Peripheral nerve blocks and neuraxial blocks are one of the most common procedures performed by anaesthetists. There has been enormous development in the use of ultrasound (US) for regional anaesthesia during last decade. In our previous article,1 we reviewed such use of US in regional anaesthesia. Many studies have been published on this subject but most of the studies are on the use of ultrasound for peripheral nerve blocks and only few look into its use for neuraxial blocks. This article is a review of recently published papers on the subject of ultrasound for neuraxial blocks.

IDENTIFICATION OF INTERVERTEBRAL LEVEL

Spinal anaesthesia is commonly performed at L3-4 level. Performing a subarachnoid injection above this level has potential for spinal damage in a proportion of normal adult population.2 Position of conus medullaris varies from middle third of T12 to upper third of L3 in adult population and mean position of conus is lower third of L1.3 The importance of correctly identifying the intervertebral level during regional anaesthesia has been highlighted in the past.4 Tuffier’s line is commonly used to identify the lumbar interspaces but this does not bear constant relationship to these spaces. Reliance on this landmark might lead to more cranial placement of epidural or spinal needles than intended and this subsequently will increase the risk of spinal cord damage.5-8

Broadbent C R and colleagues5 in their study of 100 patients undergoing spinal MRI scans demonstrated that identification of lumbar space by anaesthetists by palpatory method is not reliable. The study included total 200 observations from 100 patients by different observers. All observers had more than five years anaesthetic experience and had performed several hundred spinal anaesthetics. Correct space was identified in 58 (29%) observations. In six (3%) observations, anaesthetist identified a lower space than intended. In remaining 136 (68%) observations, anaesthetist marked higher spaces than intended. This was one, two and three spaces higher in 102 (51%), 31 (15.5%) and two (1%) occasions respectively. The marker was four spaces higher in one (0.5%) observation.

Study by Furness G and colleagues6 showed that US can identify correct intervertebral level in up to 71% of case as compared to 30% by palpatory method. The same study showed that ultrasound was inaccurate by one level only in all inaccurate cases, while palpatory method was inaccurate by more than one level in 27% of inaccurate cases. This study considered identification of intervertebral space by lateral lumbar spine X-ray as a benchmark.

Watson and colleagues9 in their study correctly identified the L3-4 space with ultrasound in nearly 76% (13/17) of cases when confirmed with MRI scan. In four cases, the anaesthetist identified one space lower than intended. It is small but otherwise simple and relevant study, where investigator used the gold standard (MRI) to confirm the level of intervertebral space.

Study by Whitty R and colleagues10 demonstrated that there was poor agreement between palpation and ultrasound estimation of the specific lumbar interspace. When there was disagreement between the two methods, the ultrasound estimate was more often higher than the palpation estimate. This study compares the two methods but does not use any gold standard to conclude superiority of one method over the other. Based on the fact from previous studies that by palpatory method clinicians select interspaces that are one or two spaces higher than intended, this study indirectly supports that US is more accurate in identifying the lumbar interstices.

In their study, Schlotterbeck H and colleagues11 reviewed 99 obstetric patients between 24 and 72 hours after delivery to check the correctness of puncture level by anaesthetists. They checked the level of puncture site with US during their follow-ups on the ward. Results showed that clinical puncture was accurate in 36.4% and it was more cephalad than the level noted in anaesthetic record in nearly 50% of patients. Results from the study are comparable to previously published studies. We noted that author assumed US to be a gold standard while discussing their results, though this has not been proved yet and accuracy of US in identifying the intervertebral level has been documented as 71 and 76% in two studies.6, 9

IDENTIFICATION OF NEURAXIAL STRUCTURES

As compared to many peripheral nerves, the neuraxial structures lie well beneath the skin. For this reason, identification of
neuraxial structure by US requires low frequency (usually 2-5 MHz) curved probes in adult population\textsuperscript{12,13}. Low frequency increases the penetration depth but compromises the image resolution. The neuraxial structures are surrounded by dense bones, which make it difficult to get good acoustic window with ultrasound scan. Higher frequency probes are preferred in young patients as the neuraxial structures are shallower and ossification is not yet complete. Rapp\textsuperscript{14} and colleagues in their study ‘Ultrasound-Guided Epidural Catheter Insertion in Children’ used probes of frequency of 7 MHz and above. The identification of neuraxial structures with US depends on frequency of probe used, density of bones and soft tissues, US approach used (transverse vs longitudinal), and operator’s experience. The sacrum, different part of vertebra (vertebral body, spinous, articular and transverse process), ligamentum flavum, dura mater, intrathecal space, spinal cord and nerve roots all are possible to identify with US.

There are two different ways in which US can be used for neuraxial blocks:

1. **Ultrasound-assisted technique (preprocedure scanning):** This involves identification of sonoanatomy before performing the neuraxial block. The technique helps in locating the middle of intended intervertebral space and the midline insertion point are marked on the skin. Epidural catheterisation is then performed by conventional technique with the skin markings guiding the entry point of epidural needle. Anaesthetist can also determine the actual depth of epidural and intrathecal spaces with the US. Many studies have demonstrated a strong correlation between the ultrasound-estimated distance to the epidural space and the actual measured needle depth.\textsuperscript{13-16}

2. **Real time ultrasound-guided technique:** With this, anaesthetist not only gets all the information provided by assisted technique but can also study the dynamic changes in neuraxial structures while performing the block. The anaesthetist observes the passage of needle in real time ultrasound. It is possible to see the anterior displacement of the posterior dura mater with Tuohy needle and widening of the posterior epidural space due to pressurised saline from the Loss of Resistance (LOR) syringe. Compression of thecal sac can also be seen in some patients.\textsuperscript{17} Main disadvantage of this technique is the requirement of assistance to hold the probe while anaesthetist performs the block. As a result of this, the coordination achieved may not be as good as achieved by single operator performing peripheral nerve blocks. Karmakar et al\textsuperscript{17} in their study overcame this problem by using an autodetect syringe (LOR syringe with an internal compression spring, which generates constant pressure).

Until recently most of the articles have described prescanning method. Studies on real time ultrasound-guided technique are few\textsuperscript{14, 16-18} and most recent. In both the techniques, good acoustic window can be obtained by paramedian (longitudinal) or transverse approach. Grau and colleagues\textsuperscript{19} compared the transverse, median and paramedian approaches and suggested superiority of paramedian over other approaches due to a wider acoustic window. Arzola and colleagues\textsuperscript{13} demonstrated that transverse approach can be reliably used to facilitate labour epidural insertion. The transverse approach has been suggested as a more useful approach in common clinical practice of midline epidural catheterisation.\textsuperscript{12} Rapp and colleagues\textsuperscript{14} in their study on paediatric epidural and Carvalho\textsuperscript{12} in his article on labour epidurals describe both approaches. Irrespective of whichever approach is used, anaesthetist should scan in both planes as they complement each other. Due to better image resolution with high frequency probe, dura mater is seen as a more distinct structure in children as compared to adults where ligamentum flavum and dura mater are commonly seen as one unit. Also, high frequency probe compromises the penetration depth, which makes it less useful in adults. One needs to be aware that even with high frequency 10 MHz probe the image resolution is nearly 0.3 mm, this is why epidural catheter placement with US alone is not advisable. Even the real time technique has to be combined with other surrogate markers like loss of resistance and widening of epidural space with saline, as puncture of dura mater will not always be visible with US. Relationship of ‘window to shadow’ decreases from sacral to thoracic regions so US is more useful in looking at sacral and lumbar region as compared to thoracic region.\textsuperscript{14}

National Institute of Health and Clinical Excellence (NICE) has developed guidance on ultrasound-guided catheterisation of epidural space.\textsuperscript{20} NICE considers the use of US-guided epidural catheterisation as safe. Though one can assume that due to less number of attempts and number of bony contacts, this technique is safer compared to conventional technique, but direct evidence on this is not available at present. Survey by Mathieu S and Dalgleish DJ\textsuperscript{21} highlights the lack of training in US-guided neuraxial blocks as compared to training in its use for peripheral blocks and vascular access. In their publication, they also discussed the lack of robust evidence on this topic.

**SUMMARY**

We can conclude that ultrasound is more accurate in identifying the intervertebral level as compared to palpatory methods. Ultrasound is helpful in identifying the midline insertion point. It also decreases the number of attempts and number of bony contacts when used to perform neuraxial blocks. Most of the studies on the use of US for neuraxial blocks come from a small number of highly experienced and well-known personalities in regional anaesthesia. Their success rate with epidural catheterisation in these studies is high with or without US. These studies have been conducted mainly on paediatric and obstetric population. One small controlled study showed that junior residents’ success rate with obstetric epidural is higher with the use of US.\textsuperscript{22} Safety of US-guided technique over standard landmark technique has not been proved yet. More research is
required to look into success and safety aspects of US-guided neuraxial block when performed by junior and nonexpert anaesthetists.

REFERENCES


2. Reynolds F. Damage to the conus medullaris following spinal anaesthesia. Anaesthesia 2001;56:238-47.


