BJA Education, 24(2): 46–56 (2024)

doi: 10.1016/j.bjae.2023.10.006
Advance Access Publication Date: 15 December 2023

Revalidation FOR ANAESTHETISTS RCA Revalidation matrix Matrix codes: 1A02, 2G02, 3A09

Strategies for successful lumbar neuraxial anaesthesia and analgesia in patients with challenging anatomy

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Keywords: regional anaesthesia; spinal anaesthesia; ultrasound

Learning objectives

By reading this article you should be able to:

- Describe the technical performance and patient-centred benefits of the paraspinous approach to lumbar neuraxial anaesthesia.
- Discuss the application of spinal ultrasound imaging to the paraspinous approach and real-time ultrasound-guided techniques.
- Develop strategies to increase success in performing spinal anaesthesia in challenging scenarios, such as patients with degenerative spinal disease, suboptimal positioning, obesity and scoliosis.

Key points

- Poorly palpable spinous processes or narrowed interspinous spaces can make a midline approach to lumbar neuraxial blockade challenging.
- A paraspinous approach to spinal analgesia and anaesthesia can increase the success rate and reduce complications.
- Ultrasound imaging before the procedure facilitates both midline and paraspinous approaches.
- Real-time ultrasound-guided neuraxial anaesthesia is feasible but requires advanced imaging and needling skills.
- The L5–S1 interlaminar space is widest and often remains patent in spinal disease.

Lumbar neuraxial anaesthesia is a core skill for all anaesthetists. It is associated with improved outcomes compared with general anaesthesia in surgeries such as hip and knee arthroplasty.[1] These outcomes include lower risks of pulmonary and renal complications, venous thrombosis, blood transfusion and possibly mortality.[1] However, multiple factors can contribute to technical difficulty, including spinal degenerative disease, scoliosis, obesity, previous spinal surgery, and hindrances to optimal positioning of the patient. A large multicentre randomised controlled trial (RCT) in hip fracture surgery, a group that embodies many of these factors, reported a failure rate of 8.6% with spinal anaesthesia.[2] This article presents high yield strategies for successful neuraxial anaesthesia in the patient with challenging anatomy, specifically the paraspinous or paramedian approach and the application of spinal ultrasound imaging. Whereas the focus is on spinal anaesthesia, the principles for successful needle insertion into the interlaminar space can be extrapolated to lumbar epidural anaesthesia. Fluoroscopic guidance has also been described to assist with difficult spinal anaesthesia, but this is limited to one case report.[3] It is not feasible in labour epidural analgesia because of the radiation exposure, and its main

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Accepted: 12 October 2023

role in anaesthesia to date has been to assist thoracic epidural catheter insertion. One RCT demonstrated that fluoroscopy increased correct catheter placement within the thoracic epidural space from 74% to 98% compared with the conventional loss-of-resistance technique alone.[4] Fluoroscopic guidance in lumbar neuraxial anaesthesia is likely to remain a niche application as it requires a degree of expertise not possessed by most anaesthetists unless trained in chronic pain interventions, and we therefore consider it outside the scope of this article.

The paraspinous approach to neuraxial blockade

The fundamental reason for using the paraspinous approach is to avoid having to locate and traverse the midline interspinous space accurately. This space can be difficult to identify in patients with poor-quality surface landmarks, or it may be narrowed by degenerative disease and inadequate lumbar flexion resulting from suboptimal positioning. It is thus a useful technique where these considerations apply, and a valuable fallback option if there is persistent bony contact when attempting a midline needle approach.

Paraspinous or paramedian?

We favour the term paraspinous instead of paramedian in describing the needle approach as it emphasises a critical principle that simplifies the technique and increases success: insert the needle close to the midline (spinous process) at a small lateral-to-medial angle.[5,6] This is a subtle but important variation on the traditional paramedian approach, which is often taught as needle insertion in a lateral-to-medial direction starting at a skin insertion site up to 2 cm or a finger-breadth away from the midline.[7] However it then becomes challenging to triangulate the needle trajectory accurately in order to enter the interlaminar space, as the appropriate angle varies both with this distance and the depth to the space. Without knowledge of the depth to the space, the anaesthetist is faced with a wide range of potential lateral-to-medial angles to choose from during initial insertion and subsequent redirections. Redirection is further complicated by the choice of appropriate cranial angulation. An inappropriate lateral-to-medial angle will potentially contact the bony surface of not just the lamina, but also the spinous process (too medial) or the articular processes (too lateral) (Fig. 1). Distinguishing between these bony structures based on tactile feedback can be challenging for novice anaesthetists. They may not

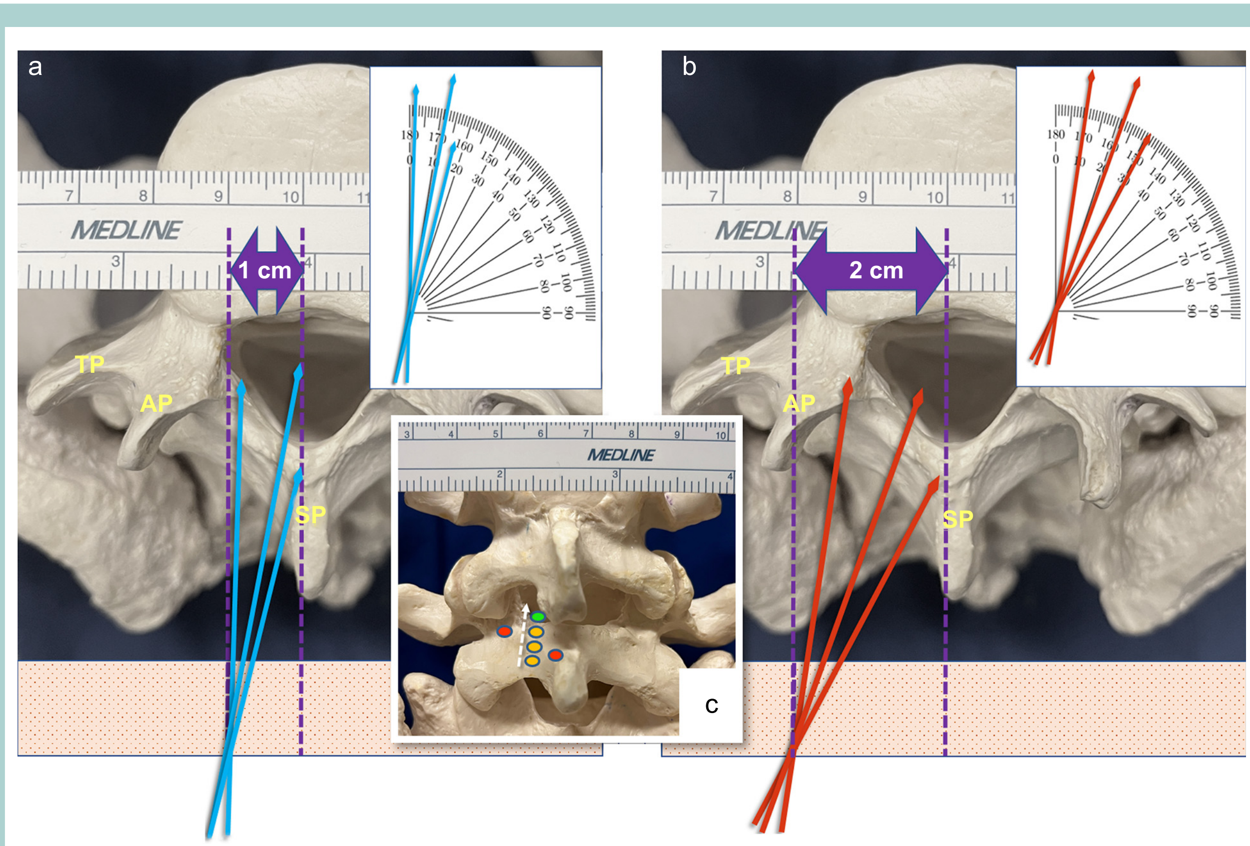

Fig 1 In a paraspinous approach, an appropriate lateral-to-medial angle is crucial for successful entry into the interlaminar space and vertebral canal. An angle that is too small will contact the bony pedicle and articular process (AP), and an angle that is too large will contact the spinous process (SP). A needle insertion site closer to the midline—1 cm (blue arrows in image A) rather than 2 cm (red arrows in image B)—narrows the potential range of angles and thus greatly simplifies decision-making. A lateral-to-medial angle of 5–10° will almost always be appropriate over the range of needle insertion depths commonly encountered in adult patients and is easily reproducible. The inset image C illustrates typical points of bony contact. A paraspinous approach utilising the appropriate needle insertion site and lateral-to-medial angle will allow the needle to be 'walked' cranially along the lamina (yellow circles) into the interlaminar space (green circle). Inappropriate lateral-to-medial angles will contact the AP or SP (red circles).

appreciate the difference in needle insertion depth when contacting the side of the spinous process (shallower) *vs* the lamina (deeper), or the significance of back pain localised to one side that often accompanies needle contact with the articular processes and facet joint. An inability to make a reasoned deduction as to what bony structure is being contacted by the needle will hamper decision-making around corrections to needle trajectory on subsequent passes.

As the entire premise of the paraspinous approach is merely to avoid the midline interspinous space, the needle only needs to be inserted immediately lateral to the spinous process. By starting much closer to the midline, the lateral-to-medial angle can be kept small, allowing the needle to slide alongside the spinous process. We recommend a skin insertion site no more than 0.5–1 cm lateral to the midline and a lateral-to-medial angle of 5–15°, typically about 10°. In this trajectory, depending on the transverse plane of the skin insertion site relative to the interlaminar space, the needle tip will either (i) pass directly from paraspinous muscle into the ligamentum flavum, a transition that is clearly signalled by a distinct and characteristic change in tactile feedback from the soft buttery feel of muscle to the firm rubbery resistance of ligamentum flavum; or (ii) contact a bony surface, which will almost inevitably be the vertebral lamina (Fig. 1). In the latter instance, incremental cranial angulation will walk the needle tip off the superior edge of the lamina and into the ligamentum flavum, which will again be clearly signalled by its feel and ability to advance the needle deeper.

The advantage of the paraspinous approach compared with the traditional paramedian technique was demonstrated in a magnetic resonance imaging study, which found that a skin insertion site 1 cm lateral to the midline, instead of 2 cm, resulted in less variation in the optimal lateral-to-medial angle of insertion with increasing depth to the subarachnoid space.[7] Successful needle entry at the usual depths from skin to the vertebral canal (4–8 cm in adults) could be achieved with a narrower range of lateral-to-medial angles (5–15°), thus reducing the guesswork involved in selecting an appropriate trajectory (Fig. 2). This principle was confirmed by a large RCT that found significantly higher first-attempt success rates of lumbar spinal (59% *vs* 20%), epidural (65% *vs* 14%) and combined spinal-epidural (CSE) blockade (47% *vs* 15%) among trainees who utilised a needle insertion point 0.5 cm lateral to the midline *vs* 1 cm lateral.[8] In the the epidural and CSE groups that used the closer insertion point of 0.5 cm there was also a lower complication rate (composite of post-dural puncture headache, infection, haematoma) and lower rates of epidural catheter-related mishaps (difficulty threading, dural puncture, intravascular placement).[8] In summary, inserting the needle closer to the midline demands less precision when considering an appropriate lateral-to-medial angle, thus simplifying the technique and increasing the odds of success.

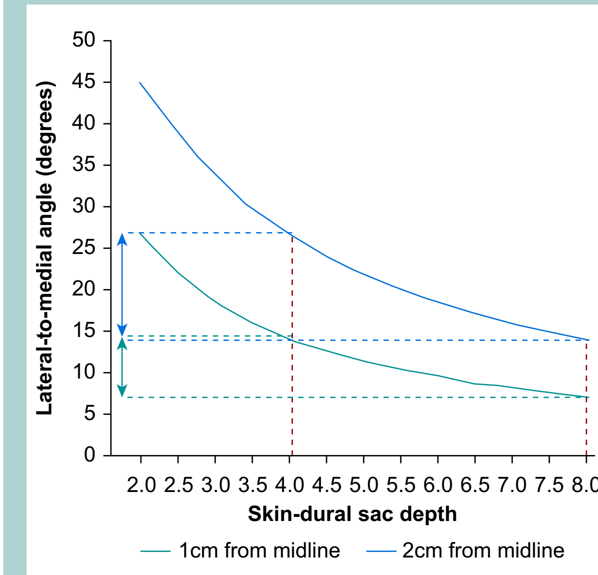

Fig 2 Graph adapted from data in Puigdellívol-Sánchez and colleagues,[7] illustrating the optimal lateral-to-medial angle (y-axis) for dural puncture at different skin-to-dural sac depths (x-axis). Across the range of depths commonly encountered in adult patients, the optimal angle will always lie within the narrow range of 7–15° (blue arrow) if the needle is inserted closer to the midline (1 cm *vs* 2 cm). Adopting a 10° lateral-to-medial angle will thus be successful in most patients if the needle is inserted within 1 cm of the midline. Inserting the needle further away increases the upper limit of the range of potential angles to choose from, to 25°, and consequently increases the chance for error.

Patient-centred benefits with the paraspinous approach

In addition to the benefits described above, technical advantages of the paraspinous approach over the midline approach have been demonstrated, particularly in older patients who are more likely to have narrowed interspinous spaces. In particular, lumbar epidural catheters were easier to insert with less frequent paraesthesia.[9] A study using epiduroscopy in cadavers found that epidural catheters inserted in a midline approach caused more dural tenting and tended to deviate laterally or turn caudally, whereas paraspinous catheters threaded more consistently in a cranial direction.[10] Possible reasons for these observations include the steeper cranial angle of insertion usually used with the paraspinous approach *vs* the more perpendicular angle of a midline approach, and the presence of posterior epidural ligaments that may impede midline catheter advancement.

The paraspinous approach may confer additional patient-centred benefits. Randomised controlled trials have shown that back pain after the procedure is less common with the paraspinous *vs* midline approach.[11,12] In one study, the overall incidence of back pain after a single pass with a 25 G spinal needle was 16% in the paraspinous group compared with 36% in the midline group.[11] This suggests that needle trauma to supraspinous and interspinous ligaments, rather than paraspinal muscles, may be a more important factor in back pain after neuraxial blockade.

A lower incidence of post-dural puncture headache has also been observed with the paraspinous *vs* midline approach.[12] In an RCT of 100 patients undergoing spinal anaesthesia with a 25 G needle for lower abdominal surgery, the incidence of mild-moderate headache over the following 7 days was 4% when a paraspinous approach was used *vs* 20% with a midline approach.[12] It is postulated that the cranial angulation of the needle in a paraspinous approach results in perforations of the ligamentum flavum, the densely multilayered dura mater and the arachnoid mater, that are slightly offset relative to each other. As a result, the edges of each layer overlap one another, creating a flap-valve effect that minimises cerebrospinal fluid (CSF) leakage.

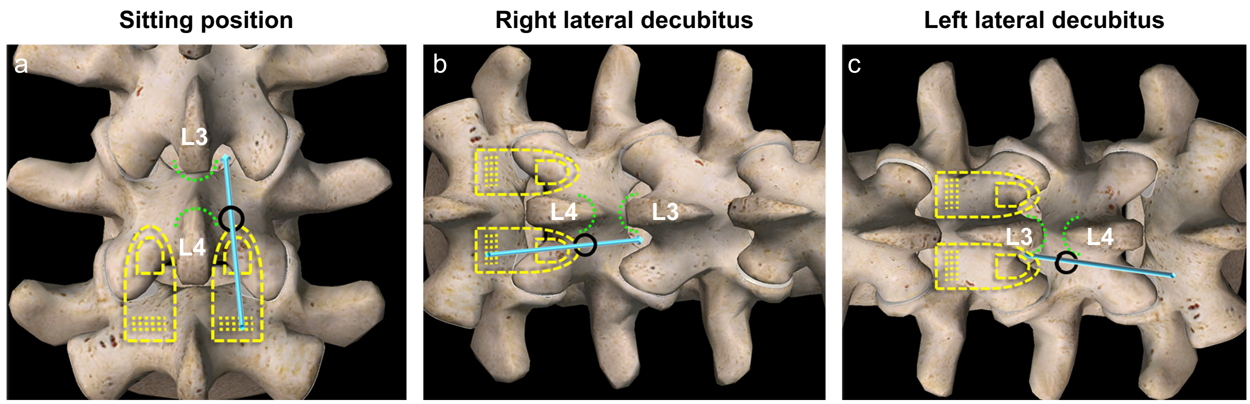

Fig 3 Illustrations of the recommended needle insertion site (black circle) and finger placement of the palpating hand in (A) sitting, (B) right lateral decubitus and (C) left lateral decubitus patient position. This illustration applies to a right-handed operator and finger placement will have to be mirrored for a left-handed operator. The palpating fingers are spread slightly to grasp the edges of the spinous process bordering the chosen lumbar intervertebral space. In the right lateral decubitus position (B), this will be the lower spinous process bordering the space. In the left lateral decubitus position (C) it will be the upper spinous process bordering the space. The recommended needle insertion site (black circle) is in the same transverse plane as the superior edge of the lower spinous process, and not more than 0.5–1 cm lateral to the midline. The midpoint of the palpating fingertip is a useful marker for judging this distance. The needle should always be inserted in a caudal-to-cranial direction and from the dependent side (for gravity-assisted CSF backflow).

The paraspinous approach to lumbar neuraxial blockade

There are four fundamental steps to the anatomical surface landmark-guided paraspinous approach. The ultrasound-assisted method is described in a later section.

(i) Determine the needle insertion site.
  (a) Establish the position of the tips of the lumbar spinous processes and the interspinous spaces by palpation. Choose a desired interspinous space and palpate the superior border of the lower spinous process.
  (b) We recommend using two fingers of the non-dominant hand for palpation, rolling the fingertips over the protrusions of the spinous processes and down into the depressions of the intervening interspinous spaces. The fingers are then separated slightly to straddle the width of the spinous process tips and chosen interspinous space, and to stabilise the overlying skin relative to the bony landmarks.
  (c) The appropriate needle insertion site is in the same transverse plane as the superior border of the lower spinous process, and ~0.5–1 cm lateral to the neuraxial midline—the midpoint of your fingertip is a useful marker for judging this distance (Fig. 3).

(ii) Scout the planned trajectory of the spinal needle with the local anaesthetic skin infiltration needle.
  (a) Infiltrate the skin and deeper underlying paraspinal muscles with local anaesthetic along the planned trajectory of the spinal needle. There should be no resistance to injection or advancement. Readjust the needle insertion site and angle as needed if the tip engages the bony spinous process or midline ligaments rather than passing smoothly through muscle.

(iii) Insert the introducer or spinal needle with an initial trajectory comprising a lateral-to-medial angle of ~10° with little to no cranial angulation (Fig. 4).
  (a) There should be a characteristic soft feel as the needle tip advances through paraspinal muscle. This will be followed by either a change in tactile feedback to the typical rubbery resistance of ligamentum flavum, or bony contact. If there is bony contact at a shallow depth <3 cm, this is likely to be the lateral aspect of the spinous process and signifies that the lateral-to-medial angle is too large (Fig. 1). Deeper bony contact is almost always the lamina. Gentle contact should not elicit any pain. If the patient reports back pain localised to the side of insertion, this usually represents contact with the ipsilateral facet joint and signifies that the lateral-to-medial angle is too small or that there is a rotational scoliotic deformity.

(iv) Perform systematic incremental redirections as needed.
  (a) If the lamina is contacted, the needle should be redirected cranially without altering the lateral-to-medial angle, to walk the tip of the needle off into the interlaminar space. This is signalled by an increase in needle insertion depth and the tactile feedback from penetrating the ligamentum flavum (Fig. 4). It is critical that the redirections are small and incremental to avoid overshooting the interlaminar space. Smaller-gauge needles should be handled carefully to avoid flexion of the needle shaft and inadvertent deviation during advancement.

If the patient is in the lateral decubitus rather than the sitting position, the anaesthetist's mental construct is now rotated 90° when computing angles and redirecting the needle. The principles governing site and angle of needle insertion relative to the spine itself remain the same. The needle should be inserted from the dependent side of the body to allow gravity-assisted CSF backflow. Depending on patient position and handedness of the operator, the fingers of the non-needling hand will straddle either the upper or lower spinous process bordering the chosen interspace, as illustrated in Figure 3.

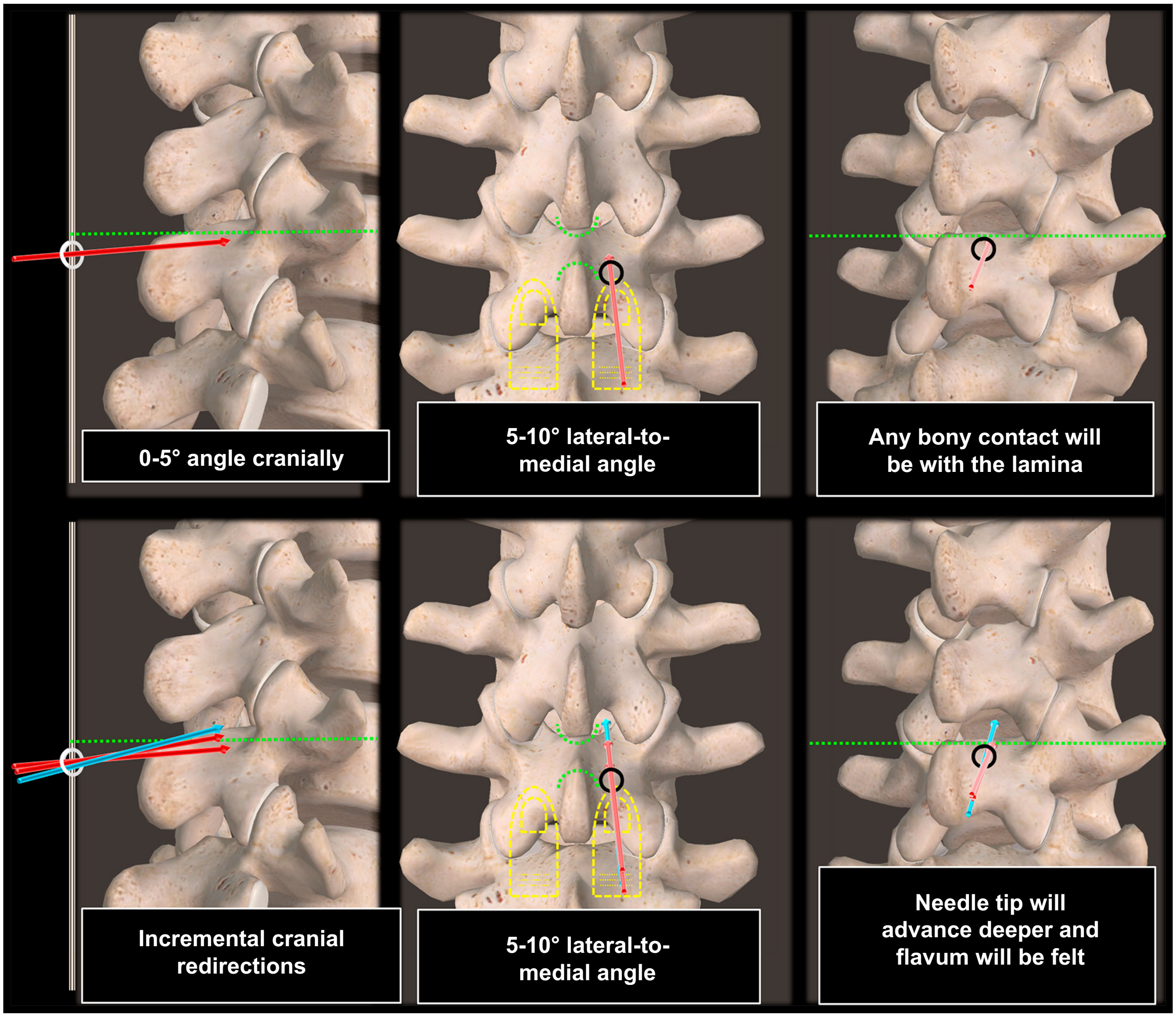

Fig 4 The introducer/spinal needle is inserted 0.5–1 cm from the midline in the same transverse plane as the superior edge of the lower spinous process bordering the chosen interspace. The initial needle trajectory should be at a lateral-to-medial angle of approximately 10°, with little-to-no cranial angulation. If the needle tip contacts bone this will almost inevitably be with the lamina of the lower vertebra. The needle should then be re-inserted with small incremental changes in cranial angulation to walk the needle tip off the lamina and into the interlaminar space. This is signalled by a perception of the needle tip advancing deeper and engaging the ligamentum flavum with its characteristic rubbery feel.

Spinal ultrasound imaging

Using ultrasound before needle insertion

Ultrasound imaging before the procedure is very useful in delineating spinal anatomy and thus is invaluable in patients with poorly palpable surface landmarks or anatomical distortion. The standard technique of ultrasound imaging and skin marking for a midline approach is well established and described in detail elsewhere.[13] In this section, familiarity with the basic principles of neuraxial ultrasound is assumed and the focus will be on aspects pertinent to the paraspinous approach.

The pre-procedural ultrasound-assisted (PPUSA) paraspinous technique involves using ultrasound imaging to first obtain a parasagittal oblique (PSO) view and perform a qualitative assessment of the patency and size of paraspinous interlaminar spaces on either side, based on the length of the gap between bony lamina shadows and visible anterior complexes (Fig. 5A). Visualisation of an anterior complex confirms that this trajectory will successfully enter the vertebral canal. In patients with narrowed interlaminar spaces, the anterior complex may not be visible. In this same PSO view, the transverse plane of a suitable intervertebral space is marked on the skin. The transverse midline view is then used to identify and mark the location of the spinous processes (Fig. 5B). An appropriate skin insertion point is 0.5–1 cm lateral to the marked midline and 0.5–1 cm caudad to the selected interspace, so that the needle trajectory adheres to the principles outlined in the surface landmark-guided paraspinous approach (Fig. 6).[6] Needle advancement is guided by tactile feedback as described above.

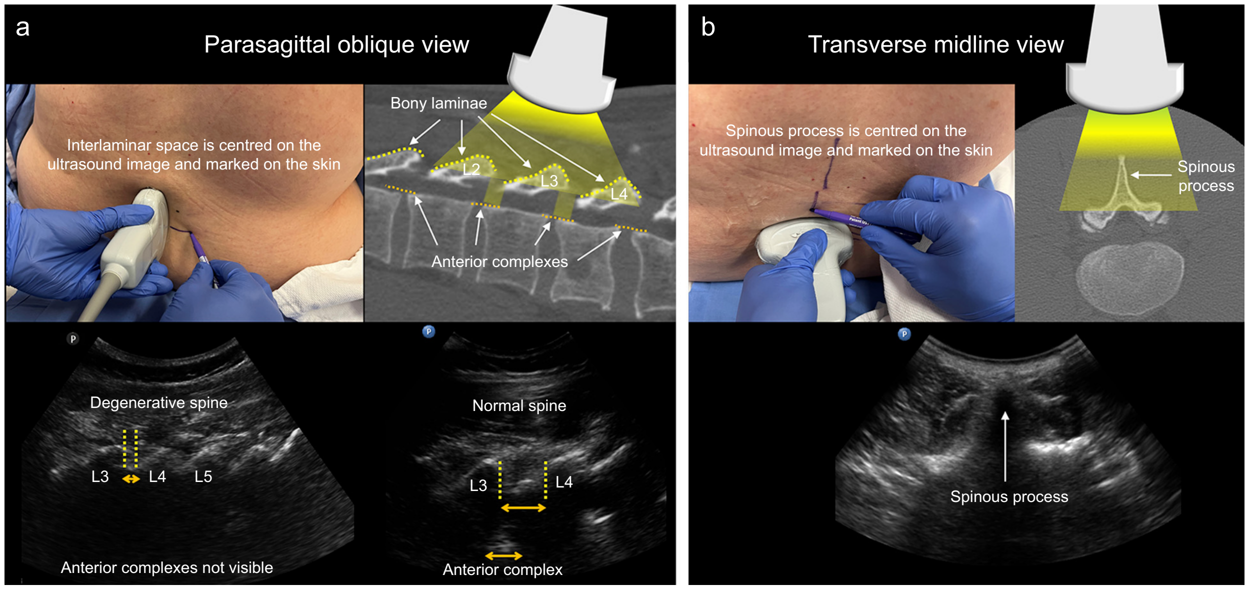

Fig 5 Preprocedural ultrasound imaging for a paraspinous needle approach. First, a parasagittal oblique view (A) of the vertebral laminae and the intervening interlaminar spaces is obtained. In normal lumbar spines, the gap between successive laminae (red lines) are wide and the anterior complexes are visible. A qualitative assessment of the width of the interlaminar space is provided by the length of this gap and the visible anterior complex (yellow arrows). If the interlaminar spaces are narrowed (for example by degenerative disease, or scoliosis), the gaps between laminae are much smaller and anterior complexes are difficult or impossible to see. The transverse plane of suitable interlaminar spaces is marked on the skin as shown. Next, a transverse midline view (B) is obtained with the primary aim of locating and marking the spinous processes. These skin markings are then used to guide needle insertion as illustrated in Figure 6.

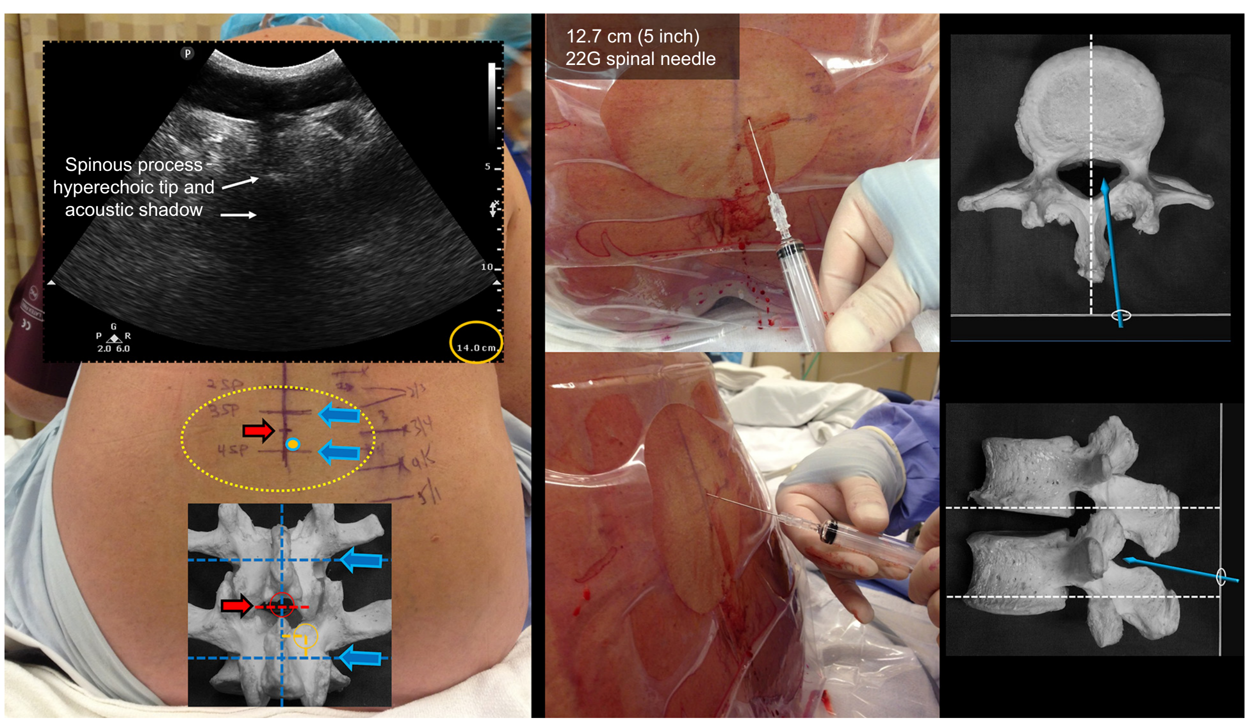

Fig 6 Paraspinous approach using pre-procedural ultrasound imaging to identify landmarks. This is especially useful in obese patients as illustrated here. The location of the spinous processes can always be identified by their characteristic hyperechoic tip with acoustic dropout shadow, and then marked on the patient's skin (blue arrows) together with the midline. The interlaminar space should lie somewhere between adjacent spinous processes (red arrow). The appropriate skin insertion point (yellow circle) can be estimated from these marks using the principles described earlier. Incremental cranial angulation, while maintaining a constant lateral-to-medial angle, will walk the needle tip off the lower vertebral lamina and into the interlaminar space.

It is important to note that this method differs significantly from the PPUSA paramedian technique described elsewhere in the literature.[14–17] In these studies, a PSO view of the interlaminar space is obtained and the needle insertion site is marked by the intersection point of two lines joining the midpoints of long and short borders of the probe. The lateral-to-medial angulation of the probe is noted for later replication when inserting the needle. The main drawback of this technique is that the large footprint of a curved probe invariably results in a more lateral needle insertion site and a larger lateral-to-medial angle. This re-introduces the challenges of triangulation and correct replication of the angulation of the curvilinear probe that produced the required image, thus increasing the chance of error.[18] These challenges may explain conflicting results in the literature. One study reported the PPUSA paramedian technique to be more effective in patients with abnormal spinal anatomy compared with a surface landmark-guided technique using either a midline or paramedian approach (at the operator's discretion) when performed by experienced anaesthetists.[17] However, other studies involving consultant anaesthetists have failed to demonstrate any advantages over a surface landmark-guided midline technique.[14,15] On the contrary, in the hands of novice practitioners, the PPUSA paramedian technique resulted in more needle passes compared with either a surface landmark-guided or PPUSA midline technique (median of 4 *vs* 2 *vs* 2), and a longer block performance time (mean of 155 *vs* 87 *vs* 116 min).[16] Block performance time, compared with a landmark-guided or PPUSA midline approach, was also a median of 67 s and 38 s longer, respectively, in the hands of novice practitioners.[16] We therefore recommend that ultrasound imaging be used only to identify the location of spinous processes and to confirm the presence of a patent interlaminar space. The position and angle of the probe should not determine the needle insertion site or lateral-to-medial needle insertion angle. These should instead follow the principles outlined for the surface landmark-guided paraspinous approach.

Real-time ultrasound-guided technique

Real-time ultrasound-guided (RTUSG) neuraxial blockade is an advanced technique that requires expertise with both conventional spinal ultrasound imaging and neuraxial blockade. It invariably utilises a paraspinous needle approach to the interlaminar space, although multiple variations using different imaging views have been described.[19] A recent RCT involving three experienced anaesthetists compared RTUSG paraspinous and PPUSA paraspinous techniques of neuraxial blockade in elderly patients with hip fractures.[19] They observed that the RTUSG technique was significantly more difficult, as demonstrated by lower first-pass success rates (32% *vs* 63%), more needle passes overall (median of 3 *vs* 1) and longer block performance times (median of 488 *vs* 200 s). Furthermore, CSF backflow was absent in 14% of the RTUSG group; in these patients, successful spinal anaesthesia was obtained with crossover to the PPUSA technique. The authors postulated several reasons for this including needle blockage, and misplacement of the needle tip because the insertion point was too lateral or deviated from the intended trajectory. The RTUSG technique cannot therefore be recommended for routine use at this time. Nevertheless, we have occasionally found it helpful in certain circumstances, notably where the target interlaminar space was adequately seen but so small as to require a degree of precision that could only be obtained with real-time guidance. It should also be noted that concerns have been raised regarding potential toxicity of ultrasound gel introduced into the neuraxial space.[20] This can be avoided by applying gel sparingly and meticulously cleaning the site of needle puncture, or by using saline as an alternative medium for probe-skin contact.

Specific strategies for challenging scenarios

The lateral position

If the patient is in a lateral decubitus position, adopting a modified Sims position, in which the patient's back slants away from the operator, can be helpful as it provides a more stable position and creates more space between the needle hub and bed surface during insertion, particularly if using a long needle >90 mm in length. However, this slant of the surface of the patient's back must be factored in when estimating the lateral-to-medial angle of needle trajectory relative to the horizontal plane of the patient's bed (Fig. 7).

Flexion of the hips and lumbar spine is not critical to successful paraspinous neuraxial blockade, as the width of the paraspinous interlaminar space is minimally affected.[21] This is a distinct advantage when optimal positioning is not feasible, such as in hip fracture. However, a recent RCT found that elevating the chest and shoulders by 30° significantly improved metrics of technical performance in elderly patients with hip fracture (Fig. 8).[22] This was attributed to widening of the dependent paraspinous interlaminar space created by lateral flexion in the thoracolumbar spine and is a concept worthy of further investigation.

Calcification of spinous processes and supraspinous ligaments

In some older patients, the skin insertion site may have to be >1 cm lateral to the neuraxial midline. This is because age-related calcification of the supraspinous ligaments can distort and widen the tip of the spinous process, creating a 'mushroom top' shape (Fig. 9). This is often evident during palpation but will also be signalled by gritty or bony needle contact during local

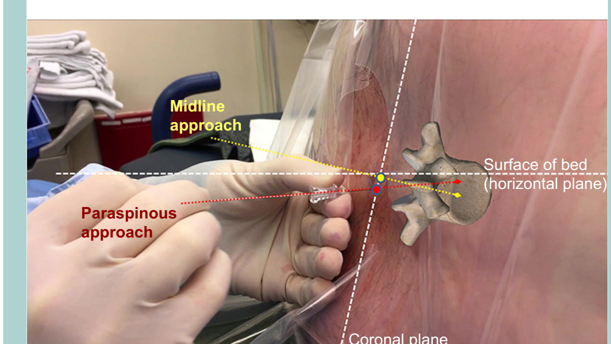

Fig 7 A more stable lateral decubitus position can be obtained by having the patient lean slightly away from the operator. However the surface of the patient's back will no longer be perpendicular to the horizontal, and this must be taken into account when estimating the lateral-to-medial angle. Reference should always be made to the planes of the patient's torso, and not the bed or surrounding environment.

Fig 8 A 30° elevation of the upper torso may improve the ease of performance of the paraspinous approach.[22] This is attributed to lateral flexion of the lumbar spine and widening of the dependent interlaminar spaces.

anaesthetic skin infiltration. The skin insertion site should be adjusted as needed until it is lateral to the enlarged tip of the spinous process and the needle can pass unimpeded through the paraspinal muscles. The lateral-to-medial angle should be increased slightly up to 15–20° to geometrically compensate for this lateral shift in insertion site (Fig. 9).

The patient with obesity

Accurate localisation of the spinous processes by palpation may be difficult in patients with obesity. Their approximate position can sometimes be determined by deep palpation and then confirmed by using the skin infiltration needle to probe for bony contact or injection resistance, signifying engagement of supraspinous or interspinous ligaments. Ultrasound imaging is also extremely helpful as the location of the midline and spinous processes can always be ascertained, even if the anterior and posterior complexes signifying interlaminar windows cannot be clearly seen (Fig. 6).

Other major challenges in obesity are the increased needle insertion depth and mobility of overlying soft tissues. This can lead to inadvertent deviations in needle trajectory during insertion. The precision of needle handling demanded by a midline approach thus makes it more susceptible to failure, particularly if the patient also has narrowed interlaminar spaces. As discussed earlier, the paraspinous approach is more forgiving of imprecision during needle insertion. Systematic redirection is also simplified by the fact that deep bony contact almost certainly signifies the ipsilateral lamina and incremental cranial angulation is therefore the logical next step to eventual success (Fig. 1). For these reasons, we often adopt the paraspinous approach as the first-line technique in patients who are very obese. Finally, when using needles >90 mm in length, regardless of approach, we recommend using 22 G (*vs* 25 G) Quincke-tip needles to reduce tissue resistance to insertion and the risk of needle shaft flexion and deviation.

Related to this, some anaesthetists suggest a CSE technique to achieve spinal anaesthesia in patients with challenging anatomy, citing the greater rigidity and better tactile feedback of the epidural needle. One RCT demonstrated non-inferiority, but not superiority, of the CSE technique compared with single-injection spinal anaesthesia in morbidly obese patients undergoing Caesarean section.[23] It should be further noted that reported incidences of spinal haematoma and other instances of permanent injury are several orders of magnitude greater with CSE and epidural anaesthesia compared with spinal anaesthesia.[24,25] We therefore do not advocate this strategy of using an epidural needle purely for its handling characteristics in non-obstetric and particularly in older patients. The CSE technique remains a valuable clinical option where the flexibility of extending the duration or height of neuraxial anaesthesia is desired.

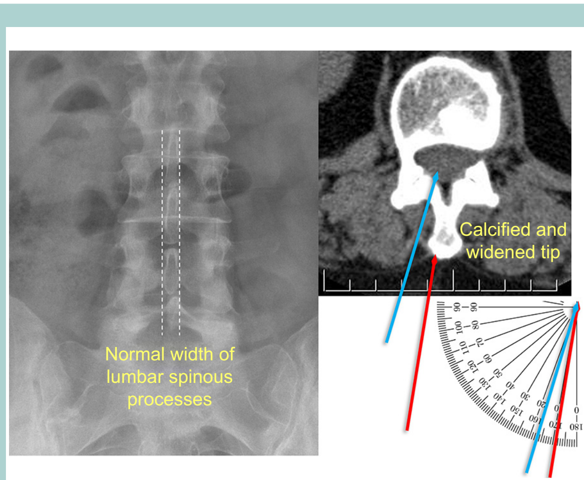

Fig 9 Calcification of the supraspinous ligament in older patients can result in widening of the spinous process tip. This mushroom top will obstruct needle insertion at the usual recommended distance of 1 cm lateral to the midline (red arrow). The insertion site will have to be shifted slightly more laterally to bypass this (blue arrow). The lateral-to-medial angle may also have to be increased slightly but should still be within 15–20° in most cases. The appropriate insertion site and trajectory can be determined by prior exploration with the needle used for local anaesthetic skin infiltration.

The patient with scoliosis

Challenges with a midline approach in scoliotic patients include narrowed interspinous spaces and rotational deformity. It is critical to identify the direction of the lateral scoliotic curve in the lumbar spine; this will be opposite to that of the thoracic curve, which is often more clinically obvious. The paraspinous interlaminar spaces are widened on the convex side of the curve and narrowed on the concave side, and the needle should thus always be inserted on the convex side (Fig. 10). A lateral curve of the spine is always accompanied by an axial rotational deformity of the vertebrae, with the body of the vertebrae rotating towards the convex side of the lateral curve. This means that little to no lateral-to-medial angulation may be needed for entry into the vertebral canal with a paraspinous approach. Conversely, medial-to-lateral angulation is now required if inserting the needle along a midline approach (Fig. 11). Ultrasound imaging is very helpful in identifying the direction and degree of curvature and rotation

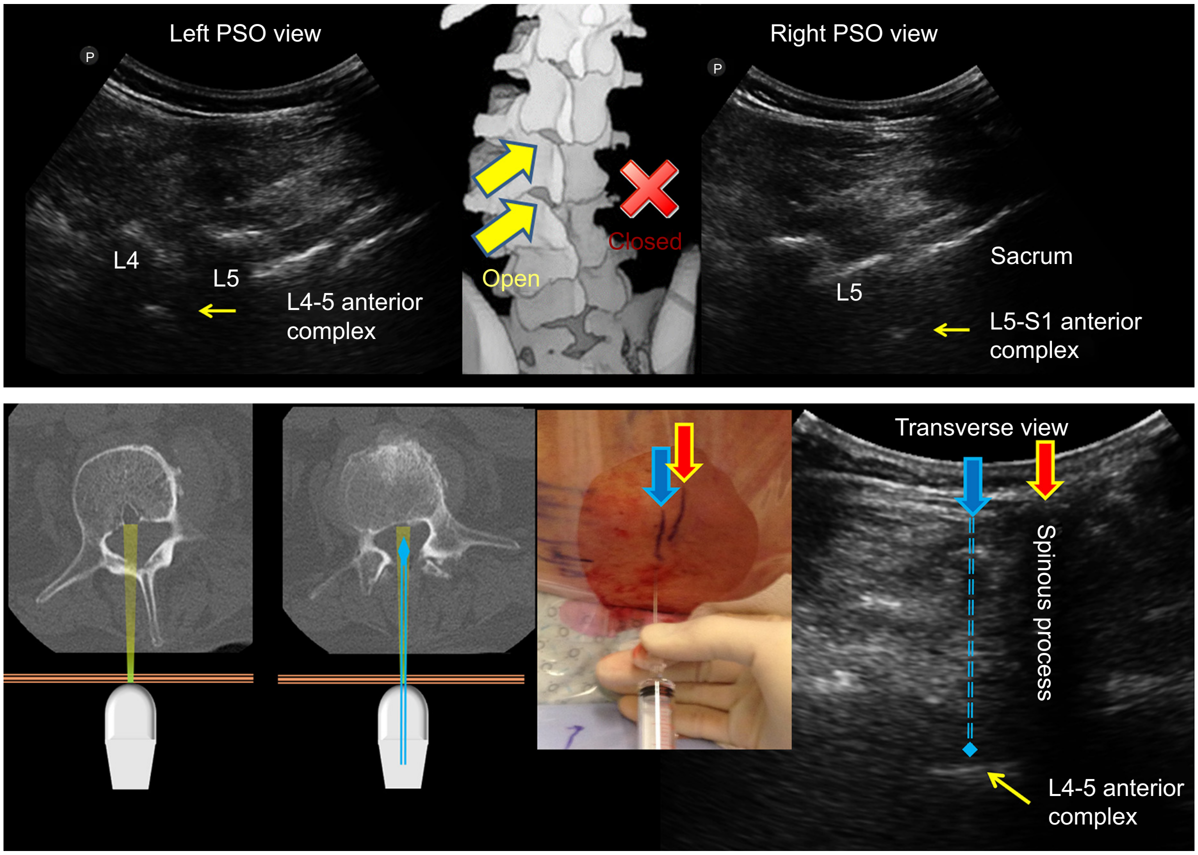

Fig 10 Upper panel: parasagittal oblique (PSO) ultrasound images of a scoliotic lumbar spine, illustrating that the interlaminar spaces are narrowed or closed on the concave side of the curve (red 'X'), as evidenced by an inability to see the anterior complex at L4–5 on the right side in this example. The interlaminar spaces are wider and more open on the convex side of the curve (yellow block arrows), and thus the anterior complex at L4–5 can be seen on the left in this example. This is the side that should be utilised in the paraspinous needle approach. Lower panel: the rotational deformity that accompanies spinal scoliosis means that a paraspinous approach can be achieved by advancing the needle perpendicular to the patient's back, without any lateral-to-medial angulation. This is also often evident on the transverse ultrasound view in which the anterior complex is visible lateral to the acoustic shadow of the spinous process and neuraxial midline. This transverse ultrasound image can be used to mark the parasagittal plane for perpendicular needle insertion (blue arrow) on the patient's skin. This is lateral to the neuraxial midline which is also marked as a secondary reference (red arrow).

in these patients, in locating suitably wide paraspinous interlaminar spaces and in planning the appropriate needle trajectory.

Targeting the L5/S1 interlaminar interspace

The L5–S1 interlaminar space tends to remain patent in degenerative spinal disease and is thus a useful option in challenging neuraxial blockade. The original description, Taylor's approach, was for spinal anaesthesia in the prone position in elderly patients and advocated a paramedian approach utilising a needle insertion point 1 cm medial and 1 cm caudal to the posterior superior iliac spine, with subsequent craniomedial redirections to walk the needle off the sacrum into the interspace. This bony surface landmark is difficult to reliably ascertain, especially in the obese. However, the L5–S1 space can be easily located with ultrasound imaging and its patency simultaneously confirmed.[13] A PPUSA midline or paraspinous approach can then be performed. Note that the S1 foramen can sometimes mimic the sonographic appearance of the L5–S1 space. The latter is characterised by the sawtooth appearance of the L5 lamina and its constant visibility with small lateral-medial sliding motions of the probe.

One important consideration when targeting the L5–S1 space for spinal anaesthesia is adequate cranial distribution. Insufficient block height is a common cause of secondary spinal anaesthesia failure even when injection is performed at higher levels.[26] A recent dose-finding study reported that sensory loss above the T10 dermatome with Taylor's approach was only consistently obtained with a relatively large dose of at least 25 mg of plain bupivacaine 0.5%.[27] A detailed discussion of baricity and the most appropriate local anaesthetic solution for spinal anaesthesia performed at the L5–S1 space is beyond the scope of this journal.

Although the densities of plain local anaesthetic solutions are numerically lower than CSF, their distribution within the CSF is not affected by postural changes in as predictable a manner as hyperbaric solutions.[28,29] Using

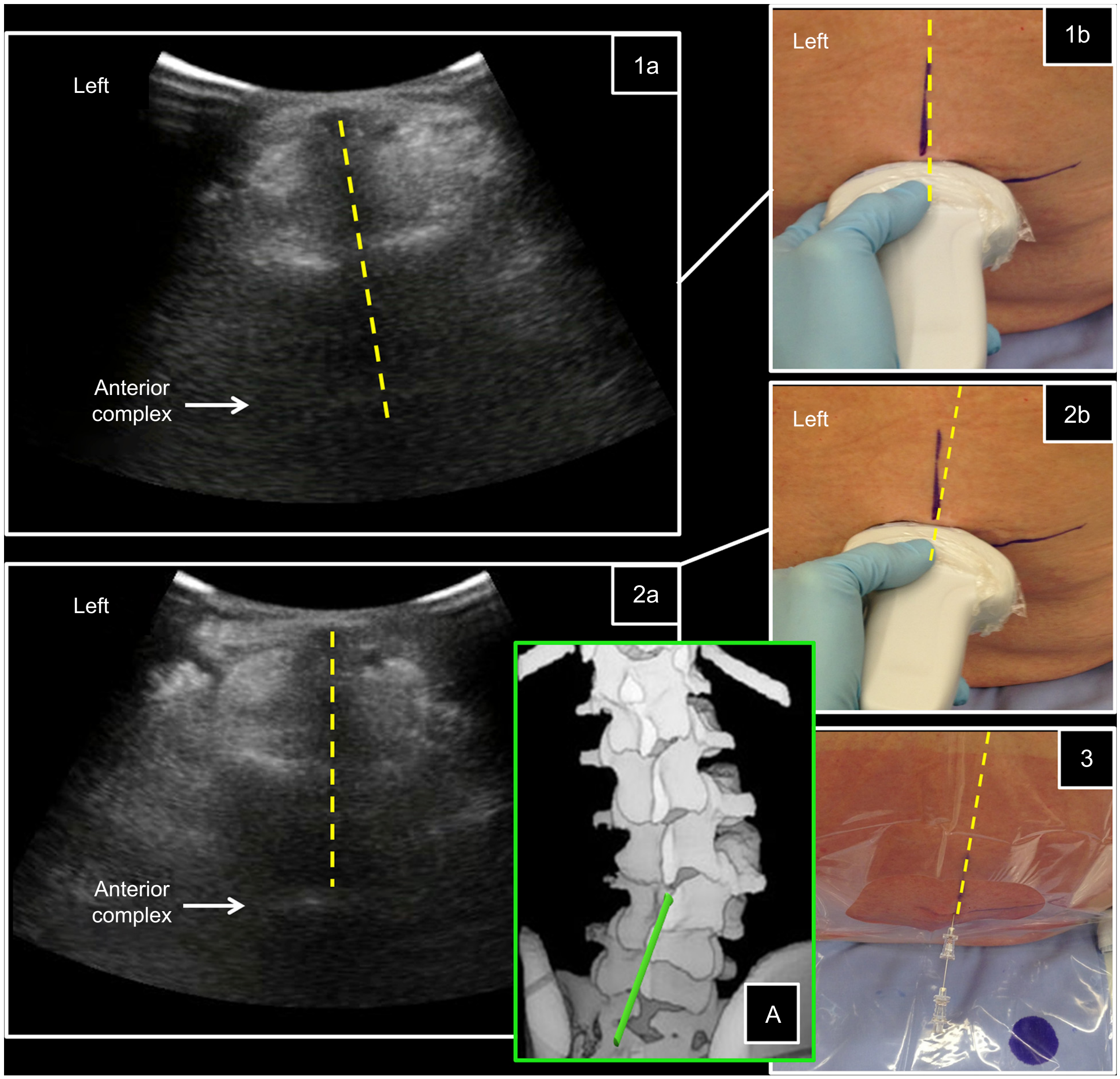

Fig 11 A scoliotic curve in the spine is always accompanied by a rotational deformity (inset image A). This is evident on ultrasound imaging as a midline acoustic shadow (yellow dashed line) that is tilted away from the vertical when the probe is placed in a transverse orientation with the beam perpendicular to the surface of the back (image 1A and 1B). The direction and angle of rotation is determined by rocking the probe in the transverse plane to bring the midline acoustic shadow back to the vertical (image 2A and 2B). This medial-to-lateral probe-beam angle must be replicated for successful needle insertion using a midline approach (image 3).

hyperbaric or hypobaric local anaesthetic solutions should be considered, in conjunction with appropriate positioning of the patient after the block to achieve the desired cranial distribution.[30–32]

Conclusions

Lumbar neuraxial analgesia and anaesthesia is a core skill for all anaesthetists but can be technically challenging to perform in patients with abnormal spinal anatomy. Using some combination of the strategies presented in this article should help to maximise success when difficulty is anticipated or encountered.

Declaration of interests

The authors declare that they have no conflicts of interest.

MCQs

The associated MCQs (to support CME/CPD activity) will be accessible at www.bjaed.org/cme/home by subscribers to *BJA Education*.

Acknowledgements

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