Ultrasound assisted lumbar puncture

Why

Lumbar puncture is a very common procedure performed by the Acute Medical Team and often can be difficult due to a number of reasons. Traditionally the landmark technique has been used however research has shown that often this is inaccurate, and higher spaces are identified incorrectly such as L2/3 or even L1/2 posing a significant risk given the proximity to the Conus Medullaris[1].

Ultrasound (US) assisted lumbar puncture (LP) allows you to identify the correct level accurately and identify the midline which can be difficult to detect. US assisted LP is recommended by the Society of Hospital Medicine in the USA [2] and has been shown to be cost –effective and results in a better patient journey. Ultrasound guidance has also been shown to be particularly useful in patients with BMI>35 which has a strong correlation with failure rate[3].

Evidence

A meta-analysis found that when compared to traditional lumbar puncture techniques, point of care US assisted LP improved the likelihood of success, required fewer needle passes, took less time to complete the procedure, had a lower incidence of traumatic LPs and pain was reduced[4].

Anatomy

Lumbar punctures should be performed at L3/4 or L4/5 to ensure the Conus Medullaris is avoided. US assisted LP aims to identify the correct level as well as the midline. Via ultrasound the spinal processes and articular processes (Figure 1) are identified which help to target the correct site.

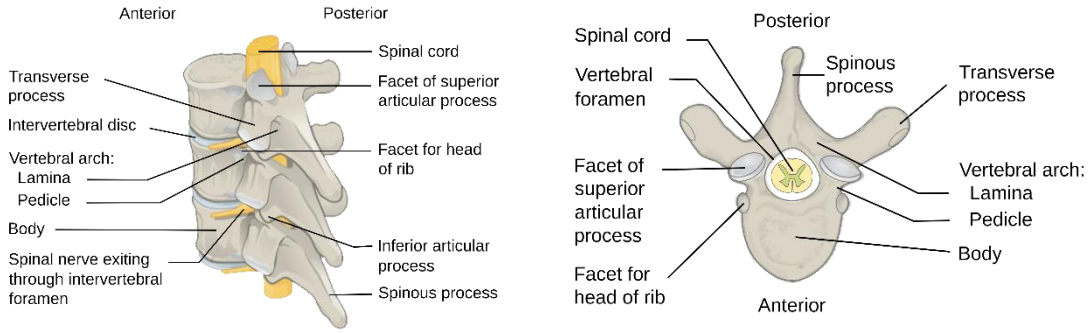

Figure 1 A section of the spinal column highlighting the different anatomical components of a vertebrae. Images from Wikipedia licensed under the Creative Commons Attribution-Share Alike 3.0. Attribution: Jmarchn, CC BY-SA 3.0 <https://creativecommons.org/licenses/by-sa/3.0>, via Wikimedia Commons. Found at: https://commons.wikimedia.org/wiki/File:718_Vertebra-en.svg

Ultrasound technique *Please note: This guidance will only describe use of ultrasound to mark site for LP needle insertion i.e. not directly visualising the needle on insertion.*

Both the high frequency linear and low frequency curvilinear probes can be used for US assisted LPs. The linear probe is best used in patients with low BMI as it gives more detailed views however it may not provide adequate depth for many patients. The curvilinear probe is best used for patients with a raised BMI as it allows structures to be visualised at greater depths. Set the depth to around 10-12cm. US assisted LP relies on median and paramedian views to identify the correct space which will be described below.

As with all lumbar punctures the position of the patient is paramount and needs to be prioritised before using the ultrasound. The patient can be in either left lateral or a sitting position. Once the patient is in the correct position the ultrasound can be used to identify the correct site for needle insertion. *It is important to note that once the spinal landmarks have been identified and marked, the patients' position should not change as the markings will no longer be accurate.*

Firstly, the correct spinal level needs to be identified via the median view. Palpate the back to identify L4-L5. The probe is placed over the presumed midline in the longitudinal orientation, with the probe marker pointing cranially (Figure 2.1).

Figure 2.1 i) Longitudinal midline probe placement in sitting position. **ii)** Longitudinal midline probe placement in the left lateral position. *Images from US for the Generalist, Clare S, Duncan C ©. Reproduced with permission of the Licensor through PLSclear.*

With the probe in the correct position the spinal processes should be visualised as superficial hyperechoic lines with the acoustic shadowing below. The US is unable to penetrate the bone due to the high acoustic impedance of the bone so no other anatomy will be identified.

Following this, move the probe laterally either side of the midline by 1-2cm to obtain views of the paramedian articular processes (Figure 2.2). This will reveal the articular processes (AP) which appear like hyperechoic 'camel humps' (Figure 2.3).

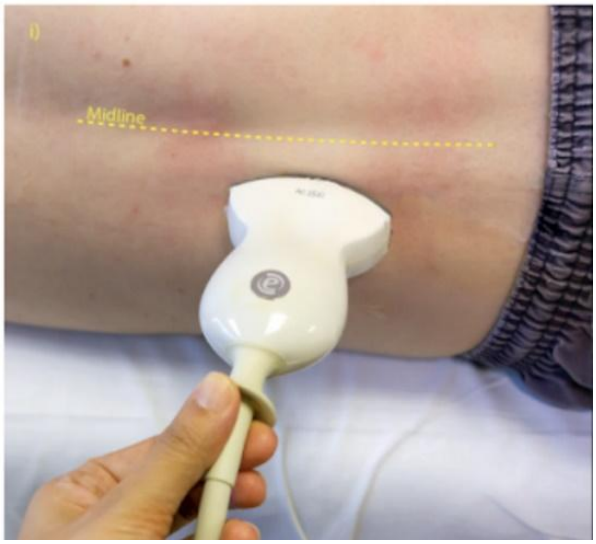

Figure 2.2 Probe position to obtain views of paramedian articular processes. *Images from US for the Generalist, Clare S, Duncan C, ©. Reproduced with permission of the Licensor through PLSclear.*

Figure 2.3 Ultrasound image highlighting the erector spinae muscles (ESM) and the 'camel hump' articular processes (AP). *Images from US for the Generalist, Clare S, Duncan C, ©. Reproduced with permission of the Licensor through PLSclear.*

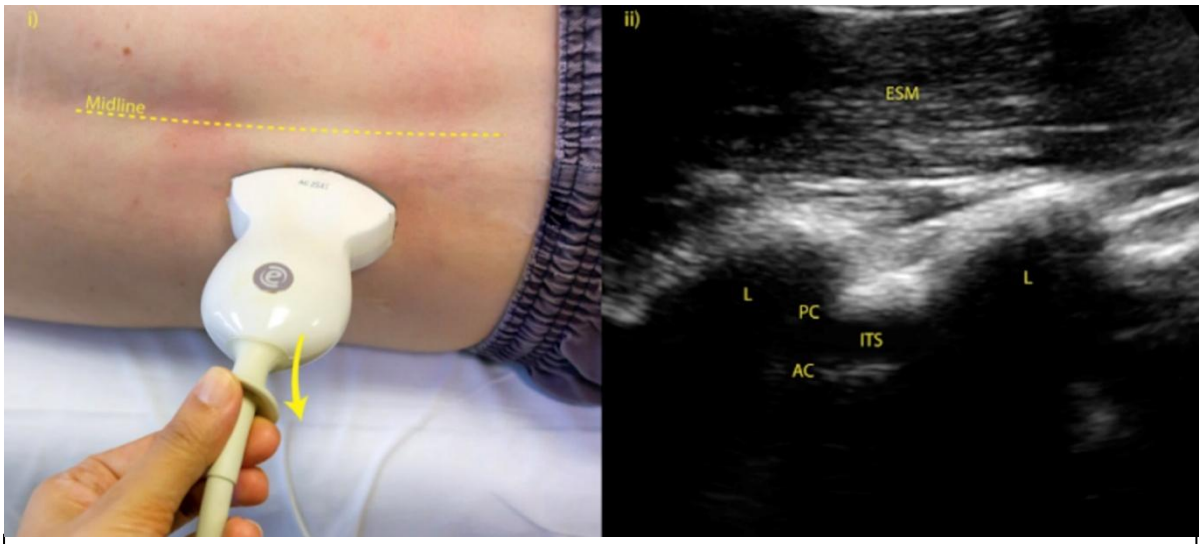

Figure 2.4 i) Tilting the tail of the probe inferiorly to visualise the oblique paramedian view. **ii)**

The articular processes now appear as a 'sawtooth' appearance which represent the laminae (L). The intrathecal space (ITS) is located between the posterior complex (PC) and anterior complex (AC). The erector spinae muscles (ESM) are located above. *Images from US for the Generalist, Clare S, Duncan C, ©. Reproduced with permission of the Licensor through PLSclear.*

At this point tilt the probe to point the probe towards the midline to obtain the oblique paramedian view. The 'camel humps' will appear as more of a 'sawtooth pattern' which represents this down sloping of the lamina into the interlaminar spaces. In this view you are able to identify the intrathecal space (ITS) (Figure 2.4). To identify the correct spinal level move the probe in the longitudinal orientation caudally until a flat, hyperechoic line appears, this represents the sacrum. From this view slowly move the probe cranially to identify each vertebrae (Figure 2.5).

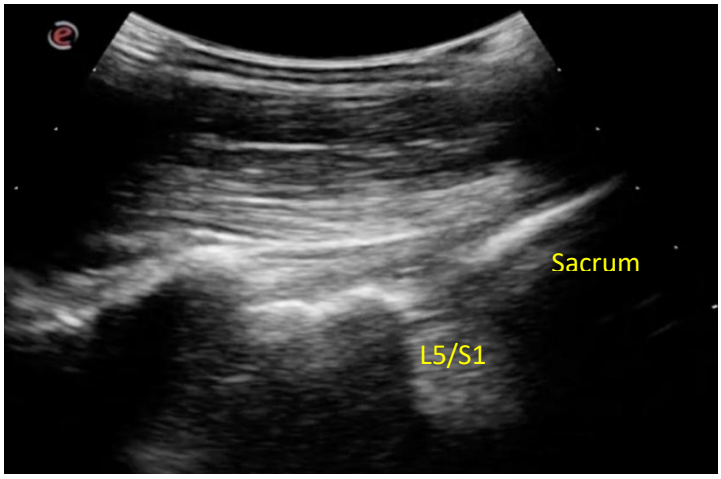

Figure 2.5 Probe moved caudally in the longitudinal orientation to reveal L5/S1 and the sacrum.
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To identify the spaces line up the midline of the US machine with the space between each vertebrae. Once the L3/4 and L4/5 levels are identified - mark on the skin at the midpoint of the probe.

Once the correct levels have been marked the midline can be identified. To do this, rotate the probe 90 degrees into a transverse orientation with the probe marker pointing to the right of the patient and place the probe back over the presumed midline see Figure 2.6 in sitting position and Figure 2.7i in lateral position. In this position the spinous processes will be visible (Figure 2.7 ii).

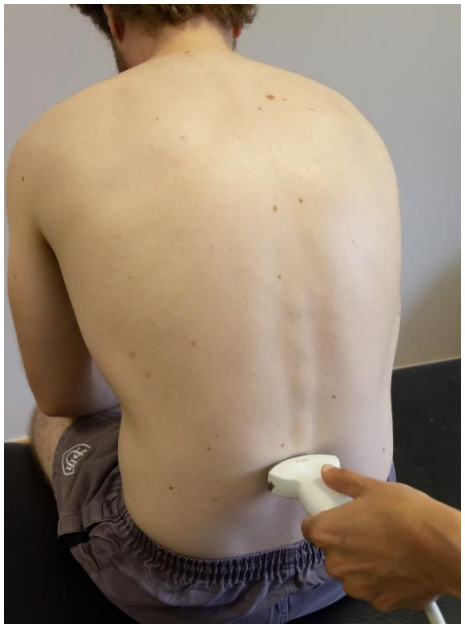

Figure 2.6 Probe in midline transverse orientation in sitting position. *Images from US for the Generalist, Clare S, Duncan C, ©. Reproduced with permission of the Licensor through PLSclear.*

Identify two spinal processes and line up with the centre of the probe. At these two points make a mark to identify the midline.

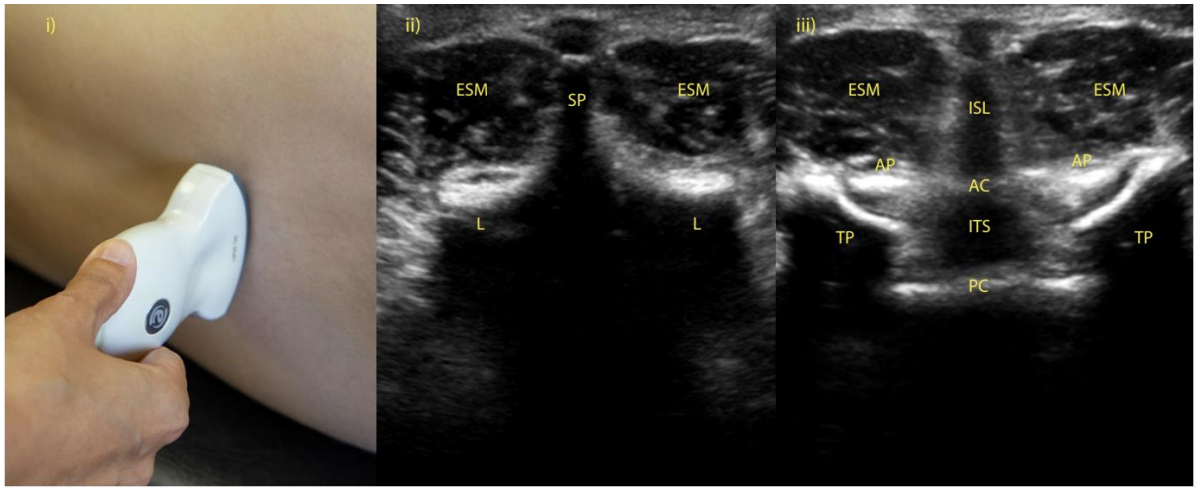

Figure 2.7 (i) Position of probe to reveal transverse spinous process and interspinous view. **(ii)** Spinous process view highlighting the post-acoustic shadowing of the laminae, erector spinae muscles are visible above. **(iii)** By tilting the probe the user can scan between the spinous processes to reveal the interspinous ligament, anterior complex, intrathecal space and posterior complex. The distance between the skin and intrathecal space can be measured in this view. *SP, spinous process; ESM, erector spinae muscle, L, Laminae; ISL, interspinous ligament; AP, articular process; AC, anterior complex; ITS, intrathecal space; PC, posterior complex; TP, transverse process.* *Images from US for the Generalist, Clare S, Duncan C, ©. Reproduced with permission of the Licensor through PLSclear.*

Once the spinal process has been identified it is possible to visualise the interspinous ligament (ISL) and intrathecal space (ITS). To do this obtain the interspinous view by making small tilting movements with the probe to visualise between the spinous processes (Figure 2.7iii). From this view you can estimate the needle depth to the ITS.

At this point there should be four marks on the patient – two for each level L3/4 and L4/5 and two midline points (marked in black in Figure 2.8). Connect the midline points to create a line along the patients' spine. Extend the marks made for L3/4 and L4/5 transversely until they intersect the midline. The point at which they intersect demarks where to insert your needle for the lumbar puncture (marked in red in Figure 2.8).

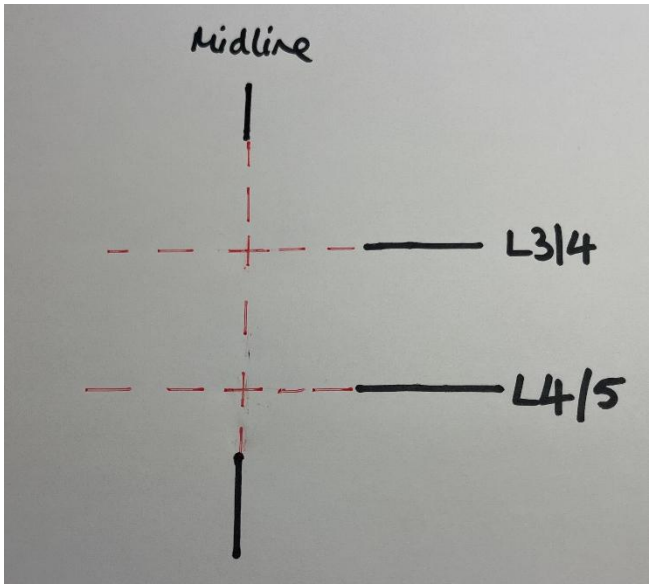

Figure 2.8. Illustration of markings made on skin highlighting the midline and spinal levels (black) and intersection to demark needle insertion (red).

You are now ready to proceed with the procedure following normal aseptic protocol. Needle insertion and re-direction should be guided by tactile feedback (contact with bone, 'feel' of the ligamentum flavum, loss of resistance, etc.) in the same manner to the conventional landmark-based technique.

Top tips to ensure success include:

- Marking and anaesthetising two interspace levels before performing standard aseptic technique for a lumbar puncture
- Ensure that the patient does not make significant movements in between skin marking and lumbar puncture needle entry

References

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