A new horizon in paediatric anaesthesia – Ultrasonography

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Introduction

The technology and clinical understanding of anatomical sonography has significantly evolved over the past decade. As a result, ultrasonography has become a routine guidance technique for regional anaesthetic nerve blocks. Recent studies have shown that direct visualization of the distribution of local anaesthetics with high-frequency probes can improve the quality and avoid complications of upper/lower extremity nerve blocks and neuraxial techniques. Ultrasound guidance enables the anaesthesiologist to secure an accurate needle position and to monitor the distribution of the local anaesthetic in real time. These advantages over conventional guidance techniques such as nerve stimulation or "loss of-resistance" procedures are quite significant.

Special considerations in children

Particular children should profit from ultrasonographic guidance during various regional anaesthetic techniques. Possible advantages are:

- Lower volumes of local anaesthetics [1,2]
- Faster performance of block procedures [3]
- Safe avoidance of complications

It is important to state that the above described advantages are not proven in an evidence based manner, where large multicenter outcome studies would be necessary. It is also clear that particular knowledge is a prerequisite for safe and effective use of these techniques in the daily clinical practice.

Ultrasound equipment

A crucial requirement allowing these techniques to be routinely used has been met by the introduction of portable ultrasound equipment offering almost the same level of image resolution as larger (and more expensive) systems. Special operating systems have proven useful in daily practice because they offer excellent stability and short start-up times. Today's portable designs offer resolutions high enough to visualize nerve structures.

While high sound frequencies are needed for high-resolution imaging, there is an inverse relationship between frequency and penetration depth. Most nerve block applications require frequencies in the range of 8–14 MHz, which provide an excellent resolution of superficial structures in the upper limbs and good penetration depths in the lower limbs.

Orientation of cannula and ultrasound probe

Ultrasound techniques for nerve blockade fall into two major categories depending on the needle position relative to the transducer.

In plane technique

This method relies on a transversal needle orientation. Only the needle tip can be visualized with this approach and therefore must be precisely advanced to the depth of the target structure by selecting an appropriate puncture angle. The ultrasound image will reveal both the target structure and the needle position. The needle can be identified by the tissue it displaces and by an acoustic shadow emerging dorsally at its tip. Cross-sectional imaging allows us to maintain well-established puncture angulations in developing sonographic block techniques. In plane imaging is usually preferable because the needle has to be advanced significantly less to reach the target structure, which reduces the degree of puncture-related trauma and pain. Examples for regional anaesthetic techniques with the cross sectional methods are interscalene or axillary brachial plexus blocks.

Out of plane technique

The second option is to advance the needle longitudinally to the ultrasound probe and is known as the *inline* technique (new terminology "Out of plane technique"). This will ideally allow the shaft of the needle to be visualized in addition to its tip if the needle is strictly located within the range of the emitted ultrasound signals. Hence the relative orientation of the probe is crucial. Transversal deviations as small as 1–2 mm will remove the needle from the image. The spectrum of clinical indications for the in-line technique is narrow. One example for the use of the inline technique in the clinical practice is the popliteal nerve block.

Appearance of nerve structures in ultrasonography

The correct technique of ultrasonographic guided nerve visualization is in a transversal view, where they appear as hyperechoic of hypoechoic oval or round structures. The echogenicity of a particular nerve depends on the diameter, the histological structure and the angle of the ultrasound beam (anisotropy).

By using high resolution ultrasonography even the inner architecture of the nerve is visible. It maybe difficult to assess a static ultrasonographic figure and therefore a dynamic investigation is mandatory for optimal identification of nerve structures. Prerequisites for such investigations are a good understanding of ultrasonographic physical background and adequate anatomical knowledge.

Nerves are structures which are continuously visible from proximal in a distal direction, which allows a simple differentiation in comparison to tendons. In addition, nerves are visible as discontinuous bands in a longitudinal ultrasonographic view (fascicular pattern) in comparison to tendons, which are described as parallel or continuous bands (fibrillar pattern).

It is also important to identify adjacent anatomical structures in order to perform safe and effective blocks. Arteries, veins or muscles are in a close relationship to nerve structures and should be identified before the performance of a regional anaesthetic technique. Therefore an adequate knowledge in small part and vascular ultrasound is helpful.

Limitations of ultrasonography are artefacts. Bones and air are the main causes for an impaired view in ultrasonography.

Future perspectives

We are far away from the implementation of ultrasonographic guidance in paediatric regional anaesthesia. The future will show if this useful and promising technique will find its way in the daily clinical practice of paediatric anaesthetists. Particular efforts in terms of education and specific hand skills are necessary for a safe and effective use of ultrasonographic guidance in paediatric regional anaesthesia.

References

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