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Integrating ultrasound with the combined spinal-epidural kit as a rescue technique during difficult spinal anaesthesia

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Accepted 21 October 2021

SUMMARY

Conducting spinal anaesthesia in patients with elevated body mass index is commonly difficult, yet there are no guidelines to direct best practice. Landmark techniques are sometimes insufficient, leading to increased failure rates and suboptimal patient outcomes. Although ultrasound-guided techniques are now considered standard care for central venous access and regional anaesthesia, there has been relatively sparse uptake of this widely available resource for central neuraxial block, despite evidence of its efficacy.

This article outlines a successful case of ultrasound-assisted spinal anaesthesia, after landmark techniques failed, in conjunction with a combined spinal-epidural kit. This unique combination of techniques has not been published as an amalgamated rescue strategy for difficult spinal anaesthesia. This article adds to current evidence by highlighting the potential benefits of combining these techniques into a novel approach either when difficulties are expected or as a rescue technique after failed landmark-based attempts.

BACKGROUND

According to WHO global estimates, more than 1.9 billion adults (39%) were overweight and 650 million adults (13%) were obese in 2016.[1] This represents over 50% of the global adult population. A body mass index (BMI) of ≥25 kg/m^2 is overweight, of ≥30 kg/m^2 is obese and over 40 kg/m^2 is morbidly obese.

Anaesthetic morbidity and mortality rise sharply at a BMI of ≥30 kg/m^2.[2] Physiological changes such as delayed gastric emptying, impaired gas exchange, altered pharmacokinetics and technical aspects such as difficult intubation make risk minimisation paramount.[2] Sleep disordered breathing causing hypoxaemia further complicates anaesthesia and opioid analgesia.[2] Oftentimes, particularly for obstetric and orthopaedic anaesthesia, a spinal anaesthetic is the preferred anaesthetic, but this too can present significant technical challenges.[3 4]

Some authors have highlighted the benefits of ultrasound (US) for lumbar puncture and neuraxial block, with the benefits being greatest in high BMI patients or when difficulties are expected.[4–7] Some suggest that US should be considered routine when there is a high risk of failure.[6] Yet US remains infrequently used for this indication.

Similarly, combined spinal-epidural (CSE) is espoused as the recommended technique for caesarean section in the obese parturient, primarily due to the ability to extend the block in the event of prolonged surgery, but it is also recognised that identifying the epidural space can be easier with the rigid Tuohy needle, creating tactile advantages.[3] A recent randomised trial demonstrated that fewer attempts were required to establish spinal anaesthesia in obese parturients with a CSE compared with a single-shot spinal[8]; however, this technique is commonly overlooked. This case highlights potential advantages of combining these two techniques as a novel approach for the expected or unexpected difficult spinal anaesthetic.

CASE PRESENTATION

A 62-year-old female presented for elective robot-assisted (Makoplasty) partial knee replacement. She was 116 kg, 157 cm tall, with a BMI of 45.8 kg/m^2.

Background was significant for hypercholesterolaemia, osteoporosis, osteoarthritis, exertional dyspnoea (~50 m) and probable obstructive sleep apnoea (6 out of 8 on 'STOPBANG' questionnaire). She had experienced no previous problems with anaesthesia and took vitamin D3 1000 IU. She denied of cardiorespiratory disease, gastro-oesophageal reflux disease and was appropriately fasted.

Vital signs and cardiorespiratory examination were unremarkable. Airway examination revealed Mallampati 2 and mouth opening of >3 cm. Bony landmarks were not visible or palpable on examination of her spine.

The anaesthetic plan was a combined general-neuraxial anaesthetic and an adductor canal block to provide quality postoperative analgesia, allow sparing of hypnotics and opioids (thus reducing respiratory suppression and postoperative nausea and vomiting) and allow early mobilisation to expediate rehabilitation.

TREATMENT

An 18G cannula was inserted. The patient was positioned in the sitting position, with full monitoring and supplemental oxygen via Hudson mask. Two milligrams of midazolam was administered. Strict asepsis and alcoholic chlorhexidine skin preparation was used. Using surface landmarks, two unsuccessful midline attempts were made with a 25G Sprotte spinal needle. Bone was encountered in both instances.

A quick recourse was made to US assistance using a Sonosite Xport (Fujifilm Sonosite, Bothell, Washington, USA). A probe cover and sterile

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To cite: Stagg P. *BMJ Case Rep* 2021;**14**:e246727. doi:10.1136/bcr-2021-246727

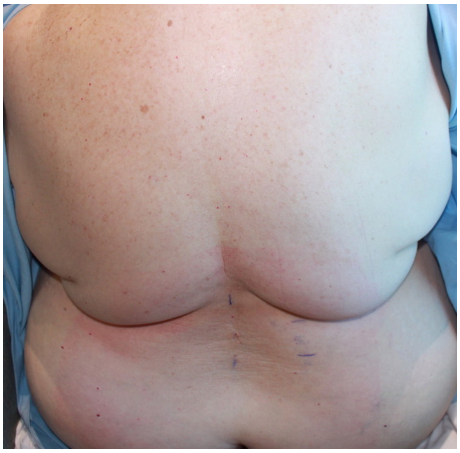

Figure 1 Day 1 postoperative image of the patient's spine. Vertical lines indicate midline and were marked in transverse interlaminar view. Horizontal lines were marked in the parasagittal oblique view, indicating interlaminar levels. *Informed consent was obtained from the patient for using clinical images.*

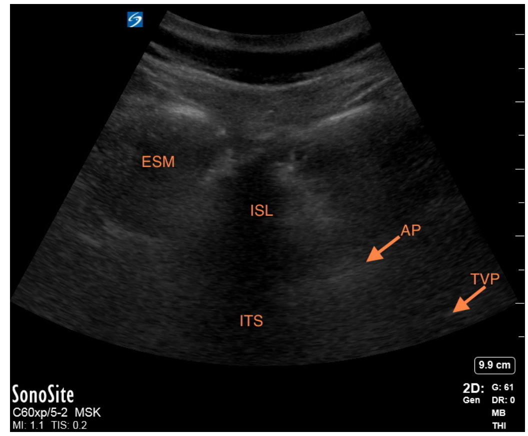

Figure 3 . Transverse interlaminar/interspinous view (TI view). A key view for marking both the midline and each interlaminar/interspinous space. The ligamentum flavum and vertebral bodies were not visible in this view and are usually more hyperechoic in the parasagittal oblique view. Estimated depth can be approximated to transverse process depth when ligamentum flavum or vertebral bodies are not seen on either view. AP, articular process; ESM, erector spinae muscle; ISL, interspinous ligament; ITS, intrathecal space; TVP, transverse process. *Informed consent was obtained from the patient for using clinical images*.

surgical marking pen were opened onto the surgical field. A low-frequency curvilinear probe (2–5 MHz) was set at 12.6 cm depth for the scan. The systematic approach published by Ghosh *et al*[7] was used to estimate depth and identify the midline and interspaces. US was used to mark the midline with an interrupted vertical line, and horizontal lines were carefully placed on the skin corresponding to L3/L4, L4/L5 and L5/S1 interspaces (figure 1). An estimated depth of approximately 9 cm to the neuraxis was obtained from the faintly visible hyperechoic vertebral body at approximately 10 cm depth on parasagittal oblique (PSO) view (figure 2). Figure 3 shows transverse interlaminar (TI) US images. US scanning revealed that initial attempts had been slightly right of midline and over the L5 spinous process.

After US mapping, one attempt was made at L4/5 and again the spinal needle encountered the bone, likely to be the base of the L5 spinous process, but despite redirection, the needle returned slightly bent. A 16G/26G Portex CSEcure CSE minipack with locking pencil-point spinal needle was used (Smiths Medical, Minneapolis, Minnesota, USA). The 16G Tuohy needle was inserted at the L4/5 interspace and bone was encountered, presumed to be the base of the L5 spinous process. The Tuohy needle was then sequentially stepped off the spinous process, and at 8 cm depth and moderate skin indentation with the hilt of the Tuohy needle, loss of resistance to saline identified the epidural space. The 26G spinal needle was inserted and locked with a quarter-clockwise turn at 12 mm when the dural pop was felt. Clear cerebrospinal fluid (CSF) was obtained, and 2.6 mL of 0.5% hyperbaric bupivacaine with 20 µg of fentanyl was injected.

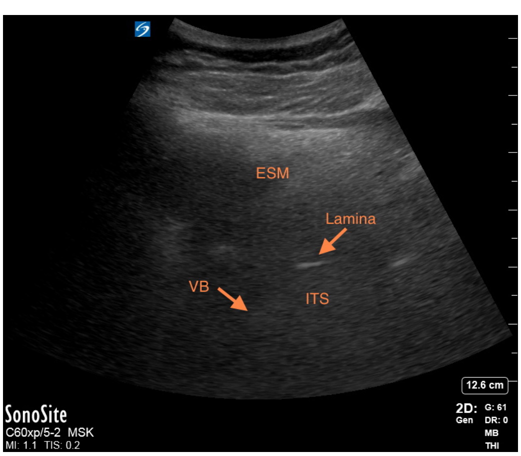

Figure 2 . Parasagittal oblique (interlaminar) view (PSO view). L3/4 space mid-screen. Suboptimal view, yet saw-tooth pattern of lamina and interspaces easily identified. Vertebral body cortex between lamina faintly seen at 10 cm depth. The ligamentum flavum was not visible in this patient. In the PSO view, with an interspace centred mid-screen, mark the skin at each level during the prescan. ESM, erector spinae muscle; ITS, intrathecal space; Lamina, L4 lamina; VB, vertebral body. *Informed consent was obtained from the patient for using clinical images*.

Anaesthesia was induced with 50 µg of fentanyl and 6 µg/mL of TCI propofol (Marsh model), an i-gel (InterSurgical, Wokingham, Berkshire, UK) size 4 supraglottic airway device was inserted, and the patient was ventilated with pressure support (PSVPro) at a respiratory rate of 10, inspiratory pressure of 20 cm$H_2$0, positive end-expiratory pressure of 5 cm$H_2$0 and tidal volume of 6–8 mL/kg. Anaesthesia was maintained with propofol TCI 2–3 µg/mL. Appropriate antibiotics and antiemetics were given. Oxygen saturations were maintained at 98% on end-tidal control of 50% oxygen; end-tidal $C0_2$ was maintained at 38–44 mm Hg; and bispectral index monitoring was maintained between 40 and 60. She remained haemodynamically stable throughout, and anaesthesia ensued uneventfully for 1:45 minutes. At the conclusion of the case, a single-shot US-guided adductor canal block was aseptically inserted, using 20 mL of 0.75% ropivacaine with 70 µg of dexmedetomidine to prolong the block.

OUTCOME AND FOLLOW-UP

Day 1 follow-up on the ward revealed a comfortable haemodynamically stable patient. She had received regular paracetamol, meloxicam and slow-release tapentadol, but had only required four additional doses of immediate-release (IR) tapendadol and 25 mg of sublingual ketamine in the first 24 hours. She required only five total doses of tapentadol IR during the following 4 days and did not require any additional oral or parenteral opioid-agonists.

She was successfully mobilised and discharged uneventfully on day 5. Outpatient polysomnography was recommended to the patient due to her risk of obstructive sleep apnoea.

DISCUSSION

This case highlights how a quick recourse to using US for spinal anaesthesia in conjunction with a CSE kit led to procedural success and a good outcome in a patient with high BMI.

US for neuraxial block enables the user to acquire three useful pieces of information: the depth to the intrathecal space, the anatomical midline and the location of spinal interspaces. This better informs both needle insertion site and needle selection, including whether a long needle will be required.

There is growing evidence that the use of US for neuraxial block and lumbar puncture significantly increases success.[5 9] Shaikh *et al* conducted a meta-analysis of 14 randomised controlled trials (RCTs) covering US-assisted epidurals and lumbar punctures incorporating 1334 patients and demonstrated a statistically significant reduction in failures ($p=0.001$), decreased traumatic taps ($p=0.005$), a reduction in insertion attempts ($p<0.001$) and a reduction in the number of needle redirections ($p<0.001$).[5] Sahin *et al* reported in an RCT of 100 parturient that an US prescan resulted in significantly less overall needle passes and less spinal levels attempted, and a first pass success was 92% vs 44% with US ($p<0.001$).[9] In addition, a trend to reduced procedural duration was also observed. Measured depth has been shown to reliably correlate with actual depth.[9 10]

A systematic approach to US-assisted central-neuraxial block has been published by Chin *et al*, incorporating five US views: the parasagittal transverse process view, the parasagittal articular process view, the PSO (interlaminar) view (PSO view), the transverse spinous process view and the TI/interspinous view (TI view). This technique has been published in the *British Journal of Anaesthesia* and *Anesthesiology*, and a full description is beyond the scope of this report.[7 11] Chin has authored an excellent video resource that is freely available.[12] These techniques can be learnt with relative ease. Gaining initial experience with normal BMI patients is recommended, and studies suggest that 30–40 procedures may be required for competency.[13] As with all US techniques, pattern recognition is vital when learning the views. Colourful names have been created to describe the patterns of sono-anatomy, including 'the trident sign', 'the camel hump sign', 'saw-tooth pattern' and 'the bat wing sign', which can make teaching and learning this technique entertaining and enjoyable.

There are a number of limitations to US use for neuraxial block, highlighted by this case.

A pitfall of US-guided neuraxial block is that textbook sono-anatomical images are often simply not identifiable in high BMI individuals, when you need them most. Identification of the hyperechoic ligamentum flavum and vertebral body cortices are considered gold standard in confirming that the intrathecal space has been penetrated by the US beam.[7] These structures are often easier to visualise on the parasaggital oblique view,[14] but were extremely difficult to identify in this patient. However, invaluable information was still able to be obtained, as shown in figures 2 and 3.

Despite completing a careful anatomical survey with the US and marking the skin, bone was still encountered. Two recognised technical factors may have contributed this: marking error and needling error.[12]

First, the skin was marked with short, interrupted horizontal and vertical lines (figure 1). It is recommended to connect these interrupted lines to form an intersection point, to provide a better visual aid to inform needle insertion.[7] Furthermore, the patient position must not change between marking and needle insertion, as even slight changes in position can render skin markings inaccurate.

Second, operators must be aware that in high BMI patients where the intrathecal space is further from the skin than normal, small changes in the angle of insertion will lead to a much greater increment of change at the tip of the needle. This concept is often overlooked, and it is even more important to take your time and make fine adjustments in the needle angle for obese patients.

Notwithstanding these potential sources of error, it was felt that the needle was midline within an interlaminar space and most likely encountering the base of a spinous process. Furthermore, the anatomical survey had suggested that the depth was likely to be around 8+ cm, and skin indentation needed to be accounted for. Therefore, a CSE kit was used.

The CSE provided four distinct advantages: rigidity and tactile feedback, a spinal of increased length, a spinal of fine gauge and the ability to insert an epidural if deemed necessary.

Long spinal needles are sometimes needed for high BMI patients[3]; however, these are often flimsy and more difficult to handle. In fact, a case of a broken 4.5 inch (11.4 cm) 25G spinal needle in an obese parturient was recently reported.[15] Wide-bore spinal needles are easier to manoeuvre, however significantly increase the incidence of postdural puncture headache, creating a conundrum.[16] This issue can be overcome using a CSE kit. In this case, a 26G/16G Portex CSEecure CSE kit was used. The rigid Tuohy needle facilitated walking off the spinous process with excellent tactile feedback without the risk of bending the needle and obtained access to the intrathecal space with the spinal needle on first attempt thereafter. The depth to the CSF was about 9.2 cm, and a standard CSE needle will allow up to 9.5 cm, which should be sufficient for most cases. Sahota *et al* in an US study of 60 parturients with an average BMI of 39.6 kg/m^2 found the average actual needle depth to be 6.6 cm.[14] The highest BMI was 66.2 kg/m^2, and the greatest needle depth was 9.7 cm.

CSE anaesthesia confers the benefit of continuous anaesthesia if the spinal block is inadequate, fails or surgery is prolonged, which is more common in high BMI patients. For this reason, CSE has been espoused as the anaesthesia of choice in this context.[4] Although the epidural was not inserted in this case, on reflection this is recommended, as it is quick and easy to accomplish with inherent benefits.

Successful insertion of a spinal anaesthetic often obviates the need for a general anaesthetic for knee arthroplasty. However, despite the recognised benefits of regional anaesthesia, patients often have misgivings, particularly the fear of being awake,[17 18] as was the case with this patient.

Moderate-level evidence supports the use of neuraxial anaesthesia alone or in combination with general anaesthesia for joint arthroplasty. Two large systematic reviews and meta-analyses demonstrated that compared with general anaesthesia alone, neuraxial anaesthesia or general-neuraxial anaesthesia significantly improved outcomes of blood loss, thromboembolic events, hospital stay, intensive care unit admissions, pulmonary complications, wound infection and acute renal failure,[19 20] and a significant reduction in 30-day mortality.[20] These benefits are primarily believed to be due to the neuraxial technique (such as improved blood flow, opioid sparing) and are not lost with the inclusion of general anaesthesia; however, the diversity of benefits is considered slightly better with neuraxial alone.[20]

Given her absence of major cardiorespiratory disease or gastro-oesophageal reflux, her reassuring airway, fasting status, and consideration of the patient and surgical preference, the addition of a low-dose intravenous target-controlled infusion anaesthetic was considered reasonable. The postoperative goals of minimising postoperative respiratory suppression in view of possible obstructive sleep apnoea were achieved by maintaining a low-dose hypnotic infusion, minimising opioids and using regional anaesthesia. Intrathecal morphine was avoided due to potential issues of delayed respiratory suppression.

Finally, some authors have recommended that US should be used for all cases where difficulty is expected.[7] The present report supports this and the development of protocols that incorporate US-assisted and CSE-based approaches in obese patients, and ideally a US prescan for all morbidly obese patients.

Future studies could objectively evaluate the benefits of a combined US-assisted and CSE-assisted spinal anaesthetic technique for morbidly obese patients. Education and training are recommended to facilitate the implementation of this underused yet valuable technique.

Patient's perspective

After two attempts of the initial method, it was explained to me how the ultrasound would work for guidance and make the procedure easier and less risky. During the ultrasound procedure, at no time was I in any pain or uncomfortable in any way. It also made the procedure quicker.

Learning points

- Obesity is a prevalent health problem and is associated with increased anaesthetic morbidity
- Procedures such as spinal anaesthesia can be technically difficult in high body mass index (BMI) patients
- Ultrasound-assisted spinal anaesthesia has been shown to be safe and increases success
- Ultrasound should be considered early when preforming spinal anaesthesia in high BMI patients
- Integrating ultrasound with a combined spinal-epidural kit for difficult spinal anaesthesia represents a potent combination, providing useful clinical information and tactile advantages

Acknowledgements The author thanks Harmony Robinson-Stagg and Dr Brendan Stagg for inspiring him to contribute to medical education.

Contributors Patient was under the care of PS. Manuscript concept was conceived, written and edited by PS.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Consent obtained directly from patient(s).

Provenance and peer review Not commissioned; externally peer reviewed.

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