

Case report

Ultrasound-guided lumbar plexus block through the acoustic window of the lumbar ultrasound trident

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Lumbar plexus block (LPB) is frequently used in combination with an ipsilateral sacral plexus or sciatic nerve block for lower limb surgery. This is traditionally performed using surface anatomical landmarks, and the site for local anaesthetic injection is confirmed by observing quadriceps muscle contraction to peripheral nerve stimulation. In this report, we describe a technique of ultrasound-guided LPB that was successfully used, in conjunction with a sciatic nerve block, for anaesthesia during emergency lower limb surgery. The anatomy, sonographic features, technique of identifying the lumbar plexus, and the potential benefits of using this approach are discussed.

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Lumbar plexus block (LPB) is traditionally performed using surface anatomical landmarks and the site for local anaesthetic injection is identified using loss of resistance,¹ paraesthesia,² or by observing quadriceps muscle contraction to nerve stimulation.^{3–4} Surface anatomical landmarks are useful but are only surrogate markers and can vary among patients. This can result in a failure to contact the transverse process or elicit quadriceps muscle contraction resulting in inadvertent deep needle insertion, renal,⁵ or vascular injury.⁶ Kirchmair and colleagues⁷ recently described the sonoanatomy relevant for posterior LPB. Although they were unable to visualize the lumbar plexus⁷ they were able to accurately guide a needle (in cadavers) using ultrasound to the posterior part of the psoas muscle,⁸ where the roots of the lumbar plexus are located.⁹ Despite this encouraging result, published clinical data on ultrasound-guided LPB are limited.¹⁰ In this report, we describe an alternative technique of ultrasound-guided LPB that was successfully used in conjunction with sciatic nerve block for anaesthesia in a small series of patients undergoing emergency lower limb surgery.

Case report

Ultrasound-guided LPB was performed for anaesthesia in five ASA physical status II–III patients (36–66 yr old,

weight 56–78 kg) who were undergoing emergency lower limb surgery (Table 1). This was combined with a sciatic nerve block, either at its exit from the pelvis¹¹ (high approach) or at the subgluteal space.¹² No premedication was prescribed before operation to any of the patients. Routine monitoring and i.v. access was established before the patients were positioned in the lateral position with the side to be blocked uppermost, and with the hip and knees flexed. Fentanyl (50–75 µg) was administered i.v., immediately before the positioning, to patients with fractures. The ultrasound scan was performed using a low frequency, 5–2 MHz, curved array transducer, and a Micromaxx ultrasound system (Sonosite Inc., Bothell, WA, USA) with tissue harmonic imaging (THI) capabilities. Liberal amounts of ultrasound gel were applied to the skin over the lumbar paravertebral region for acoustic coupling and the ultrasound transducer was positioned approximately 3–4 cm lateral and parallel to the lumbar spine, with its orientation marker directed cranially, so as to produce a longitudinal scan of the lumbar paravertebral region (Fig. 1).

The transducer was then moved caudally, while still maintaining the same orientation, until the sacrum and the L5 transverse process were visible. The lumbar transverse processes are identified by their hyperechoic reflection and an acoustic shadow distal (anterior) to them (Fig. 1), which is typical of bone. Once the L5 transverse process

Table 1 Patient characteristics and lumbar plexus block details

Patient no	Age (yr)	Gender	Weight (kg)	ASA	Diagnosis	Surgery	Motor response elicited	Ultrasound visualization of the lumbar plexus
1	50	Male	70	III	Diabetic ulcer left foot with ankle osteomyelitis	Below knee amputation	Quadriceps muscle contraction	Nerve roots of the LP seen. The nerve roots were better delineated after the local anaesthetic injection
2	36	Male	60	II	Deep laceration left knee and foot	Debridement and split skin grafting	Quadriceps muscle contraction	Nerve roots of the LP seen. The nerve roots were better delineated after the local anaesthetic injection
3	66	Female	56	II	Fracture left neck of femur	Screw fixation of hip fracture	Quadriceps muscle contraction	The whole ultrasound image appeared whiter and brighter (increased echo intensity), and it was not possible to delineate the LP
4	51	Female	60	II	Fracture right neck of femur	Screw fixation of hip fracture	Quadriceps muscle contraction	Nerve roots of the LP seen. The nerve roots were better delineated after the local anaesthetic injection
5	52	Female	78	II	Fracture right ankle	Open reduction and internal fixation of fracture right fibula	Quadriceps muscle contraction	Unable to delineate LP. Obese lady

was located, the other lumbar transverse processes were identified by counting them from below upwards. The transducer was finally positioned over the L2, L3, and L4 transverse processes. In the resultant longitudinal sonogram, the acoustic shadow of the transverse processes produced what we refer to as the ‘trident sign’ because of its similarity to the trident (Latin for *tridens* or *tridentis*) (Fig. 1) that is often associated with Poseidon (the God of

the sea in Greek mythology) and the Trishula of the Hindu God Shiva. The psoas muscle was seen through the acoustic window of the trident, as multiple longitudinal hyperechoic striations against a hypoechoic background typical of muscle (Fig. 1).¹³ In three out of the five patients, the roots of the lumbar plexus were also seen, as longitudinal hyperechoic structure, in the posterior part of the psoas muscle (Fig. 1). The nerve roots appeared hyperechoic and were sonographically distinct from the muscle fibres. They were also thicker than the muscle fibres and took an oblique course through the muscle. A laterally positioned transducer produced a ‘sub-optimal’ scan without the ultrasound ‘trident’ and the lower pole of the kidney, which lies anterior to the quadratus lumborum muscle and can reach the L3–4 level in some patients, was seen (Fig. 2).

With the lumbar ultrasound ‘trident’ in view, local anaesthetic ‘lignocaine 1%, 2–3 ml’ was infiltrated to the skin and deeper structures. An insulated nerve block needle (Stimuplex® A, 21-gauge, 100 mm, B. Braun Melsungen AG, Germany) connected to a nerve stimulator that was delivering a current of 1 mA at a frequency of 1 Hz was then inserted in the long axis (in-plane) of the ultrasound transducer (Fig. 1) from the caudal end and advanced through the space between the transverse processes of L3 and L4 into the posterior part of the psoas muscle. As the needle was inserted in the plane of the ultrasound beam it was possible to follow the needle in real time. However, as the angle of insertion was relatively steep, it was not possible to see the whole length of the needle and the position of the needle tip could only be inferred by jiggling the needle and observing tissue movement or at times as a bright spot on the ultrasound scan. Entry of the block needle into the posterior part of the psoas muscle was initially confirmed by observing subtle

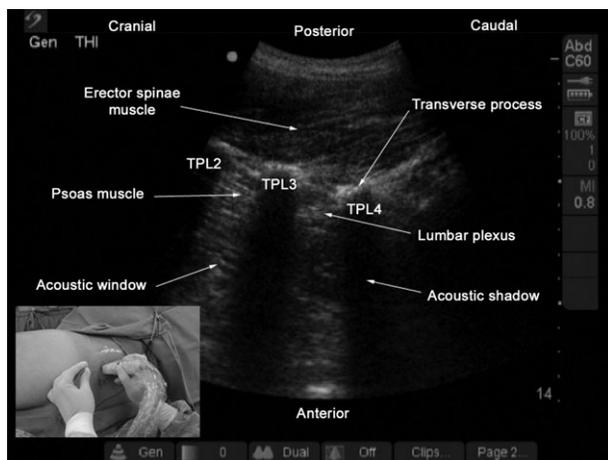


Fig 1 Longitudinal sonogram of the lumbar paravertebral region showing an optimal scan for lumbar plexus block. Note the hyperechoic transverse processes with their acoustic shadow that produces the ‘trident sign’. The psoas muscle is seen in the acoustic window between the transverse processes and is recognized by its typical striated appearance. Part of the lumbar plexus is also seen as a hyperechoic shadow in the posterior part of the psoas muscle between the transverse processes of L3 and L4 vertebra. Picture in the inset shows the orientation of the ultrasound transducer and the direction in which the needle is introduced (long axis) during an ultrasound-guided lumbar plexus block. TP, transverse process. (Reproduced with permission from www.aic.cuhk.edu.hk/usgraweb)

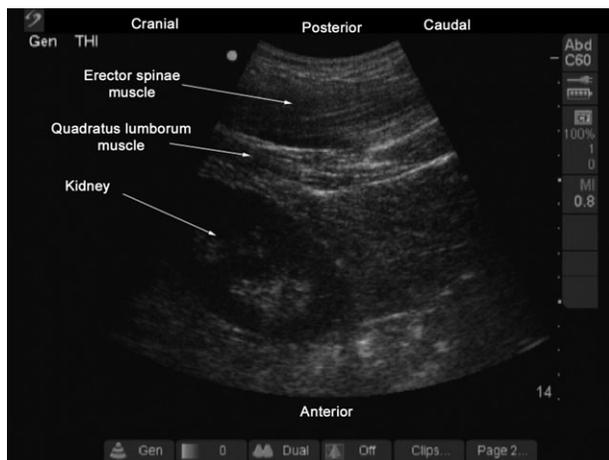


Fig 2 Longitudinal sonogram of the lumbar paravertebral region with the transducer positioned lateral to the transverse processes illustrating a suboptimal scan for lumbar plexus block. Note that the hyperechoic transverse processes with their acoustic shadow and the 'trident sign' are no longer visible. The lower pole of the kidney is now visible and is anterior to the quadratus lumborum muscle. (Reproduced with permission from www.aic.cuhk.edu.hk/usgraweb)

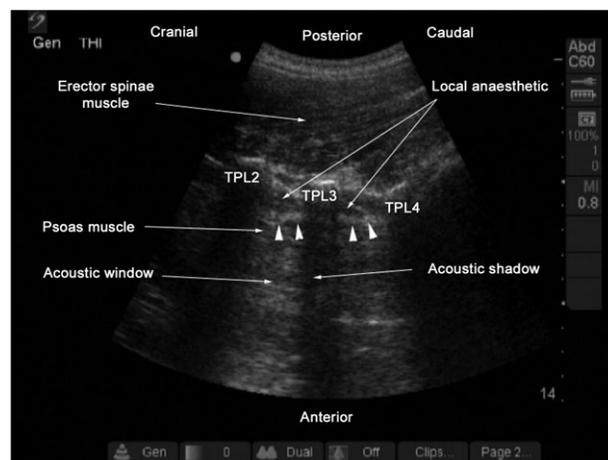


Fig 3 Longitudinal sonogram of the lumbar paravertebral region after local anaesthetic injection during an ultrasound-guided lumbar plexus block. Note that the roots of the lumbar plexus (white arrow heads) are now more prominent against the hypoechoic background of the injected local anaesthetic in the posterior part of the psoas muscle. (Reproduced with permission from www.aic.cuhk.edu.hk/usgraweb)

contractions of the psoas muscle, as a result of direct muscle stimulation, on the ultrasound scan followed by ipsilateral quadriceps muscle contraction indicating that the tip of the needle was close to the lumbar plexus. The tip of the block needle was often seen to lie in the vicinity or in contact with the nerve root when the motor response was elicited. After negative aspiration through the needle, 20–25 ml of lignocaine 1% and ropivacaine 0.25% with adrenaline 1:400 000 was injected in small aliquots over 2–3 min while observing the distribution of the local anaesthetic within the psoas muscle in real time. The local anaesthetic was seen to spread to the adjacent levels along the posterior part of the psoas muscle. The nerve roots of the lumbar plexus were also better delineated after the local anaesthetic was injected, a common observation during ultrasound-guided peripheral nerve blocks (Fig. 3). Video of the technique can be viewed at www.aic.cuhk.edu.hk/usgraweb.

The LPB was combined with an ultrasound-guided sciatic nerve block (20–25 ml of lignocaine 1% and ropivacaine 0.25% with epinephrine 1:400 000) with the patient in the same position, at its exit from the pelvis¹¹ (for patients undergoing fracture hip surgery) or at the subgluteal space (for surgery on the leg or foot).¹² Complete anaesthesia of the ipsilateral lower limb adequate for surgery developed in all patients within 20–25 min of completing the injections. Midazolam (1–4 mg i.v. bolus) and propofol (1–2 mg kg⁻¹ h⁻¹) or dexmedetomidine (bolus, 0.4 µg kg⁻¹ over 10 min followed by 0.1–0.5 µg kg⁻¹ h⁻¹) were used for intraoperative sedation, and oxygen (4 litre min⁻¹) was administered via a facemask. There were no complications directly related to the technique or the local anaesthetic injections and recovery from anaesthesia was uneventful.

Discussion

Various techniques of LPB, using surface anatomical landmarks, have been described in the literature.^{1 2 4 14} Recently, there has been an increase in interest in the use of ultrasound to guide peripheral and central neuraxial blocks and the sonoanatomy of the lumbar plexus,⁷ and ultrasound-guided LPB¹⁰ have also been described. However, published reports to date have failed to identify the roots of the lumbar plexus during block placement.^{8 10} Therefore, it is questionable if the report by Morimoto and colleagues¹⁰ can be described as an ultrasound-guided LPB because neither the lumbar plexus nor the psoas major muscle were sonographically identified in their patient.¹⁰ In this report, we have demonstrated that parts of the lumbar plexus can be successfully identified on a longitudinal sonogram of the lumbar paravertebral region in some patients. We have also shown that a needle introduced under real time ultrasound guidance through the acoustic window of the lumbar ultrasound 'trident' places it in the posterior part of the psoas muscle close to the roots of the lumbar plexus and local anaesthetic injected under ultrasound guidance is effective in producing LPB.

The psoas major muscle has a sonographic appearance that is similar to that of other muscles,¹⁵ that is it exhibits hyperechoic striations on a hypoechoic background.¹³ The hyperechoic striations in the muscle represents the perimysium which is the connective tissue layer surrounding the fascicles of the muscle.¹³ As the psoas is a fusiform muscle, the perimysia are also oriented in the long axis of the muscle¹³ and are recognized on a longitudinal sonogram as thin linear hyperechoic lines, and on a transverse sonogram they appear as fine lines and dotted reflective areas.¹³ Additional prominent echogenic planes and areas of increased and decreased echogenicity are also

present within the psoas muscle.¹⁵ These echogenic planes, representing i.m. tendon fibres of the psoas muscle, are located more towards the central part of the muscle and are most prominent below the iliac crest.¹⁵ We performed the paravertebral ultrasound scan above the iliac crest and between the L2 and L4 transverse processes. The psoas muscle could be identified through the acoustic window of the ultrasound trident by its typical striated appearance. In three out of our five patients, we were also able to identify the roots of the lumbar plexus within the posterior part of the psoas muscle. The nerve roots appeared hyperechoic, but they were less hyperechoic than peripheral nerves in the extremities, were sonographically distinct from the muscle fibres and were more posterior in location than the i.m. tendons of the psoas muscle.¹⁵ They were also thicker than the muscle fibres and took an oblique course through the muscle. The tip of the block needle was often seen to lie in the vicinity or in contact with the nerve root when the motor response was elicited. The nerve roots were also better delineated after the local anaesthetic was injected.

Our observation of the lumbar plexus is consistent with the previously published data showing that the lumbar plexus is located in the posterior part of the psoas muscle⁹ and is in agreement with Koyama and colleagues who were also able to see parts of the lumbar plexus within the psoas muscle using a low frequency (3.5 MHz) curved array transducer¹⁶ comparable with ours. However, Kirchmair and colleagues were unable to delineate the lumbar plexus in healthy volunteers using low-frequency transducers (4–5 MHz),⁷ which they attribute to a loss of spatial resolution at depths with low-frequency transducers and an inability to distinguish between the i.m. tendon fibres and the roots of the lumbar plexus within the psoas muscle.⁷ Recent advances in ultrasound technology, improved image processing capabilities of ultrasound machines and the use of THI, which improves image quality in patients who are difficult to scan, may have allowed us to see parts of the lumbar plexus in some of our patients. It is not clear as to why we were unable to delineate the lumbar plexus in two of our patients. Despite the small number of patients in this case series, possible reasons may have been age (patient 3, only patient >60 yr old) and obesity (patient 5, 78 kg), both of which can affect the quality of musculoskeletal ultrasound images. The echo-intensity of muscles are significantly increased in the elderly^{7 17} and we have observed that ultrasound images are generally whiter and also much brighter in elderly patients. This loss in image resolution often makes it difficult to delineate peripheral nerves, let alone the LP which is much deeper in location, using ultrasound in the elderly. Currently, there are no objective data on age-related differences in echogenicity of peripheral nerves and further research in this area is warranted. Obesity also limits ultrasound imaging and can make it difficult to scan the paravertebral region.⁷ Excessive fat in obesity decreases image resolution by attenuating the transmission of the ultrasound

energy and by causing scattering of the ultrasound in the tissues.

Compared with the traditional methods of LPB, ultrasound guidance during LPB may offer several advantages. The relevant anatomy is clearly delineated, the advancement of the block needle to the posterior part of the psoas muscle, where the lumbar plexus is located,⁹ and the distribution of the local anaesthetic during the injection can be seen in real time. This may translate into higher success rates and reduced needle-related complications⁵ after LPB. Currently, there are very few practitioners of ultrasound-guided LPB. This may reflect the greater degree of skill required to perform the block. Therefore, we believe, ultrasound-guided LPB should only be performed by anaesthesiologists with the appropriate level of training and skill. It may also be preferable to start performing ultrasound-guided LPB in patients undergoing elective surgery. Finally, one has to consider the cost-effectiveness of a new technique or technology (ultrasound) over existing methods before adapting it into clinical practice. Currently, there are limited cost-effectiveness data on ultrasound-guided regional anaesthesia,¹⁸ and further research in this area is warranted.

In conclusion, we have demonstrated that parts of the lumbar plexus can be identified through the acoustic window of a longitudinal sonogram of the lumbar paravertebral region. We have also shown that local anaesthetic injected through a needle positioned close to the lumbar plexus under real time ultrasound guidance is effective in producing ipsilateral LPB. Despite the potential advantages of using ultrasound for LPB, published data are limited. Future studies should compare the safety and efficacy of ultrasound-guided LPB with traditional methods of performing LPB using surface anatomical landmarks.

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