use of electrical stimulation in addition to the use of U/S for localizing the targeted nerve. Nerve stimulation can especially be useful in situations where the nerve is not clearly identifiable using U/S. Clinical studies show no increased rate of success or a reduction of intraneural punctures when both techniques are combined.

Electrical stimulation may be used for optimal placement of the cannula or when the target structure cannot be clearly visualized with ultrasound. In these cases, a lower initial current can be used compared to cases where electrical stimulation is the only technique used for identification of the target structure. The nerve stimulator is set to the required threshold current (1 mA at 0.1 ms pulse duration), which will trigger the appropriate response and alert the user when in close proximity to the nerve. The needle position should be verified either by U/S or hydro-localization. The needle has to be retracted if U/S shows the needle position to be intraneural. If the injected liquid indicates an adequate spread or the needle tip position is optimal in U/S visualization, the desired amount of local anaesthetic can be injected. If the target structure or needle tip cannot be identified, electrical N/S is required. This may especially be the case when performing a block on nerves situated deep in the tissue, e.g. psoas compartment block or anterior proximal sciatic nerve block. In these situations U/S can aid in the identification of structures associated with the target nerve. These may be blood vessels or structures in the thorax, abdomen or retroperitoneum.

5. Use of N/S for Epidural Anaesthesia

There is general consensus regarding the lack of safety when performing RA in anaesthetized patient, due to the inherent risk associated with performing blocks where there is minimal feedback pertaining to the warning signs of neural damage. This is particularly relevant for neuraxial blockade where the anatomic structures are tightly positioned leading to a reduced margin of safety for needle placement. The epidural space can be as narrow as 2 mm, and puncture depth to the subarachnoid and

epidural space may be difficult to predict because of the large variation in body habitus especially in the pediatric population. The use of preprocedural or real-time U/S guidance appears promising in this regard. The mostly cartilaginous posterior vertebral column affords adequate beam penetration to view spinal structures, needle tip trajectory, and spread of fluid during injection. There is an increasing body of literature describing U/S guided neuraxial techniques, but there is insufficient evidence to demonstrate any benefit based on relatively small studies.

Moreover, N/S may be used during epidural needle and catheter placement. It utilizes principles of electrophysiology similar to those of peripheral nerve blockade. The test has shown 80–100% positive prediction for epidural catheter placement and is effective for guidance to within two segmental levels. It allows detection of intrathecal, intravascular, or subdural catheter placement. The test may also be used during either single injection or continuous caudal anaesthesia with cephalad catheter advancement.

U/S is undoubtedly less popular for central neuraxial blockade (spinal, epidural) due to the efficacy of the landmark technique and the limitations of the U/S of the adult spine, namely that visualisation of the structures encased within the bony vertebrae is possible only through the interlaminar spaces. However, this argument also shows the utility of U/S in neuraxial blockade: that is, if it is possible to shine an U/S beam through an acoustic window, it is also possible to direct a needle through that interlaminar space. As such, incorporating preprocedural U/S into one's practice can be suggested to be available for difficult cases, due to available evidence as to its proven utility in:

- Identifying internal landmarks (midline, intervertebral level)
- Measuring depth-to-target distance
- Improving clinical efficacy
- Improving technical performance
- Predicting the feasibility of neuraxial blockade in anticipated difficult cases (preoperative assessment)

Noteworthy though, one can 'demolish' the perceived barriers to the routine use of U/S for neuraxial blockade, such as lack of expertise and evidence-based curriculum, financial and time constraints, and equipment availability. Also, when neuraxial blocks were performed by anaesthetists experienced in both US and landmark techniques, the use of US does not increase the success rate or reduce the number of attempts in patients with easily palpable spines. These are the reasons why U/S has not widely spread in the routine practice of neuraxial blocks, despite the NICE recommendations.

6. Use of nerve stimulation for training of novices

Successful U/S guided nerve blockade is predicated upon consistent, clear views of the entire needle, neural target with surrounding tissue, and circumferential spread of local anaesthetic. In practice, while expertise in recognition and location of the relevant sonoanatomy may be acquired with time, haptic perception and consistent hand–eye coordination are more challenging skills to acquire. Indeed, failure to maintain needle tip visualization was the most common error observed in residents learning UGRA.

Concomitant use of N/S may serve to increase the confidence of the learner at this early stage while lessening the anxiety of the attending preceptor. Other common sources of error during novice practice and beyond include failure to distinguish between adjacent isoechoic structures, for example, tendon and nerve, and failure to appreciate the nuances between acoustic artifact and nerve.

The use of a dual guidance may improve block efficiency and efficacy while preventing injection of local anaesthetic at a nonneural location.

Finally, the experienced practitioner may benefit from the reassurance provided by N/S when challenged with an obese patient where target neural structures may be difficult to identify with precision, particularly at a deep location.

In conclusion, the introduction of UGRA is an epochal development in the evolution of RA. It has advanced our understanding of the needle–nerve relationship and inspired further investigation into the incongruities thereby revealed. U/S guided peripheral nerve blockade is more efficient, less painful, and more successful than landmark and N/S techniques. However, U/S guidance does not lessen the possibility of block-related nerve injury. Occasional calls for the dispatch of N/S have come with alarming alacrity. Minimum stimulating threshold and electrical impedance may provide valuable information regarding the needle–nerve relationship. When combined with the superior nerve-locating qualities of ultrasound guidance, peripheral nerve blockade may be more prolonged but more successful and safer. As such, RA can be performed without U/S use under specific circumstances and based on individualized physicians experience. Through analogy with fibreoptic intubation, one should gain proficiency in routine cases before approaching the difficult ones. Future trainees will likely become so familiar and relaxed with U/S technology (dubbed ‘the new stethoscope’) that it will be inconceivable to them not to use it for RA blockade — the same way as currently they would not attempt a central venous catheter insertion without U/S. Nevertheless, also taking into account the cost of U/S machines, an anaesthesiologist claiming a spherical RA needs to have deep anatomical knowledge and be familiar with all other modalities except U/S, in order to confront successfully any worse case scenario and in order to succeed.

REFERENCES

1. *Dillane D, Tsui BCH. Is there still a place for the use of nerve stimulation? Pediatric Anesthesia, 2012; 22: 102 – 108.*
2. *Klein SM, Melton MS, Grill WM, Nielsen KC. Peripheral nerve stimulation in regional anesthesia. Reg Anesth Pain Med, 2012; 37: 383 – 392.*
3. *Steinfeldt T, Schwemmer U, Volk T, Neuburger M, Wiesmann T, Heller AR, Vicent O, Stanek A, Franz M, Wulf H, Kessler P; German Society of Anaesthesiology and Intensive Care Medicine. Nerve localization for peripheral regional anesthesia. Recommendations of the German Society of Anaesthesiology and Intensive Care Medicine. Anaesthesist, 2014; 63: 597 – 602.*
4. *Neuburger M, Schwemmer U, Volk T, Gogarten W, Kessler P, Steinfeldt T. Localization of peripheral nerves. Success and safety with electrical nerve stimulation. Anaesthesist, 2014; 63: 422 – 428.*

5. *Munirama S, McLeod G. A systematic review and meta – analysis of ultrasound versus electrical stimulation for peripheral nerve location and blockade. Anaesthesia, 2015; 70: 1084 – 1091.*
6. *Bomberg H, Wetjen L, Wagenpfeil S, Schöpe J, Kessler P, Wulf H, Wiesmann T, Standl T, Gottschalk A, Döffert J, Hering W, Birnbaum J, Kutter B, Winckelmann J, Liebl-Biereige S, Meissner W, Vicent O, Koch T, Bürkle H, Sessler DI, Volk T. Risks and Benefits of Ultrasound, Nerve Stimulation, and Their Combination for Guiding Peripheral Nerve Blocks: A Retrospective Registry Analysis. Anesth Analg, May 2018 [epub ahead of print]*