Nerve localization for peripheral regional anesthesia: Recommendations of the German Society of Anaesthesiology and Intensive Care Medicine

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Nerve localization for peripheral regional anesthesia

Recommendations of the German Society of Anaesthesiology and Intensive Care Medicine

Peripheral regional anesthesia has experienced a huge increase in technical innovation like only few other anesthesia techniques in recent years. The introduction of ultrasound visualization is considered the driving force behind this development. The visualization of nerve structures by ultrasound led to a paradigm change in daily routine for anesthetists undergoing training as well as experienced practitioners of regional anesthesia. 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 practitioners alike to further optimize and develop regional anesthesia. Blocks previously associated with an increased risk, e.g. transversus abdominis plane (TAP) block and supraclavicular blocks became popular, as vulnerable structures can now be identified and avoided. In parallel, ultrasound can also be used in conjunction with nerve stimulation. This has led to a new understanding of the distance between needle tip and nerve tissue when using electrical nerve stimulation [1, 2, 3, 4, 5]. Questions arose as to the minimum required threshold current for successful stimulation of nerve tissue. How safe is nerve stimulation really? Is it needed at all? Or should both techniques be combined when identifying nerve structures? Ultrasound also led to new explorative approaches. Where should local anesthetic agents be injected [6, 7], intraneurally or extraneurally? Does local anesthesia 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. Hence, it was the aim of the German Society of Anaesthesiology and Intensive Care Medicine (DGAI) to convene an expert panel including members of the scientific group for regional anesthesia and obstetrics and the scientific group for ultrasound in anaesthesia, which are both parts of the DGAI. The constituted panel of 11 experts developed recommendations for nerve localization in regional anesthesia based on expert knowledge and scientific data. Recently, the DGAI published the presented recommendations in German [8]. Moreover, the recommendations are registered as scheduled guidelines of the German Society of Medical Guidelines (AWMF Reg. No. 001-026).

All authors are members of the German Society of Anaesthesiology and Intensive Care Medicine, Nürnberg, Germany.

Presentations The recommendations were presented at the Annual Regional Anaesthesia Symposium of the German Society of Anaesthesiology and Intensive Care Medicine (DGAI) in Hamburg, Germany (2 November 2013) and at the Annual Congress of the German Society of Anaesthesiology and Intensive Care Medicine in Leipzig, Germany (8 May 2014).

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Recommendations

Nerve localization techniques

Localizing the nerve is an important prerequisite for successful regional anesthesia and aids avoiding damage to nerves and surrounding structures. Basically, the anesthetist combines two techniques for nerve localization. One technique locates nerves indirectly by electrical nerve stimulation due to the assessment of elicited motor responses. Its application is well established and has been in use for decades [9]. The other technique, ultrasound, is capable of visualizing nerve tissue structures directly. This technique has become established in the daily routine over the last 15 years.

Ultrasound

The correct guidance of the cannula is as important as the visualization of the target structure. Puncture complications can be avoided with clear visualization of the needle tip [10]. The most frequent mistake is uncontrolled transducer and needle movement that counteracts accurate needle visualization and thus should be avoided. Key features of the needle, which influence visualization, are the surface, the diameter and the shape of the needle tip. A larger diameter may mean improved ultrasound visibility but because of the greater tissue trauma the smallest possible should be chosen [11, 12].

With regard to the transducer, i.e. ultrasound beam, the cannula may in principle be inserted using two different techniques: in-plane or out-of-plane. The needle should be advanced only after the position of the needle tip has been clearly determined. This is achieved either through direct visualization of the needle tip or indirectly with the hydro-localization technique.

Problems in visualizing the cannula may arise in cases of [13, 14]:

- deep blocks ≥4 cm
- steep puncture angles (>40°)
- thin diameter of needles

Needles in which the shaft material has been optimized for ultrasound-assisted punctures using notches or particles reflect more sound waves to the transducer and should facilitate improved visualization [15, 16, 17]. However, there is no evidence of their clinical benefit in regional anesthesia. With conventional regional anesthesia cannulas the needle tip is usually easier to visualize compared to the needle shaft due to its configuration. The needle tip is particularly visible when the needle opening faces upwards to the transducer [13, 14].

In-plane technique

The in-plane technique describes the guidance and therefore the sonographic visualization of the entire needle in the imaging plane. In comparison to the "out of plane" technique this method is more likely to allow control of the entire needle and puncture path. Especially beginners have difficulty in placing the cannula within the ultrasound beam. Mechanical needle guidance aids restrict freedom to guide the needle and probes and to date there is no evidence of their benefit in regional anesthesia.

Out-of-plane technique

In the out-of-plane" technique the puncture needle is led transversely to the scanning plane and is therefore shown only in cross-section [10]. The aim is to visualize the needle tip in the image plane. The out-of-plane technique offers short needle paths and is particularly suitable for superficial blockades. A problem with the out-of-plane technique is that the cannula tip can be confused with the shaft or its echo, resulting in reduced control of the cannula tip. The needle tip is particularly visible when the needle opening faces upwards to the transducer [13, 14].

Selection of the needle guidance technique

The decision whether to use the in-plane" or out-of-plane technique depends on the puncture site and experience of the practitioner. Often the favorable approach is predetermined by the anatomical circumstances. In the vicinity of pleura and very deep nerve blockades with surrounding structures at risk of being damaged, an in-plane guiding of the needle appears to be safer if the needle is visualized in its entirety in the image plane. The in-plane technique is mainly used for single shot blockades. There is little scientific data that an in-plane approach may result in a lower incidence of inadvertent needle-nerve contact [18]. Currently there is no scientific data on the use of ultrasound during the placement of catheters on which to base a recommendation for the out-of-plane or in-plane technique.

Indirect techniques for needle visualization

Indirect signs are used supportively in the orientation and determination of the needle position. The introduction of the needle will produce a visible tissue displacement in the B-mode scan as an indication of the cannula position before entering the scanning plane. However, this cannot be taken as a sure sign of the tip as motion artefacts in the tissue may be propagated and may also be generated by the shaft. Localizing the needle tip can be achieved by injecting small amounts of liquid (hydro-localization, approximately 0.5 ml, [19]). This is especially useful in the out-of-plane technique. Saline, glucose 5% solution or a local anesthetic can be used for hydro-localization. When electrical nerve stimulation is used additionally, it should be kept in mind, however, that nerve responsiveness to electrical stimulation might be adversely affected by local anesthetics and electrolyte solutions. Therefore, the application of glucose 5% solution is recommended in this situation [20].

Injecting local anesthetics

When reaching the targeted structure, visualization of injected local anesthetic is mainly used to determine if the injected solution is spreading in the correct tissue layer (interfascial space) or along the nerve. Particularly in field or compartment blocks (e.g. TAP, pectoralis and rectus sheath blocks) ensuring the correct distribution of the local anesthetic in the corresponding interfascial space is important. On no account should an injection be continued if the spread of the local anesthetic could not be visualized. In this case, the needle tip can be in front, or worse, behind the image plane or intravascular. This requires correcting the needle position.

Intraneural injection

Regardless of which technique is used, in ultrasound visualization it is important to avoid intraneural punctures and injections. Intraneural injection should be suspected if the radius of the nerve increases and if injection requires a large amount of pressure or causes pain [21]. Onset of painful neurological symptoms as an indication of a needle-nerve contact should be avoided and should result in a verification of the needle position. Paresthesia should be interpreted as a sign of the needle being very close to the nerve and should also result in reappraisal of the needle location.

Electrical nerve stimulation

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 [3, 4, 6]. 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 [22]. 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 [23, 24]. 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 [25].

The tissue resistance which modern stimulators will display, can also be of clinical use. Due to the high electrical re-

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Nerve localization for peripheral regional anesthesia. Recommendations of the German Society of Anaesthesiology and Intensive Care Medicine

Abstract

The German Society of Anaesthesiology and Intensive Care Medicine (Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin, DGAI) established an expert panel to develop preliminary recommendations for nerve localization in peripheral regional anesthesia. Based on expert knowledge and the relatively limited data, the recommendations state how ultrasound and/or electrical nerve stimulation should be used in daily practice, and where and when local anesthetics should be injected. Moreover, it was defined under which conditions a peripheral nerve block under general anesthesia or deep sedation is applicable.

Regarding the use of ultrasound the expert opinion was that out-of-plane and in-plane-techniques can be considered equal with respect to patient safety. Nevertheless, the direct or indirect visualization of the needle tip has to be assured. The injection of local anesthetics has to be visualized. Injections into nerves or those requiring an injection pressure should be avoided. The sole use of electrical nerve stimulation or ultrasound for nerve localization is still a suitable option as well as their combined use. To avoid accidental intraneural needle placement, an electrical current threshold ≥0.5 mA should be used. Moreover, it was stated that peripheral nerve blocks or continuous nerve block techniques under sedation or general anesthesia are applicable in adult patients who are unable to tolerate the block being performed in an awake state or have difficulty cooperating.

Article published in English

Keywords

Review · Electrical nerve stimulation · Intranueral injections · Ultrasound · Paresthesia

Lokalisation peripherer Nerven für Regionalanästhesieverfahren. Empfehlungen der Deutschen Gesellschaft für Anästhesiologie und Intensivmedizin

Zusammenfassung

Die Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin (DGAI) hat durch eine Expertengruppe eine Handlungsempfehlung zur Lokalisation peripherer Nerven im Rahmen von Regionalanästhesieverfahren erstellen lassen. Aufgrund der bestehenden Datenlage basiert die Empfehlung in erster Linie auf „Expertenmeinungen". Neben Fragestellungen zur klinischen Anwendung der Ultraschalltechnik werden Aspekte der elektrischen Nervenstimulation erläutert. Des Weiteren werden Fragen zur intra-/extraneuralen Lokalanästhetikainjektionen sowie zur Durchführung von Regionalanästhesieverfahren unter Sedierung oder in Vollnarkose beantwortet.

Die Expertengruppe erklärt die „Out-of-plane"- und „In-plane"-Technik als ebenbürtig im Hinblick auf die Patentensicherheit. Allerdings ist eine direkte oder indirekte Nadelspitzenvisualisierung zu gewährleisten. Die Injektion von Lokalanästhetika ist zu visualisieren. Intraneurale Punktionen oder intraneurale Injektionen gilt es sicher zu vermeiden. Ultraschall und elektrische Nervenstimulation können allein oder in Kombination verwendet werden. Bei Nutzung der elektrischen Nervenstimulation ist eine Reizstromschwelle von 0,5 mA nicht zu unterschreiten. Bei Erwachsenen können periphere Nervenblockaden unter Sedierung oder Allgemeinanästhesie durchgeführt werden, wenn eine Toleranz oder Kooperationsfähigkeit im Wachzustand nicht zu gewährleisten ist.

Schlüsselwörter

Überblick · Elektrische Nervenstimulation · Intraneurale Injektionen · Ultraschall · Paraesthesie

sistance of the perineurium a sudden increase in impedance could indicate an intraneural positioning of the cannula [26]. Likewise an absent increase in impedance after injection of the glucose 5% solution, due to its poor conduction, can indicate an intravascular position [27, 28].

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 [29], 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 [30, 31].

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, [32]). 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 [33]. 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 [34]. A defibrillator should be deactivated with a magnet and the device functionality should be verified after the procedure [33].

Stimulation of the nerve is not possible after injection of conducting liquid [35]. Glucose 5% as a test dose allows for further stimulation, although the interpretation of a stimulation response should be critically evaluated [28]. 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.

Combining ultrasound and electrical nerve stimulation

Combining both techniques is another possibility to achieve a successful peripheral nerve block. Clinical investigations revealed a frequent use of electrical stimulation in addition to the use of ultrasound for localizing the targeted nerve [36, 37]. Nerve stimulation can especially be useful in situations where the nerve is not clearly identifiable using ultrasound. Clinical studies show no increased rate of success or a reduction of intraneural punctures when both techniques are combined [38, 39].

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 ultrasound or hydro-localization. The needle has to be retracted if ultrasound shows the needle position to be intraneural. If the injected liquid indicates an adequate spread or the needle tip position is optimal in ultrasound visualization, the desired amount of local anesthetic can be injected. If the target structure or needle tip cannot be identified, electrical nerve stimulation 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 ultrasound 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.

Peripheral regional anesthesia in sedated/anesthetized patients

Nerve damage or irritation after peripheral regional anesthesia is a rare and usually temporary occurrence [37, 40]. As case reports frequently link paresthesia or pain during the procedure with newly occurring neurological deficits, performing the block on an awake or lightly sedated patient is recommended [41, 42, 43, 44, 45]. Current published data are unable to confirm if an anesthetized or deeply sedated patient is at an increased risk of nerve damage. When managed appropriately, and with sufficient analgesia, patients in an awake state will usually tolerate regional anesthesia well. Deep sedation or general anesthesia for the block can be considered should the patient be unable to tolerate the block under light sedation or have difficulty cooperating. Performing the block in deep sedation or general anesthesia is especially preferable when dealing with uncooperative children [46].

Before a regional anesthesia technique is carried out, patients must be comprehensively informed in writing about the intervention and possible complications. Empathic patient guidance and adaptive analgesic sedation are as essential for successful regional anesthesia as adequate premedication and local anesthesia.

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