Introduction and background

In the last decade there have been significant changes in the practice of regional anesthesia with a shift from landmark-based nerve block techniques to image-guided ones. Traditional landmark-based techniques of nerve blockade relied mainly on our knowledge of surface anatomy to decide on a needle entry site at the skin. This was followed by elicitation of either a paresthesia (usually using sharp block needles) or a motor response to electrical nerve stimulation (PNS, using blunt insulated needles) as markers of needle-to-nerve proximity. Even though the first reports of ultrasound guidance for regional anesthesia (UGRA) date back to the late 1980s and early 1990s, this technology has only been used consistently for the past 10 years or so, during which time there has been an “explosion” of literature on the topic.

UGRA and peripheral nerve blockade

The arrival of image guidance has been enthusiastically embraced by most regional anesthesiologists throughout the world. It seems logical that the possibility of imaging each patient’s particular anatomy in real time, during block performance, rather than relying on “average” patient findings would result on more precise techniques. One would anticipate that the ability to “target” needle position and local anesthetic spread under real time guidance with great accuracy would ensure highly consistent block success. Likewise, one would think that the ability to image important blood vessels, the pleura and other surrounding structures would render regional anesthetic procedures much safer, almost complication-free.

In the year 2010, Regional Anesthesia and Pain Medicine published in a special supplement a comprehensive evidenced-based review of the existing literature on the possible outcome benefits of ultrasound guidance in regional anesthesia.¹ The existing literature on the efficacy, efficiency and safety of UGRA for both children and adults was thoroughly reviewed in this publication. Upper extremity, lower extremity, truncal and neuraxial blocks were examined. Most studies on peripheral nerve blockade suggested a shorter procedure time and faster block onset times (by about 11-14 minutes). However, only about 10% of the studies published reported a higher block success with ultrasound guidance, while the remaining report similar success rates to the control groups.²-⁴
Several factors may have contributed to the relatively modest efficacy benefits demonstrated in these early studies. Firstly, it is likely that many of the anesthesiologists performing these blocks were actually in their early part of their personal learning curves for UGRA and could actually have been relatively more experienced with the techniques used for the “control groups”. Secondly, UGRA is not a uniform standard way of performing nerve blockade. It is likely that especially during the early phases of the development of UGRA techniques, individual practitioners or groups of practitioners interpreted and used the information obtained by ultrasound in varying ways. These practitioner-related factors are intrinsic determinants of both efficacy and safety and are very difficult to account for or control for in clinical studies.

**Neuraxial Ultrasound**

The application of bedside ultrasonography for neuraxial techniques is of a more recent development than peripheral nerve blockade. Ultrasound is at the very minimum a valuable extension or addition to the physical examination for the identification of bony landmarks relevant to the performance of neuraxial techniques. Several early studies demonstrate that ultrasound is superior to the palpation of surface landmarks for the identification of given lumbar vertebral interspaces. Ultrasound can also predict the depth of the epidural space with great accuracy both in adults and children. When ultrasound is used to define the landmarks prior to a labour epidural, a lower number of needle passes are required for successful placement and a higher success rate is achieved by junior anesthesia residents. More recent studies suggest that ultrasound facilitates spinal anesthesia in patients for total joint arthroplasty. In a prospective randomized controlled trial, a pre-procedure ultrasound doubled the rate of success at first attempt of spinal anesthesia in patients with difficult surface landmarks secondary to either morbid obesity or lumbar scoliosis. Similarly to other ultrasound-related skills, individual learning curves vary widely, but several studies suggest that a minimum of 20 supervised scans are required to achieve competency at neuraxial ultrasound.

**UGRA and the safety of regional anesthesia**

The important question of patient safety is a more elusive one to study. Serious complications of regional anesthesia include severe systemic local anesthetic toxicity (LAST), usually resulting from unintended intravascular injection of local anesthetic, pneumothorax, and peripheral nerve or spinal cord injury.

Studies encompassing approximately 15,000 patients suggest that UGRA reduces the incidence of unintended vascular punctures to about half the incidence in PNS techniques. One retrospective study suggested UGRA is associated with a lower incidence of LAST (0 in 2146 patients) compared to PNS techniques (5 cases in 3290 or 1:700). However, given the low baseline incidence of severe local anesthetic systemic toxicity (estimated at 1:700 to 1:3,000) most existing studies do not have sufficient power to detect an outcome benefit.

The issue of nerve injury deserves special attention due to the potential serious long term consequences for patients and the current debate regarding the appropriate use of intentional intraneural injections. Similar to other complications, the baseline
incidence of peripheral nerve injury associated with regional techniques is very low (in the order of 1:2,000 to 1:3,000). Therefore, it is not surprising that multiple small prospective studies and several large patient series totalling approximately 17,000 patients have been unable to demonstrate a significant reduction in the incidence of neurologic injury with UGRA. In this setting, the lack of clinical data for a safety advantage does not necessarily imply a lack of an effect, but possibly the inability to study it by traditional prospective studies. Most likely, information about safety should be obtained from other types of studies such as animal models and experimental designs.

It has been well documented that needle penetration of nerves can result in physical injury to both nerve fascicles and their vascular capillaries, especially when sharp needles are used. We also know from a number of experimental animal studies that intraneural injection of local anesthetic frequently results in nerve cell injury and axonal death. It is however, somewhat reassuring to know that peripheral nerves are quite resilient structures and a significant degree of nerve cell damage does not always correlate with a functional or clinically obvious deficit. This has been used as an argument to support the practice of intentional intraneural injections of local anesthetic, considered to be not as “dangerous” as once thought. This is still very controversial practice and the subject of heated debate. However, it is hard to find a compelling reason why intentional intraneural injections may be necessary for the purpose of providing regional anesthesia or analgesia. Blocks can be very effective and efficient with perineural injections, ad this is likely a better way to respect and preserve nerve integrity in order to minimize the possibility of nerve injury.

Finally, we should consider that ultrasound guidance by itself does not make a technique more effective or safer. It is a great tool, but no more than a tool. The efficacy and safety of a procedure will depend ultimately on the individual practitioner’s correct interpretation and use of the information obtained by the imaging tool.

References


3. Salinas F. Ultrasound and review of evidence for lower extremity peripheral nerve blocks. RAPM 2010; 35 (2) S16-25


