Ultrasound use in Anaesthesia

A workbook for anaesthetic trainees in North Queensland
2012

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Contents

Introduction

This workbook is designed for anaesthetic trainees in North Queensland. It is meant to provide a framework for learning basic ultrasound skills relevant for anaesthetic practice. Trainees are encouraged to progress through it at their own rate, completing modules in chronological order.

As a general guide we suggest trainees aim to complete modules at the following rate:
BTY 1 modules 1 to 12
BTY 2 modules 13 to 20
ATY 1 modules 21 to 31
ATY 2 complete all remaining modules
ATY 3 consolidate skills and practice with a lower level of supervision

Each module consists of **Essential Reading** which covers the minimum amount of information required to gain the most basic understanding of the module. **Recommended Reading** gives a more complete understanding of the topic and is the level that is recommended for trainees. **Further Reading** includes advanced concepts and greater detail and is for those who want to develop a special interest in ultrasound.

Exercises are included in most modules. These give the trainee practical experience and skills. The usefulness of ultrasound is very much operator dependent and to be effective requires a lot of hands-on training and experience. The exercises are designed to teach and improve these practical skills, before performing procedures on patients. These practical skills cannot be gained by reading alone.

Assessments are also included at key stages through the modules. These are designed to provide trainees with feedback on their progress and skill acquisition. Assessments will be used by consultants to know what level trainees have reached, so appropriate teaching, supervision, and procedural experience can be provided. Although trainees may perform any ultrasound guided procedure under the direct supervision of a consultant at any stage during their training, consultants may use their progress through these modules as a guide to their level of experience before allowing them to perform procedures on patients.

There is no requirement to complete any of this workbook for the ANZCA training program. It is merely provided for trainees who wish to learn techniques in ultrasound guided procedures in anaesthesia and is supported by the anaesthetic departments in North Queensland. Trainees who do not have an interest in ultrasound may acquire some experience in vascular access and regional anaesthesia using landmark and nerve stimulator techniques. Current trends in the anaesthetic departments of NQ suggest a shift towards image guided techniques.

Have fun, happy scanning.

Mark, M and Andy.

Disclaimer:

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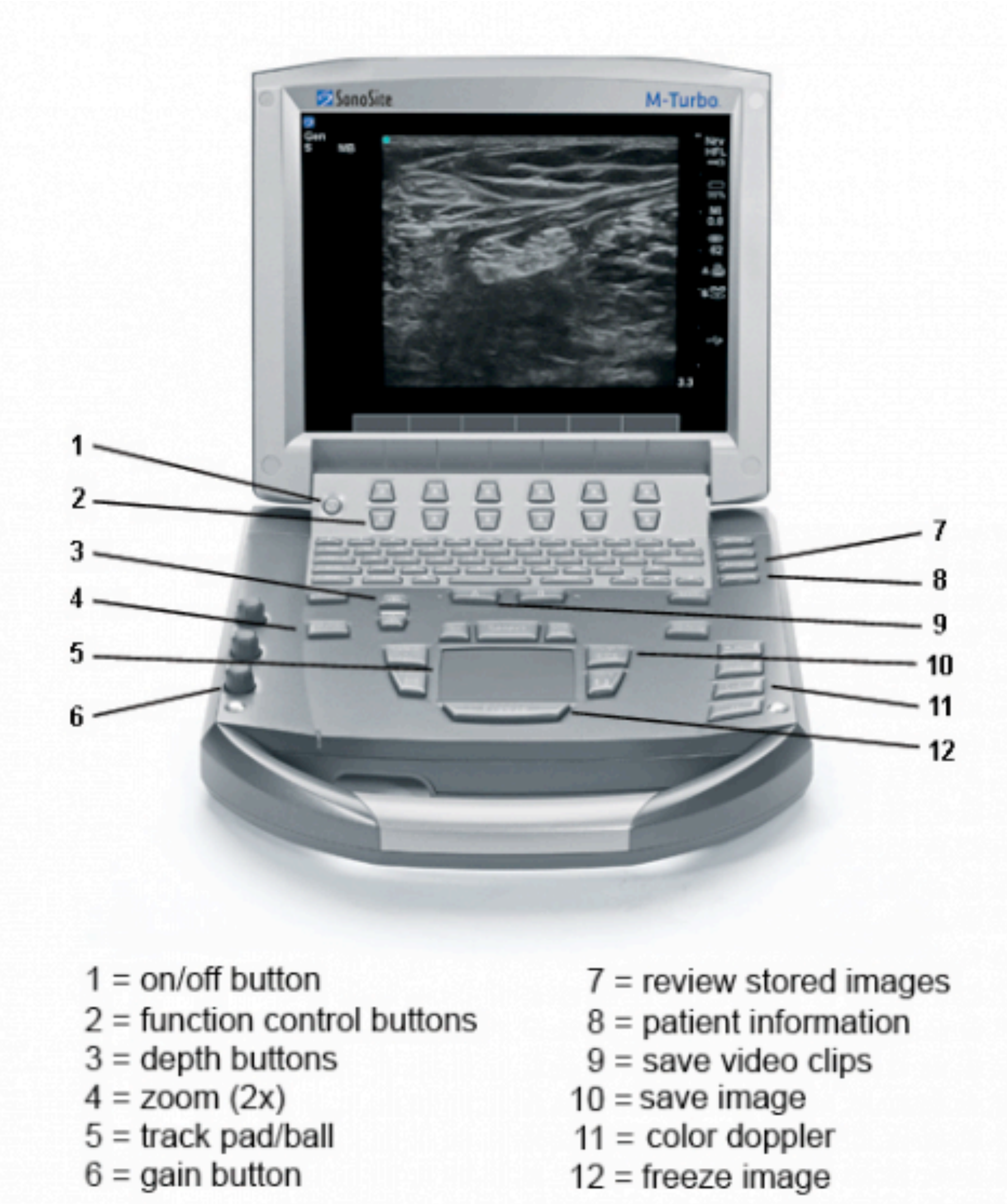
Module 1. Understanding Ultrasound

Essential Reading:

[Ultrasound for regional anaesthesia website – basic principles]

Recommended Reading:

Artifacts and Pitfall Errors Associated With Ultrasound-Guided Regional Anesthesia. Part I: Understanding the Basic Principles of Ultrasound Physics and Machine Operations. Brian D Sites, Richard Brull, Vincent W S Chan, Brian C Spence, John Gallagher, Michael L Beach, Vincent R Sites, Gregg S Hartman. Regional Anesthesia and Pain Medicine (2007) vol. 32 (5) pp. 412-8.



Module 2. Using the Sonosite

Essential Reading:

The best way to learn how to use the machine is to spend time using the machine under the guidance of an experienced mentor. We suggest you get a machine and work through the exercises below, preferably with a mentor guiding you, however you can easily work through them by yourself and still learn much about the essentials of using the machine.

Use the following guides to jog your memory:

- M-Turbo Quick User Guide - basic functions
- M-Turbo Quick User Guide - advanced functions
- M-Turbo Cheat Sheet
- S Series Quick User Guide

Further Reading:

Micromax User Manual
M-Turbo User Manual
S-Series User Manual

Essential Exercises:

(Note: button positions described refer to Micromax/M-Turbo)
15 mins

1. Turn machine on (push on/off button top left of keyboard)
2. Change presets
    a. Note preset indicator in top right of screen. Displays NRV, or VAS etc.
    b. Presets are factory software settings that optimise the machine for different types of scanning procedures.
    c. The “patient” button, (top right of keyboard) brings up data entry screen
    d. Scroll down exam type options
    e. Select nerve with “select” key above touch pad on M Turbo, below touch pad on Micromax.
    f. “done” soft key, (soft keys are those immediately under the screen, functions change and are indicated on the screen above the button).
    g. Note newly selected preset indicated on top right of screen
    h. On the M-Turbo only, the “Exam” button (top right of touchpad) also takes you to the presets menu.
    i. What presets are available on your machine?
3. Change probes
    a. Note current probe identified on top right of screen display eg. HFL (high frequency linear).
    b. What probes do you have available on your machine?
    c. Push button on triple transducer connect module that sits under machine. Light illuminates indicating which probe is currently selected. If you do not have a triple connect you will need to get someone to show you how to change probes by unplugging current probe from back of unit.
    d. Note the preset, depth, and other settings displayed in the right side margin of the screen will change to the default settings for the new probe.
    e. Note new probe indicated on top right of screen display eg. HFL, C60
4. Change frequency
    a. Probe frequency on the Sonosite is represented by the resolution, general and penetration settings. This is displayed on the top left of the screen as RES, GEN or PEN. Note current setting.
    b. Most of the probes we use on the Sonosite have multiple frequency settings, meaning we can change the frequency of the ultrasound beam emitted from the probe.
    c. Change the frequency by pushing the soft key at the left side of the screen that has RES, GEN or PEN above it (soft keys are those immediately under screen, functions change and are indicated on the screen above the button).
    d. Note the new setting displayed on the screen. RES (resolution) is the highest frequency setting, giving the best image resolution but limited depth penetration eg. 2-4cm. PEN (penetration) is the lowest frequency setting giving the best depth penetration but limited resolution. GEN (general) is an intermediate frequency between the two.
5. Change depth

a. Note the depth indicators down the right margin of the image display. These are dots with a cm indicator at the bottom of the margin.
b. Change depth by pushing the up arrow and down arrow depth keys located above and to the left of the touchpad.
c. Does the depth increase by pushing the up arrow or down arrow?
d. What is the minimum and maximum depth allowed?
e. What happens if you change probes? Does the min and max depth change?

6. Change gain
    a. Turn the near gain knob (left side of keyboard, top most of three knobs) until the machine beeps. Does the knob stop turning at the start and end of the near gain range? How do you know the start and end of the range? Watch the screen image change as you turn the near gain dial. What happens?
    b. Repeat above with the far gain knob (middle of three knobs). How does it differ from near gain?
    c. Repeat above with overall gain knob (lower of three knobs). How does it differ from above?
    d. Turn the overall gain up to maximum (machine beeps). Now push the "Auto Gain" key (just to the right of the gain knobs on the M Turbo, soft key immediately under middle of screen on Micromax). Note effect of auto gain (returns gain to what machine thinks is optimal gain).
    e. Gain makes the image brighter but will decrease resolution. Do not turn the gain up more than required especially if you are wanting the best resolution eg for nerve imaging. You will see more by turning the room lights down instead. For vessel imaging where the best resolution is not always required, you will be able to use more gain.
7. Freeze image
    a. The "freeze" button either above or below the touchpad (depending on whether you have an M Turbo or Micromax) will freeze the image on the screen
    b. You can return to live scanning by pushing the "freeze" button or the "2D" button on the bottom right of the keyboard.
8. Save image
    a. The "save" button right side of touchpad saves a still image to the internal storage. The number of images saved is displayed on a counter halfway down the right hand margin of the screen on the Micromax but not the M-Turbo. This number will increase by one each time you save an image.
    b. The "review" button, top right of keyboard, will display the saved images. After pushing "review" the number of images saved is now displayed in the bottom left of the screen e.g. 1/3 means image one of three is currently displayed. Images can be scrolled through by pushing the soft key button under this displayed image counter.
9. Save clip
    a. This is not available on the Micromax
    b. While scanning push the "clip" key to right of touchpad. What happens depends how "clips" have been set up on your machine. Usually we have the machine save a retrospective clip of up to 60 secs to the internal storage. To

review the clip you push “review” and scroll through saved images as per 8b above. For clips the “play” button is the second soft key under the screen.
    c. To return to imaging push the “done” soft key.

10. Export images and clips to USB
    a. This is not available on the Micromax.
    b. You must first end the patient exam before you can export it. Push “Patient” then “end”.
    c. Insert USB storage device into the port on the right side of the machine.
    d. Push “Review” then the “list” soft key to bring up the list of patients with saved images.
    e. Select the patient you want and push the “Exp.USB” soft key. Select the USB device, and then select Export.
    f. Return to imaging via the “Done” soft key.

<u>The following refer to the S-Nerve:</u>
(Note: button positions described refer to S-Nerve)
15 mins

1. Turn machine on (push on/off button top left)
2. Change presets
    a. Note preset indicator in top right of screen. Displays NRV, or VAS etc.
    b. Presets are factory software settings that optimise the machine for different types of scanning procedures.
    c. The “patient” button, (top left of on screen menu) brings up data entry screen
    d. Scroll down exam type options
    e. Select nerve with “select” key below touch pad.
    f. The “done” key returns to live scanning.
    g. Note newly selected preset indicated on top right of screen
    h. The “Options” button (bottom right on screen menu) and then “Exam” also takes you to the presets menu.
    i. What presets are available on your machine?
3. Change probes
    a. Note current probe identified on top right of screen display eg. L25
    b. What probes do you have available on your machine?
    c. Probes are changed manually on the S-Nerve, as it is not compatible with the triple transducer connect.
    d. Note the preset, depth, and other settings displayed in the right side margin of the screen will change to the default settings for the new probe.
    e. Note new probe indicated on top right of screen display eg. HFL, C60
4. Change frequency
    a. Probe frequency on the Sonosite is represented by the resolution, general and penetration settings. This is displayed on the top left of the screen as RES, GEN or PEN. Note current setting.

b. Most of the probes we use on the Sonosite have multiple frequency settings, meaning we can change the frequency of the ultrasound beam emitted from the probe.
c. Change the frequency by pushing the “RES”,”GEN”,”PEN” key at the left side of the screen.
d. Note the new setting displayed on the screen. RES (resolution) is the highest frequency setting, giving the best image resolution but limited depth penetration eg. 2-4cm. PEN (penetration) is the lowest frequency setting giving the best depth penetration but limited resolution. GEN (general) is an intermediate frequency between the two.

5. Change depth
    a. Note the depth indicators down the right margin of the image display. These are dots with a cm indicator at the bottom of the margin.
    b. Change depth by turning the “Depth” knob on the bottom left of screen.
    c. What is the minimum and maximum depth allowed?
    d. What happens if you change probes? Does the min and max depth change?
6. Change gain
    a. Turn the gain knob (bottom left side of screen). What happens to the image? Pushing the knob toggles between “overall gain”, “near gain”, and “far gain”. Increase and decrease each of these and observe effect on image.
    b. Turn the overall gain up to maximum (machine beeps). Now push the “Auto Gain” key (top left of on screen menu). Note effect of auto gain (returns gain to what machine thinks is optimal gain).
    c. Gain makes the image brighter but will decrease resolution. Do not turn the gain up more than required especially if you are wanting the best resolution eg for nerve imaging. You will see more by turning the room lights down instead. For vessel imaging where the best resolution is not always required, you will be able to use more gain.
7. Freeze image
    a. The “freeze” button (middle bottom) will freeze the image on the screen
    b. You can return to live scanning by pushing the “unfreeze” button or the “2D” button on the bottom right of the on screen menu.
8. Save image
    a. The “save” button (bottom mid on screen menu) saves a still image to the internal storage.
    b. The “patient” button, then “review”, will display the saved images. After pushing “review” the number of images saved is now displayed in the bottom left of the screen e.g. 1/3 means image one of three is currently displayed. Images can be scrolled through by turning the knob under this displayed image counter.
9. Save clip

    a. While scanning push the “clip” key (left on screen menu) . What happens depends how “clips” have been set up on your machine. The S-Nerve only saves prospective clips up to 60 seconds. To review the clip you push “patient”

then "review" and scroll through saved images as per 8b above. For clips the "play" button is on the bottom on screen menu.
   b. To return to imaging push the "done" key.

10. Export images and clips to USB
    a. You must first end the patient exam before you can export it. Push "Patient" then "End".
    b. Insert USB storage device into the port on the right side of the machine.
    c. Push "Patient" or "Options" then "Review" then the "list" key to bring up the list of patients with saved images.
    d. Select the patient you want and push the "Exp.USB" key. Select the USB device, and then select Export.
    e. Return to imaging via the "Done" soft key.

Recommended Exercises:

15 mins, subject or phantom, USB memory stick required.

1. Turn machine on, apply gel to probe, apply probe to subjects forearm or phantom.
2. Change preset from nerve to vascular and note any image change of vessels and nerves.
3. Change probe and note any image change.
4. Change frequency and note resolution change in superficial and deep zones.
5. Change depth from min to max and note effect on image.
6. Change near gain, far gain, overall gain, and return to auto gain setting by pushing auto gain. Turn down room lights and note effect on gain required.
7. Freeze image
8. Save image
9. Playback image
10. Save image to USB storage
11. Review images on a computer

Module 3. Using Other Machines

Essential Reading:

The principles of using an ultrasound machine are similar regardless of machine. Different machines have different control layouts, sometimes different names for the same functions, and different features. Currently mainly Sonosite machines are used in our departments, hence this guide features those machines only.

Recommended Reading:

Ultrasound for regional anaesthesia website - Ultrasound Equipment - Machine

Module 4. Obtaining and Optimising an Image

Essential Reading:

To obtain the image you want, you need to:

- Position subject, machine and yourself comfortably and ergonomically. This usually means sitting with your subject in front of you and the ultrasound machine on the other side of your subject or somewhere that you do not have to turn your head around to see the screen. Dim the room lights.
- Turn on machine, select probe, preset, frequency and depth.
- Apply gel to probe or subject and place probe over area of interest.
- Adjust gain
- Manipulate probe by applying pressure, sliding, rotating and tilting. A relaxed grip on the probe avoids fatigue and allows subtle movements. Hold the probe low near the probe head and rest the ulna side of your hand on the patient.
- Further adjust depth, frequency and gain if required.

Optimising the image means adjusting the machine settings and, more importantly, manipulating the probe to obtain the best possible image quality. Your ability to do this improves with scanning experience. Start by working through the exercises below and then spend as much time scanning as you can and your skills will rapidly improve.

Practical Knobology for Ultrasound-Guided Regional Anesthesia. Richard Brull, Alan J R Macfarlane, Cyrus C H Tse. Regional Anesthesia and Pain Medicine (2010) vol. 35 (2 Suppl) pp. S68-73

Recommended Reading:

Ultrasound for regional anaesthesia website – scanning technique

Essential Exercises:

Exercise 1: Obtain an image of the median nerve mid forearm. To optimise the image work through the following steps (20 mins, subject required):

1. Preset: are you in the nerve preset?
2. Probe: do you have the highest frequency linear probe?
3. Frequency: are you on the RES (resolution) setting?
4. Depth: is the nerve in the middle to lower third of the displayed depth on the screen?
5. Contact: do you have enough gel between probe and skin?

6. Gain: use auto gain to set gain to what the machine thinks is optimal, then adjust near, far and overall gain to make the image appear:
    i. Equally bright in the far field as the near field.
    ii. Overall brightness just enough for you to clearly see structures (too much gain will decrease resolution of structures and increase artefacts).
    iii. Turn down room lights.
7. Probe position: manipulate the probe (slide, tilt, rotate, change pressure) to:
    i. centre the nerve on the screen,
    ii. image it at 90 degrees to the direction of the nerve (anisotropy will make the nerve more or less bright with probe tilt),
    iii. image it in cross section, as compared to obliquely (make it a clearly defined round structure)
    iv. increased probe pressure brings the probe closer to the nerve and can improve image (especially for deeper structures).

<u>Exercise 2:</u> Obtain an image of the sciatic nerve mid posterior thigh. To optimise the image work through the same steps as above (20 mins, subject preferred):

1. Preset: are you in the nerve preset?
2. Probe: do you have a lower frequency linear probe? Otherwise the curvilinear probe? If not use the high frequency linear probe.
3. Frequency: are you on the RES (resolution) setting? Try lowering the frequency to the GEN (general) or even PEN (penetration) settings.
4. Depth: is the nerve in the middle of the displayed depth on the screen?
5. Contact: do you have enough gel between probe and skin?
6. Gain: use auto gain to set gain to what the machine thinks is optimal, then adjust near, far and overall gain to make the image appear:
    i. Equally bright in the far field as the near field. For deeper scanning far gain often needs to be increased a little.
    ii. Overall brightness just enough for you to clearly see structures (too much gain will decrease resolution of structures)
    iii. Turn down room lights.
7. Probe position: manipulate the probe (slide, tilt, rotate, change pressure) to:
    i. centre the nerve on the screen,
    ii. image it at 90 degrees to direction of nerve (anisotropy will make the nerve more or less bright with probe tilt). The sciatic nerve is particularly anisotropic.
    iii. image it in cross section, as compared to obliquely (make it a clearly defined round structure),
    iv. increased probe pressure brings the probe closer to the nerve and can improve image (especially for deeper structures like this nerve).

Work through these steps several times so they become very familiar to you. You should be able to quickly optimise your image every time you scan a structure. Note that once you have optimised your image, if you change any parameter (e.g. frequency or depth) you will have to quickly check all other parameters as they may need adjusting to optimise the new image.

Module 5. Probe Manipulation

Essential Reading:

You will have discovered by now that there is a lot more to probe manipulation than you may have anticipated. Certainly it is the most important part of image acquisition and optimisation. The best way to learn how to manipulate the probe is to trace the course of nerves up and down limbs. To maintain a quality image of the nerve as it changes course and depth, the probe requires constant manipulation. The nerve tracing exercises below are very challenging and require a lot of practise to master. Are you up to the nerve tracing challenge???
Rotating the probe to change from short axis views to long axis views also requires substantial practise and teaches a lot about probe manipulation.

Recommended Reading:

Transducers

Transducer Handling

Essential Exercises:

20 mins, subject preferred

1. Obtain and optimise an image of the median nerve mid forearm.
    a. Trace the nerve from wrist to antecubital fossa. Continually optimise your image as you move the probe along the nerve. Probe position is the parameter that will need the most adjusting, depth, contact with gel, and gain will also need fine-tuning. You should find the nerve easy to image from wrist to just below antecubital fossa. At this point it dives deeper then returns to very superficial at the antecubital fossa. A lot of probe manipulation is required to maintain an image of the nerve (especially pressure to shorten the distance between probe and nerve, and tilting to image the nerve at 90 degrees as it dramatically changes direction from descending to ascending, anisotropy will be obvious). Change depth and gain as required and ensure adequate gel.

2. Obtain and optimise an image of the sciatic nerve mid posterior thigh.
    a. Trace the nerve from popliteal fossa to sub-gluteal crease. Continually optimise your image as you move the probe along the nerve. Probe position is the parameter that will need the most adjusting, depth, contact with gel, frequency and gain will also need fine-tuning. You should find the nerve relatively easy to image about 10cm above the popliteal fossa. As you trace it distally it divides into posterior tibial nerve and common peroneal nerve. You should see this division. The posterior tibial nerve moves superficial and sits superficial and slightly lateral to the popliteal vessels at the level of the

popliteal crease. The common peroneal nerve moves lateral and superficial towards the neck of the fibula. As you trace the nerve proximally in the thigh it gets deeper and flatter. It is very anisotropic. You should be able to trace it to the sub-gluteal crease. You will need to continually optimise the image as above as you trace the nerve through different depths and angles. Change probes, frequency, depth and gain to try to improve your image. Manipulate the probe with variable pressure, tilting, sliding, rotating, and keeping good contact with adequate gel. You should come to realise that probe manipulation is a very sensitive parameter that requires fine control, and has a greater effect on image optimisation than machine adjustments. Probe manipulation improves with experience and practice so if you have free time in theatre practice these nerve tracing exercises whenever you can.

3. Obtain and optimise an image of the median nerve mid forearm
    a. Rotate the probe through 90 degrees to change the image of the nerve from short axis to long axis. Do this rotation very slowly always keeping the nerve in the centre of the image. Some people find it easier to use one hand to stabilise the probe over the nerve and the other hand to rotate the probe.
    b. Do the same over the radial artery distal forearm. Image in short axis then rotate the probe to image in long axis. Always keep the vessel in the centre of your image as you do this.

Recommended Exercises:

20 mins, subject preferred

1. Trace the median, and ulnar nerves the full length of the arm from axilla to wrist. This will really enhance your probe manipulation skills.
2. Image the sciatic nerve in long axis.

Module 6. Artefacts

Essential Reading:

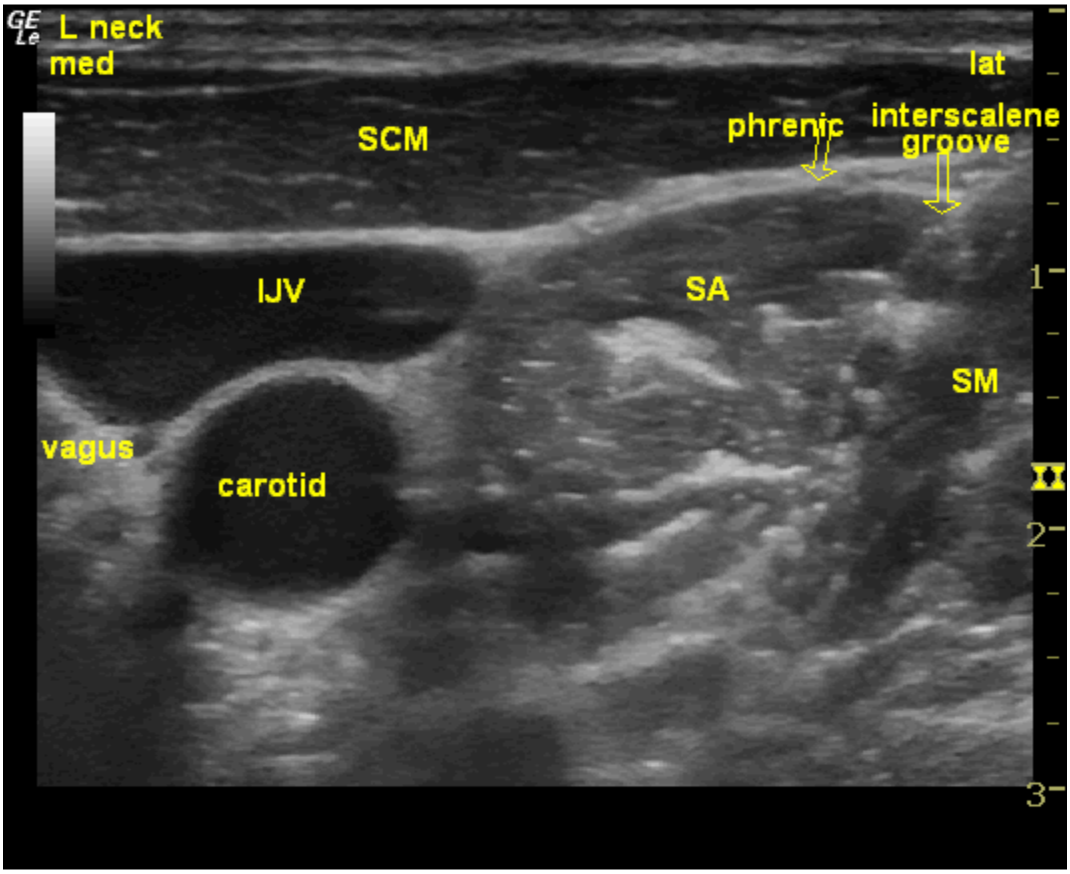
Artifacts and Pitfall Errors Associated With Ultrasound-Guided Regional Anesthesia. Part II: A Pictorial Approach to Understanding and Avoidance. Brian D Sites, Richard Brull, Vincent W S Chan, Brian C Spence, John Gallagher, Michael L Beach, Vincent R Sites, Sherif Abbas, Gregg S Hartman. Regional Anesthesia and Pain Medicine (2007) vol. 32 (5) pp. 419-33

Essential Exercises:

20 mins

1. **Lack of contact**: apply gel to one end of the probe only. Place probe with incomplete gel on your forearm. You will see only half the screen shows an image while half the screen remains black. This is drop out due to lack of contact between probe and skin. As well as inadequate gel this is seen when a long probe is used on a small limb such that only half the probe makes contact, when an air bubble is in the gel between probe and skin, when scanning over bony protuberances eg clavicle or malleoli, and when needle insertion pushes the skin away from the probe.
2. **Shadows**: As the ultrasound beam does not penetrate dense structures a black shadow is cast behind the structure and no image is displayed. This is commonly seen behind bone or needles. Place the probe over your ribs, tibia, clavicle or other superficial bone and note the bright white (hyperechoic) appearance of the superficial cortex due to strong reflection of ultrasound waves and then the black shadow behind where no ultrasound waves penetrate so no image is displayed. When a needle is inserted out of plane to the probe a similar effect is observed. The needle appears as a white dot with a black shadow below it. It is important to understand that the black shadow is not the needle. The shadow can however, help "point" to where the needle is. The appearance of structures below needles can also be obscured by this shadow.
3. **Post Cystic Enhancement**: Image your carotid, brachial or popliteal vessels. You will notice the area immediately deep to the artery appears brighter than surrounding tissue. This is due to the low attenuation of the ultrasound waves as they pass through fluid as compared to surrounding tissue. Consequently more ultrasound energy reaches the tissue immediately posterior to the vessel, hence more is reflected back to the probe than the surrounding tissues. This results in the tissues immediately deep to fluid filled structures appearing brighter than surrounding tissues. This can easily be misinterpreted as nerve structures. The margins of the enhancement are usually sharply defined and parallel for linear transducers or divergent for curvilinear transducers. There is also commonly an edge shadow which is seen deep to the edges of round fluid filled structures due to a combination of reflection and refraction occurring at the edge of the rounded structure. The identification of the posterior cord in the infraclavicular area is notoriously difficult because of this.

4. **Anisotropy**: Image the median nerve in the forearm. Tilting the probe can make the nerve appearance change from hyperechoic and easily seen to hypoechoic and poorly seen. This is due to changing amounts of reflected ultrasound waves with changing angle of incidence. All nerves and tendons, and sometimes muscles, display this effect. The sciatic nerve is particularly anisotropic.
5. **Doppler at 90 degrees**: Image the radial artery in the distal forearm. Turn on colour Doppler. Note that the artery shows red or blue pulsing colour depending on the tilt of the probe, towards or away from the direction of flow. If the probe is at 90 degrees to the direction of flow no colour will be seen. This artefact can mislead you into thinking there is no flow in a vessel or that a vessel may be a nerve.



Transverse scan of neck vessels showing post cystic enhancement

Module 7. Colour Doppler, Power Doppler, and Spectral Doppler.

Essential Reading:

The Doppler effect can be used in our ultrasound applications to show blood flow in vessels. A well known example of this effect is demonstrated when an ambulance siren comes toward you the pitch is higher than when it passes you and moves away from you and the pitch is lower.
The frequency of the ultrasound wave emitted by the transducer changes when it reflects off a moving object i.e. red blood cell. If blood is moving towards the transducer, the received frequency will be higher than the transmitted frequency. Conversely, if the blood is moving away from the transducer the received frequency will be lower than initially transmitted.
It is important to note that if the blood is travelling at 90 degrees to the transducer there will be no frequency change, i.e. the transmitted frequency and the received frequency will be the same, hence no Doppler effect.

Colour Doppler displays this frequency shifts as colour overlaid on the B-mode image (the usual image we use – Brightness mode). Usually flow towards the probe is displayed as red while flow away from the probe is displayed as blue. This can vary with machines and settings. Colour Doppler gives us quick and easy qualitative information on the existence of flow, the direction of flow and the existence of turbulence. It is the most commonly used Doppler mode for simple vascular access procedures.

Power Doppler is much more sensitive to low flow rates and flows at 90 degrees to the transducer compared to colour Doppler. However it does not give information on direction of flow or turbulence as only one colour is displayed. In regional anaesthesia power Doppler is the most useful Doppler modality because it is the most sensitive in identifying the presence of vessels.

Spectral Doppler can give more quantitative information about velocity of flow. It is displayed as a separate graphical waveform display similar to an M-mode image. It can be used to definitively differentiate between arterial and venous flow and to measure velocities. It is not usually required for regional anaesthesia but may be useful for some vascular access procedures. This is not available on current Micromax, M-Turbo and S-Nerve machines in our departments.

Once any Doppler modality is selected there is a significant reduction in image resolution due to the increased processing the machine is required to perform. Therefore always confirm anatomy first, and then use Doppler to identify vessels, then ensure you turn Doppler off to perform your procedure.

Recommended Reading:

Doppler sonography - Wikipedia

Exercises:

15 mins

1. **For Micromax and M-Turbo:**
    1. **Colour Doppler:** The "colour" button (bottom right of keyboard) turns on colour Doppler. You will notice a region of interest (ROI) box appears on the screen and a colour indicator bar appears in the top left of the screen.
    2. **Power Doppler:** After turning on colour Doppler as above you will see the "colour" soft key (bottom left of screen) appear. This button toggles between colour Doppler and power Doppler (CPD).
    3. **ROI box:** Use the touchpad to move the ROI box around the screen. Pressing the "select" button under the touchpad will toggle between moving the ROI box and changing its size. Reducing the width and the lowest depth of the box to only what is required will optimise the frame rate, improving image quality.
    4. **Flow sensitivity:** The next soft key to the colour/CPD is the flow sensitivity. Selecting "low" will optimise the settings to detect low flow rates such as those in veins and small arteries.
    5. **PRF Scale:** This is the next soft key. Pulse Repetition Frequency (PRF or Scale) determines the sampling time between emitted ultrasound pulses that is required to process the Doppler information. Low flow must be sampled for a longer period of time so it is best to select a low or medium PRF when looking for low flow such as veins and small arteries.
    6. **Invert:** reverses the colour such that flow towards the probe can be displayed as red or blue.
    7. **Steering:** This is also available from the on screen menu. Steering allows you to improve the angle of incidence of the ultrasound beam to the direction of flow thus improving the Doppler signal. This is not useful when imaging vessels in short axis when tilting the probe easily improves the angle. However when imaging vessels in long axis tilting the probe is not so practical and steering can be very beneficial.
    8. **Wall Filter:** This next soft key filters out Doppler signals generated by movement of the vessel wall with each pulsation. While quite useful in diagnostic scanning it is not so important to anaesthetists as we usually just want to know if flow is present in a vessel and if it is arterial or venous. If this is set too high you may filter out low flow signals such as flow in veins and small arteries. It is therefore important to have this set to low when looking for flow in small peripheral vessels. It then becomes important to minimise tissue movement by careful transducer and hand movements otherwise excessive colour will appear in the tissues.
    9. **Gain:** The gain knob (lower left keyboard) controls colour amplification when in Doppler mode and should be adjusted by turning it up until colour starts to appear in the tissues surrounding the vessel then turning it down until this colour just disappears leaving colour in the vessel only.

2. For S-Nerve:

1. **Colour Doppler:** The “colour” button (bottom right) turns on colour Doppler. You will notice a region of interest (ROI) box appears on the screen and a colour indicator bar appears in the top left of the screen.
2. **Power Doppler:** After turning on colour Doppler as above you can scroll down the left side menu to “CPD”. This button toggles between colour Doppler and power Doppler (CPD).
3. **ROI box:** Use the touchpad to move the ROI box around the screen. Pressing the “select” button under the touchpad will toggle between moving the ROI box and changing its size. Reducing the width and the lowest depth of the box to only what is required will optimise the frame rate, improving image quality.
4. **Flow sensitivity:** Scrolling through the on screen menus on the left side of the screen will reveal a button that toggles between “Low”, “Med”, or “High”. This is the flow sensitivity. Selecting “low” will optimise the settings to detect low flow rates such as those in veins and small arteries.
5. **PRF Scale:** This is also on the left on screen menu. Pushing this button activates one of the knobs under the screen to allow fine adjustments of the PRF. The available PRF scale settings depend on the flow sensitivity setting (see 4 above). Pulse Repetition Frequency (PRF or Scale) determines the sampling time between emitted ultrasound pulses that is required to process the Doppler information. Low flow must be sampled for a longer period of time so it is best to select a low or medium PRF when looking for low flow such as veins and small arteries.
6. **Invert:** reverses the colour such that flow towards the probe can be displayed as red or blue.
7. **Steering:** This is also available from the on screen menu. Steering allows you to improve the angle of incidence of the ultrasound beam to the direction of flow thus improving the Doppler signal. This is not useful when imaging vessels in short axis when tilting the probe easily improves the angle. However when imaging vessels in long axis tilting the probe is not so practical and steering can be very beneficial.
8. **Wall Filter:** This filters out Doppler signals generated by movement of the vessel wall with each pulsation. While quite useful in diagnostic scanning it is not so important to anaesthetists as we usually just want to know if flow is present in a vessel and if it is arterial or venous. If this is set too high you may filter out low flow signals such as flow in veins and small arteries. It is therefore important to have this set to low when looking for flow in small peripheral vessels. It then becomes important to minimise tissue movement by careful transducer and hand movements otherwise excessive colour will appear in the tissues. This control is the “WF” button on the left on screen menu. It toggles between low med and high.
9. **Gain:** The gain knob (lower left of screen) controls colour amplification when in Doppler mode and should be adjusted by turning it up until colour starts to appear in the tissues surrounding the vessel then turning it down until this colour just disappears leaving colour in the vessel only.

Module 8. Imaging Vessels

Essential Reading:

Blood vessels are probably the easiest structure to image and the first structures we learn to recognise with sonography. Blood vessels appear as hypoechoic (dark) round structures. Arteries are generally thicker walled, rounder, pulsatile and non-compressible. Veins tend to be thinner walled, more oval shaped, not pulsatile and easily compressible with probe pressure.

Nerves targeted in regional anaesthesia are often accompanied by vessels. As the vessels are more easily identified than the nerves they are commonly used as the landmarks to direct us to the nerves. Nerves can also appear as hypoechoic round structures eg interscalene brachial plexus. It is therefore essential to develop skills in identifying vessels and differentiating them from nerves.

Imaging vessels confidently is also required for ultrasound guided vascular access. Using colour Doppler or power Doppler can confirm blood flow in the vessel. Spectral Doppler should be used to definitively differentiate artery from vein.

Skills in imaging vessels are easily gained by spending time scanning vessels and using the Doppler functions of your machine.

Exercises:

1. Select the vascular preset.
2. Image the brachial vessels in your antecubital fossa. Identify artery and veins by their appearance and response to probe pressure. (remember to optimise each image with probe, contact, depth, frequency, gain etc.)
3. Turn on **colour Doppler** . First notice the overall degradation of image quality when Doppler is on. We therefore only turn Doppler on when required and turn it off before proceeding with the scan or procedure. Position the region of interest box over the vessels by using the touchpad. You will see blue or red colour in the vessels indicating blood flow and direction relative to probe. Tilt the probe to angle the beam towards or away from the direction of blood flow. You will see the colour in the vessels change from red to blue and back depending on the tilt of the probe i.e. red indicating flow towards the probe, blue indicating flow away from the probe. Turn off colour Doppler by pushing the “colour” button again or the “2D” button (which returns to 2D scanning).
4. Image the same vessels with power Doppler. If you cannot get colour to show in the veins compressing the forearm distal to the veins being imaged will cause a large pulse of flow in the vein.

5. Image your radial artery at your wrist with colour and power Doppler. Image small veins on your forearm. You will notice you need very light probe pressure to avoid compressing superficial veins. A large cushion of gel allows no probe pressure, and even “floating” of the probe off the skin. As the vessels get smaller and flow rates slower it is important to use power Doppler and optimise the Doppler settings of flow sensitivity, PRF scale, steering, wall filter and gain as described in module 7.
6. Rotate the probe through 90 degrees and image the vessels in long axis. Use steering to tilt the ROI box and improve the Doppler angle.
7. Imaging large central veins such as jugular and subclavian may reveal valves. Try to find some of these.
8. Image your popliteal vessels. Optimise your image. Turn on colour Doppler. Move the ROI box over the vessels and adjust the width and depth of the box to only what is required.
9. Tilt the probe towards and away from the direction of flow. Make the pulsing artery appear red and then blue.
10. Adjust gain as described above
11. Image flow in the vein. You may need to lighten pressure on the probe to ensure you are not compressing the vein. Squeezing the calf muscle will dramatically increase flow through the vein.
12. Image your posterior tibial artery behind your medial malleolus. Confirm it has flow by using power Doppler. Trace it above the medial malleolus, rotate the probe 90 degrees and image the vessel in long axis. Steer the ROI box to optimise Doppler angle. Check other Doppler settings and adjust gain.
13. Trace arteries and veins up and down your forearm.

Module 9. Imaging Nerves

Essential Reading:

The sonographic appearance of nerves is quite variable. In general nerves appear as a rounded structure with a hyperechoic outer perimeter and a mixed hyper/hypoechoic internal structure often described as “honeycomb” appearance. The hyperechoic appearance is thought to represent the connective tissue component of the nerve i.e. outer epineurium, and internal perineurium. The hypoechoic appearance is thought to represent the neural component of the nerve i.e. axons grouped in fascicles. Nerves very close to the spinal cord often appear mostly hypoechoic e.g. interscalene nerve roots . This is thought to be because the nerve roots are mostly nerve axons with little connective tissue inside the root i.e. mono-fascicular. As the nerves travels away from the spinal cord their axons group into an increasing number of fascicles with more connective tissue making up the structure of the nerve. This results in the classic “honeycomb” appearance e.g. median nerve. Sometimes a very small nerve may consist of a single fascicle only and may therefore once again appear as a predominantly hypoechoic round structure with a hyperechoic boarder, e.g. digital nerves.

Nerves exhibit a sonographic property called anisotropy. This means the appearance of the nerve is very dependent on the angle of incidence with the ultrasound beam. When you image a nerve you will find tilting the probe back and forward along the long axis of the nerve makes the nerve appear more or less bright. Sometimes the nerve even appears to disappear. The image is the best when the angle of incidence is 90 degrees or perpendicular to the nerve. The sciatic nerve is particularly anisotropic. If you can picture in your head the direction the nerve is travelling it makes it easier to know which way to tilt the probe to make the nerves more visible. The median nerve just distal to the antecubital fossa travels from superficial to deep requiring significant tilting of the probe.

The sonographic appearance of nerves is almost indistinguishable from tendons. Although with very high resolution machines and much experience it is possible to sometimes distinguish them on still images this is not generally possible in our practise. We therefore rely on tracing the structure along its length to see if it continues looking like a nerve and courses where we expect the nerve to run.

When you trace a tendon along its length you will find in one direction it gives off lots of muscle fibres until it is no longer a recognisable structure, and in the other direction it often ends at a bony insertion. Obviously good anatomical knowledge will help you by knowing where you expect to find the nerves and what tendons may also be in the area. Confirming a structure is a nerve is therefore a dynamic process requiring tracing the nerve along its path. Do not expect to confidently identify a nerve on a single image.

Further Reading:

Echo-texture of peripheral nerves: correlation between US and histologic findings and criteria to differentiate tendons. E Silvestri, C Martinoli, LE Derchi, M Bertolotto, M Chiaramondia, I Rosenberg. Radiology (1995) vol. 197 (1) pp. 291

Exercises:

15 mins

1. Image your interscalene brachial plexus. Note the hypoechoic circles of the nerve roots. Use colour Doppler to ensure what you are looking at are not vessels. Trace the nerve roots distally down to your supraclavicular area. Note the changing appearance of the brachial plexus as it divides. In the supraclavicular area use colour Doppler to identify vessels that commonly run around the plexus.
2. Image the medial and ulnar nerves in your forearm. Note the typical honeycomb appearance of the nerves at this level. Rotate the probe 90 degrees on the nerve to change from a short axis view to a long axis view. Keep the nerve on the screen at all times during this manoeuvre. You may find it easier to hold the probe on the nerve with one hand while rotating the probe with the other hand. This requires significant practise.
3. Tilt the probe when you have a nerve imaged in short axis and note the anisotropy. Knowing that the median nerve courses from superficial to deep just distal to the antecubital fossa allows you to tilt the probe appropriately trying to keep the angle of incidence as close as possible to 90 degrees to aid imaging.
4. Place the probe over the carpel tunnel. You will not be able to confidently identify nerve from tendons. Trace the structures proximally until you can identify which are tendons and which is the median nerve. Moving the tendons by flexing the fingers can also help.
5. Image your lateral popliteal fossa. Trace the nerve looking structures proximally until you can identify tendons from tibial and sciatic nerves.

Module 10. Imaging Other Structures

Essential Reading:

Bone is commonly imaged during anaesthetic applications. Because bone is much denser then surrounding soft tissues it acts as a strong reflector of ultrasound waves. Bone typically appears as a hyperechoic (bright white) line representing the bone cortex with underlying hypoechoic shadowing due to lack of penetration of the ultrasound waves. Consequently structures deep to the bone will not be seen. Manipulating the probe to direct the ultrasound beam around bony prominences is sometimes required to "see" structures through "bony windows" e.g. spinal imaging.

Lymph nodes are most commonly seen in the subcutaneous tissues of the groin, axilla and neck. They appear as discrete rounded or kidney shaped structures with a hypoechoic cortex and hyperechoic hilum. On a single image they may be confused with nerves but if you attempt to trace the course of the structure you will see the lymph node is a discrete structure while the nerve is a continuous structure.

Pleura appears as a linear hyperechoic structure that "slides" during ventilation. The "sliding sign" is generated by the visceral and parietal pleura sliding over each other with lung expansion and contraction. Deep to pleura, lung is not usually visualised due to ultrasound waves not being transmitted through air. Instead artefacts such as "comet tails" are seen indicating normal lung.

Peritoneum appears very similar to pleura. It usually appears as a thin hyperechoic layer that may slides on itself with ventilation. Deep to the peritoneum various visceral organs are seen to move with ventilation or peristalsis.

Muscle appears as a hypoechoic structure with diffuse hyperechoic strands and spots. Sometimes described as a "starry night" appearance. It is usually well demarcated into muscle "bellies" by encompassing hyperechoic fascial layers. If you trace the length of a muscle you often see the hyperechoic strands and spots migrating to a common location in the muscle and coalescing to form a tendon. Tracing in the opposite direction and the strands are seen to diffuse out and away from the tendon. Muscle and tendons are also markedly anisotropic like nerves.

Recommended Reading:

Clinical Sonopathology for the Regional Anesthesiologist: Part 1: Vascular and Neural. BD Sites, AJR Macfarlane, VR Sites, AM Naraghi, VWS Chan, JG Antonakakis, M Singh, R Brull. Regional Anesthesia and Pain Medicine (2010) vol. 35 (3) pp. 272

Clinical Sonopathology for the Regional Anesthesiologist: Part 2: Bone, Viscera, Subcutaneous Tissue, and Foreign Bodies. BD Sites, AJR Macfarlane, VR Sites, AM Naraghi, VWS Chan, JG Antonakakis, M Singh, R Brull. Regional Anesthesia and Pain Medicine (2010) vol. 35 (3) pp. 281

Exercises:

10 mins

1. Place the probe over the upper part of your anterior chest wall to image ribs and pleura. Notice the hyperechoic superficial rib cortex with an underlying shadow. The deep cortex of the rib is not seen.
2. Between the ribs you will see intercostal muscles and pleura. Take a deep breath to observe the pleura sliding sign.
3. The groin is usually the best place to image lymph nodes (however it is not very socially acceptable to do this on yourself in theatre!). If you have a thin patient whose groin you can image you should easily feel and image nodes. Alternatively feel for nodes in your axilla and neck and image any you find.
4. Image your abdominal wall noting subcutaneous fat, muscle layers, peritoneum and intra-peritoneal organs. Remember to optimise the machine for deeper imaging (probe, preset, frequency, depth, gain etc).

Module 11. Imaging The Needle

Essential Reading:

Imaging the needle is the most challenging part of ultrasound guided procedures. Beginners can quickly learn the machine basics and imaging anatomical structures however imaging the needle confidently throughout a procedure takes much more experience. Using models and phantoms to get this experience is essential. As well as being better for our patients it would take a long time to gain this experience doing occasional short procedures. On a phantom you can gain hours of experience with different needles, different approaches, different probes etc. all in one afternoon.

To image a needle you must first have the needle within the ultrasound beam. There are two approaches to inserting the needle relative to the probe. “Out of plane” describes the needle path perpendicular to the ultrasound beam. The needle will be imaged in cross section and appear as a bright dot with underlying shadow as it crosses the ultrasound beam. “In plane” refers to the needle path travelling parallel and within the beam with the needle shaft appearing as a bright line or two parallel bright lines with the bevel tip. As the ultrasound beam is only approx. 1mm wide keeping the advancing needle tip only (for out of plane approaches), or the whole needle shaft (for in plane approaches) within this beam is very difficult. When practising this you need to imagine the ultrasound beam deep to the probe like a torch beam, and the needle length and trajectory deep to the insertion point. Do they intersect? Is the needle likely to be within the 1mm wide beam? When you do not see the needle on the screen the first thing you must do is look down at your hands. Extrapolate where the beam and needle are deep in the tissues and correct their positioning. It is helpful to position yourself so you can easily look along the long axis of the probe for in plane approaches. After you have lined up the needle trajectory and ultrasound beam to intersect you can then look at the screen. If you do not see the needle, slight sliding movements of the probe one way then the other should identify the needle. If you cannot find the needle look back at your hands and start again. When the needle is in the ultrasound beam it will appear on the screen.

There are a few techniques to improve the image of the needle (described below) but first you must have an image of the needle! There is only one way to get an image of the needle and that is placing the needle within the ultrasound beam. To do this remember to look at your hands!

1) To improve the image of the needle the most useful technique is to have the needle trajectory as close to perpendicular to the direction of the ultrasound beam as possible i.e. parallel to probe face. This means shallow insertion angles. This will allow the most reflection of ultrasound waves back to the probe producing a brighter image. As the needle insertion angle gets steeper ultrasound waves are reflected away from the probe and the image of the needle gets poorer. To improve your needle trajectory relative to the probe the following techniques are useful:

1. choose a block site where the nerve is more superficial
2. insert the needle some distance from the probe
3. "toe" the probe. Heel/toeing the probe refers to rocking it along it long axis. By increasing pressure on the far end of the probe the probe face becomes more parallel to the needle trajectory for needles inserted in plane from the close end of the probe.

2) Have the bevel facing the probe. This helps reflect more sound waves back to the probe and improves the tip image. With out of plane approaches the tip will appear brighter than the shaft. With in plane approaches you will see the bevel angle.

3) Rotating the needle often results in the tip "winking" as the tip image becomes more and less bright with the rotation. This helps confirm needle tip.

4) Using a larger needle or the recently available "ultrasound/echogenic" needles will improve the needle image, especially at steeper angles of insertion. Superficial needles appear much better than deep ones.

6) Sonosite have recently developed Enhanced Needle Visualisation software called MBe, which improves needle visibility at steep insertion angles (available on M-Turbo).

7) Hydrolocation is a technique occasionally used to help localise your needle tip. This involves injecting a small amount of fluid (1ml or less) and seeing this fluid distend the tissues, thus identifying where your needle tip is. This is sometimes useful in deep blocks when you have a good idea of where your needle tip is but are having trouble imaging the tip because of depth, steep insertion angle, or artefact interference. This is not a substitute for keeping the needle within the ultrasound beam! If you do this when the needle tip is not within the beam you will not see the fluid distend the tissues. If you do this without knowing where your needle tip is you risk injecting intraneural or intravascular. Hence it should only be used when you are fairly sure where your tip is and that it is within the ultrasound beam but image quality is poor. In this situation it can confirm tip location and make imaging the tip easier.

5) Inserting your needle into a created pool of local anaesthetic also makes the needle image much clearer.

There are ongoing advancements in needle design and ultrasound machine software aimed at improving the image of the needle. These will only work to improve the image if you first have an image of the needle i.e. the needle is within the ultrasound beam. Keeping the needle tip in the ultrasound beam will remain a technically difficult skill to master.

Recommended Reading:

Ultrasound for regional anaesthesia website - Transducer Handling - Preparing the Transducer for Single Shot

Ultrasound for regional anaesthesia website - Needling Technique - In Plane

Ultrasound for regional anaesthesia website - Ultrasound Equipment – Needle

Sonosite MBe Enhanced Needle Visualisation Guide and Tips

Essential Exercises:

20 mins, blue phantom required, 22G block needle, (blue phantoms are damaged less by smaller gauge needles)

1. Using the blue phantom image the needle with the out of plane approach. Note the bright dot appearance of the needle. Tilt the probe, keeping the needle still, to image various points along the shaft of the needle. Confirm the needle tip as compared to a cross section of the shaft. The tip is usually much brighter than the shaft. Next slide the probe along the shaft of the needle. Follow the dot image from superficial insertion site to tip. Confirm the needle tip by observing the dot disappear and reappear as you slide or tilt the probe past the tip and back over it. Try rotating the needle and observe for tip "winking".
2. Withdraw the needle until it is only about 1cm under the surface. Image the tip. Advance the needle a few mm, slide the probe a few mm to follow the tip, confirm image is again of the tip. Continue advancing the needle a few mm at a time and sliding the probe to follow the needle tip. You need to keep confirming it is the tip you are imaging not a more proximal bit of shaft by sliding the probe off the tip and back on the tip and observing the dot appearance disappearing and reappearing. This is the critical part of the out of plane technique – keeping the tip in view and distinguishing it from a more proximal section of shaft. The tip usually appears brighter than the shaft.
3. Repeat exercise 2 above but his time instead of advancing the needle and following with the probe, advance the probe and follow with the needle. i.e. slide the probe a few mm past the tip so the image disappears then advance the needle into the beam so the tip image reappears. Continue advancing in this stepwise fashion will ensure you are always imaging the tip.
4. Repeat the above at different insertion angles.
5. Image the needle using the in plane technique. Position yourself so you can look along the shaft of the needle and along the long axis of the probe. Look first at the needle and probe and ensure the needle trajectory is along the midline of the probe long axis. If you have the needle in the 1mm wide ultrasound beam you will see the entire length of the needle shaft advancing on the screen. You will usually also see the bevel on the needle. This is best seen with the bevel facing the probe. Rotating the needle will be

seen as the bevel "winking" at you on the screen. This is a useful technique to confirm tip imaging.

6. Commonly the needle and ultrasound beam are not perfectly aligned but slightly oblique to each other. This results in only a section of the needle shaft being imaged and consequently an apparent tip that is proximal to the real tip. Correcting this requires rotation of the probe. Rotate the probe slightly and image only a section of needle. Slide the probe slightly and see this segment of needle change from proximal to distal. Rotate the probe back and image the complete shaft and tip. This is the critical part of the in plane technique – recognising an oblique view and false tip, being able to correct this by rotating the probe to image the entire shaft, and confirming the true tip by seeing the bevel or tip "winking".
7. Repeat the above at different insertion angles. You will note at angles greater than 30 degrees the needle becomes significantly harder to image. Try "toeing" the probe to improve the image. "Ultrasound" needles are usually better imaged at steeper insertion angles.

Recommended Meat Model Exercises:

Blue phantoms make imaging needles very easy. They are very convenient and a good place to start but not very realistic. Imaging on people is much harder. Meat models, although somewhat messy are much more realistic and therefore of much greater value while learning. Suggested meat cuts include chicken thighs or breasts, legs of lamb or pork, or any other cut of meat that includes a large muscle, bone and vessels or tendons.

On a meat model you can insert all needle types including Tuohy, feed catheters, hydrolocate and inject, and practise all insertion and imaging techniques mentioned above. The imaging is much more realistic than the blue phantom and this is therefore highly recommended as a learning exercise. Time spent on a meat model imaging needles will shorten the learning curve on your patients.

Set yourself up with a meat model, ultrasound machine, selection of needles, syringes and saline to inject. Work through the above exercises with different needles, in and out of plane approaches, hydrolocation, heel/toeing the probe and different insertion angles and every combination of above. The more time you spend with needle and probe in hand imaging the needle the better your skills will become.

Assessment 1

In this assessment you will have to demonstrate that you can:

1. Explain the basics of how an ultrasound machine works.
2. Set up the ultrasound machine to image a particular nerve or vessel.
3. Obtain, optimise, and save an image of a given nerve.
4. Obtain, optimise with colour doppler, and save a colour image of a given vessel.
5. Trace a given nerve along its entire course in the arm.
6. Using the blue phantom demonstrate in plane and out of plane needle tip and shaft imaging techniques.

Module 12. Ultrasound Guided Vascular Access

Essential Reading:

Ensure you have completed Module 8 Imaging Vessels and Module 11 Imaging the Needle before progressing through this module as they cover the basic skills.
Practise the techniques on the blue phantom as below. The concepts in the exercises below are very important to understand. Unfortunately the blue phantom is not very realistic and no meat models are easily available with patent vasculature for more realistic practise. Vascular access is performed daily in our jobs and complications of peripheral access are minimal so it is easy to develop these skills on your patients.

Peripheral veins:
Ultrasound guided peripheral venous access is technically more difficult than central venous access and basic nerve blocks. Peripheral venous access is challenging because:

1. superficial veins are easily compressed by the probe so very careful probe control is required.
2. the out of plane needle approach is preferred and this technique has a significant learning curve.
3. the veins are small presenting a smaller target.
4. the veins are often so superficial that it is difficult to image the needle
5. beneath the skin but before it enters or passes the vein.
6. our usual IV technique (without ultrasound) requires two hands. Holding the probe takes away one hand from the procedure which is usually the hand applying counter traction to the skin. Inserting the cannula without this counter traction is more difficult.

We suggest you become competent with the out of plane needle technique by practising on the blue phantom and meat models as per module 11 and the exercises below. Once you understand this technique you should start using ultrasound for some normal veins in your daily work to get skilled at the technique. Then you will be able to usefully use it when you need it on difficult to feel veins or deeper veins.

Central veins:
Ultrasound guided central venous access is one of the easiest procedures to perform with ultrasound as well as being one of the most beneficial procedures to use ultrasound for. Evidence for using ultrasound to reduce serious complications and increase success rates is significant. It appears to be becoming a standard of care.
It is easier than peripheral venous access because the veins are so much larger, they are deeper which makes them less collapsible with probe pressure, imaging the needle is easier as it is a larger needle, and there is more tissue space above the vein in which to image the needle.
Complications and risks are more significant however so you should ensure supervision until you are competent.
Once again the out of plane approach is recommended, to at least puncture the vein, so practise and competence with this technique is strongly recommended before attempting this procedure.

Ultrasound can be used to varying degrees to assist with this procedure:

1. Confirm normal anatomy. Anatomical variation is a significant cause of difficulty with central access. Performing a pre scan (non sterile) to confirm the anatomy is as expected (vein in expected position) and the vein is patent (not thrombosed) is useful and can be all you use the ultrasound for.
2. Confirm wire in vein. The next most beneficial level of use of the ultrasound is to confirm your wire is in fact in the vein and not the artery before you dilate. Dilating the artery is associated with significant morbidity. Competent use of the ultrasound to image the wire and to distinguish artery from vein should prevent you doing this. If you are using the ultrasound to this degree you would perform a pre scan as above. Then you would perform your usual landmark insertion technique without the ultrasound. Once you have placed the wire and before dilating you would image the wire, with a sterile sheathed probe, confirming it lies in the vein not the artery. Once confirmed the probe is put down and the rest of the procedure performed as usual.
3. Image guided whole procedure. This is the degree of use recommended to registrars. This involves the pre scan as above, image guided needle access into vein, (sterile probe sheath, out of plane technique), confirming wire in vein as above, and finally confirming the catheter is in vein.

Arterial access

Arterial lines are one of the most difficult procedures in our job. Consistent success is hard to achieve as arteries are often small, deep, tortuous, and narrowed by atheroma. This makes localisation by palpation less precise and cannula access less successful than venous lines. Ultrasound is very useful to localise arteries and guide cannula access. It also allows arterial lines to be put into arteries in non traditional locations as palpation is not required e.g. radial artery more proximal than at the wrist.

The technique used is similar to peripheral venous access. Probe pressure is less important as the arteries are usually deeper and less compressible. Advancing the cannula after entering the artery can often be difficult with our standard technique due to depth, small vessel, atheroma etc. Rotating the probe into a long axis view, after the vessel has been entered, can often aid this part of the procedure by ensuring the needle and cannula are advanced within the vessel lumen.

Recommended Reading:

Ultrasound guided vascular access: efficacy and safety. A Kumar, A Chuan. Best Practice & Research Clinical Anaesthesiology (2009) vol. 23 (3) pp. 299-311

Better anaesthesia through sonography website – vascular access

Exercises:

20 mins, blue phantom, 22G cannula

1. Image the vessel in the blue phantom in short axis. Position the vessel in the centre of the screen so you know it should lie under the midpoint of the probe. Many probes have midline markers on them and newer probes have an on screen guide you can turn on which marks the midline on your screen image. If you insert your needle at the midpoint of the probe when the vessel is centred on the screen you should be directly above the vessel. Insert a 22G cannula using the out of plane technique. Follow the needle tip from superficial in the phantom to the vessel by sliding the probe as per Module 11. As the needle tip approaches the vessel ensure it arrives at the 12 O'clock point on the vessel so it will enter from directly above. It is much easier to access the vessel from the 12 O'clock position than from the side i.e. squarely from above rather than obliquely from the side. If your needle is not approaching the vessel from directly above it is worth withdrawing and readjusting your insertion point. As your needle descends down to the vessel you will see a shadow from the needle i.e. a dark line that extends below the needle. Do not confuse this shadow with the actual needle which appears as a bright dot. The shadow is useful in indicating where the needle is i.e. at the top of the shadow. The shadow does not indicate the current needle trajectory or future course. It is a shadow so will always extend directly below the needle. When the needle tip approaches the vessel you will see the vessel indent. Commonly you will unknowingly advance the needle tip past the ultrasound beam and image a segment of needle shaft proximal to the tip. As you are directly above the vessel the shadow will extend down to the vessel. The tip now out of your view may have reached the vessel and you see the vessel wall indenting. Because you may be imaging a segment of needle shaft rather than the tip it is easy to advance the needle too far and miss the vessel or penetrate through the posterior wall. You may see and/or feel a pop as the needle enters the vessel, you may get a flashback, and the tented vessel wall may spring back into its spherical position. You should then see the needle tip (bright dot) inside the vessel. Ensure this is the tip and not a more proximal part of the needle shaft by sliding the probe past the tip and back to it. When you are sure the tip is in the vessel you can then put the probe down and advance the cannula as per normal i.e. flatten the insertion angle, advance a further mm or two and then slide the cannula off the needle.

2. A more advanced technique involves entering the vessel as above and then advancing the needle and cannula along the vessel under direct vision. This can also be useful if you have successfully entered the vessel but cannot advance the cannula. Once you have entered the vessel as above rotate the probe 90 degrees , keeping the vessel in the centre of the image, so the vessel ends up being imaged in long axis. You should be able to see your needle tip in the vessel and the shaft of the needle that is now in plane with the ultrasound probe. With this image the needle insertion angle can be flattened out and the needle advanced a few mm along the vessel under direct vision, ensuring you do not penetrate the posterior wall. You can often see when the cannula end is in the vessel. Then the cannula can be advanced off the needle (if you can do this one handed!) and the cannula can be imaged advancing along the vessel.

3. Performing the whole procedure with the vessel imaged in long axis and the needle in plane with the probe is also a very useful exercise to practise on the blue phantom. Although this results in beautiful images on the blue phantom in practise this is not used so often for the following reasons:
    a. Imaging people is much harder than the blue phantom, vessels are not always straight, keeping the vessel in long axis and the needle in plane in the 1mm wide beam is difficult.
    b. Central and large peripheral veins are often accompanied by arteries. With the short axis view both the artery and vein are imaged and the needle can be more confidently directed into the vein not the artery. With the long axis view only one vessel is imaged and it is easy to mistake the artery for the vein.
    c. A phenomena called side lobe artefact can result in strongly reflective structures (like needles) off to the side of the ultrasound beam appearing on your image as if they were within the beam. This can give an image of the needle appearing to be perfectly positioned above or inside vein when it is not, but is in fact just alongside the displayed position i.e. beside the vein. The image of the needle is therefore an artefact and you will not be in the vein when you think you are.

4. Imaging the needle tip (not the shaft) with the out of plane technique is crucial. The technique described above involves advancing the needle slightly then sliding the probe to follow the needle tip. The probe overshoots the tip, the image disappears, the probe is brought back until the image reappears, and thus confirming it is the tip and not a more proximal segment of shaft. i.e. the probe follows the advancing needle tip. The tip will often be displayed more brightly than the shaft especially if you keep the bevel facing the probe.

5. Other techniques to try include:
    a. The needle tip following the probe (this authors favourite). Instead of advancing the needle and following with the probe the probe can be slid past the needle tip, the image disappears, then the needle can be advanced until the image of the needle just reappears, confirming tip. The probe is then slid further ahead of the needle tip, image disappears, needle is advanced further into the ultrasound beam, image reappears.
    b. Tilting probe rather than sliding. You can keep the probe in the same location on the skin and follow the tip by tilting the probe instead of sliding (like fanning a torch beam around a room). Works OK on the blue phantom but not as good in practise as the needle and your target are best imaged at a certain probe angle (recall anisotropy and imaging structures perpendicular to beam direction from earlier modules). Changing the angle of insonation of the ultrasound beam with your target will change its appearance. Useful to practise on the phantom.
    c. “Walk down technique”. With this popular technique the depth to target is first measured and the needle inserted out of plane from a point the same distance from the probe as the target depth. In this way the required insertion angle should be about 45 degrees. The needle is first advanced into the ultrasound

beam at a much more superficial depth than the vessel. Once the tip is seen to enter the beam superficial to the vessel the needle is then withdrawn and the trajectory deepened a little. The needle is advanced again until the tip is again seen to enter the ultrasound beam. This time the tip will be seen deeper and therefore closer to the vessel. The needle is then withdrawn again , trajectory deepened further and re-advanced. In this stepwise manner the needle is “walked down” in the tissues above the vessel until it is deep enough to enter the vessel.

6. Once you have performed and understood the concepts above you can start using ultrasound with your regular vascular access procedures.

Assessment 2

In this assessment you will have to demonstrate that you can:

1) Image peripheral veins, arteries and central vessels in short and long axis.
2) Use and optimise colour and power Doppler.
3) Demonstrate techniques to distinguish veins from arteries.
4) Using the blue phantom demonstrate needle approaches for vascular access with the vessel imaged in short and long axis.
5) Discuss common pitfalls of both techniques.

Module 13. General Principles of Ultrasound Guided Nerve Blocks

Essential Reading:

Benefits of using ultrasound for nerve blocks include:

- Ability to visualise anatomy and anatomical variation
- More successful
- Less accidental vascular punctures
- Faster, less discomfort for patient
- Less LA required, blocks last longer
- More reliably avoid and detect intraneural needle placement
- Likely safer

The general aim of the procedure is to surround the nerve with LA without damage to the nerve or other structures.

Any probe can be used but linear high frequency probes are most commonly used as they provide the best image resolution for superficial blocks.

In plane or out of plane approaches can be used but in plane is the most popular as the full length of the needle shaft can be seen which aids tip identification.

The nerves can be imaged in long or short axis but short axis is usually chosen as this is much easier and allows clear visualisation of surrounding structures.

Consent

Consent is obtained in the usual manner. A brief description of the technique, benefits, risks and alternatives should be conveyed to your patient.

Time management

Blocks take time to perform, especially when you are learning. Plan to allow as much time as possible so you do not feel rushed. Blocking your next patient during your current case is usually safe and practical if you have a consultant with you and you perform the block in a monitored induction room adjacent to your theatre.

Sedation

Sedation is recommended to improve patient comfort.

Monitoring

ECG, BP and SaO_2 monitoring is recommended due to known risks of hypoventilation from sedation, neurological and cardiovascular toxicity from intravascular injection or overdose.

Needles

Short bevel needles are recommended to minimise the risk of intra-fascicular needle placement or fascicular damage if the needle accidentally enters the nerve.

Ergonomics

Appropriate positioning of the patient, and placement of the US machine, equipment trolley, assistant, monitors and the operator are of vital importance.

Ultrasound-guided peripheral nerve blockade. KJ Chin, V Chan. Current Opinion in Anesthesiology (2008) vol. 21 (5) pp. 624

Recommended Reading:

Better anaesthesia through sonography website - Technical Aspects of Ultrasound Guided Regional Anaesthesia

Module 14. Local Anaesthetic Toxicity

Essential Reading:

It is important to realise that LA toxicity can occur even when you are using what are considered “safe” doses. If you are injecting into a highly vascular area absorption may be more rapid and plasma levels will peak higher, accidental intravascular injection is always possible and relatively small doses given intravascularly can easily achieve toxic plasma levels, and some patients may be more prone to toxicity e.g. acidotic patients and renal failure patients.

Safe practise therefore includes always being prepared for LA toxicity. This means having monitoring (ECG, BP, SaO_2) on your patients, performing blocks in an area where resuscitation equipment and help is available, and being familiar with the signs, symptoms and management guidelines for LA toxicity.

The following management guidelines from AAGBI have been endorsed by ANZCA.

AAGBI Local Anaesthetic Toxicity Guidelines

Module 15. Catheter Techniques

Essential Reading:

Catheters are used to prolong nerve blocks past the duration of single shot blocks. The catheter technique with ultrasound is technically much more challenging than a single shot block. This is because of the extra equipment required, extra sterility, difficulty imaging the catheter and issues around securing the catheter.

It is recommended that you gain experience with single shot blocks and progress onto catheters once you feel comfortable with the single shot block technique in the area you want to perform a catheter technique.

Full sterile precautions including gown, gloves, mask, and probe sheath are considered essential.

As we usually only have two hands, once the Tuohy tip is correctly located the probe is usually put down to feed the catheter through the needle. Other techniques involve using an assistant or feeding the catheter without holding the needle.

In-plane, out-of-plane, long axis and short axis approaches to the nerve are all used. Inserting the needle in long axis to the nerve may theoretically assist the catheter to advance along the nerve. Whether you insert the catheter in long axis or short axis to the nerve it seems the more catheter you advance the greater the likelihood of the catheter tip ending up away from the nerve. When only a couple of cm of catheter is fed, careful securing of the catheter becomes crucial.

The catheter itself is extremely difficult to see with ultrasound. You may see it in superficial locations. Ultrasound techniques to identify the catheter tip location include injecting LA, air or agitated saline/LA through the catheter and seeing this in the tissues. Power Doppler can also be used as solution is injected to detect flow in the catheter and tissues.

Ultrasound for regional anaesthesia website - Catheter Technique

Module 16. Axillary Nerve Block

Essential Reading:

The axillary approach to the brachial plexus is probably the safest due to its distance from spinal cord, phrenic nerve and pleura. This eliminates some of the risks of more proximal approaches. As well as this the nerves are relatively superficial making this a good approach for the beginner to start with. Anatomical variability is high however and distinguishing the nerves from other tissues can be quite difficult. You need to practise the exercises below to become competent at identifying the nerves in the axilla. To confidently identify the nerves it is necessary to trace them distally and confirm that what you think is the nerve is a continuous nerve looking structure that courses where you expect the nerve to run. It is unreliable to identify the nerves on a single image.

Axillary block of the median, ulna, radial and musculocutaneous nerves is useful for all surgery below the elbow. Tourniquet tolerance is usually good.

There are usually multiple veins in the axilla. To minimise the risk of intravascular injection it is recommended to occlude veins with probe pressure after identifying their location and ensure you see LA distending the tissues upon injection. If you have the needle tip in view and you do not see LA spreading in the tissues upon injection of 1 or 2 ml you may be intravascular, in a collapsed, non-visible vein. It is recommended if this occurs to stop injecting and reposition the needle tip slightly.

Ultrasound for regional anaesthesia website - Axillary Block

Nerve Imaging atlas musculocutaneous nerve – Andrey Gray

Recommended Reading:

Anatomical study of the brachial plexus using surface ultrasound. CF Royse, S Sha, PF Soeding, AG Royse. Anaesthesia and intensive care (2006) vol. 34 (2) pp. 203-210

Assessment of topographic brachial plexus nerves variations at the axilla using ultrasonography. JL Christophe, F Berthier, A Boillot, L Tatu, A Viennet, N Boichut, E Samain. British Journal of Anaesthesia (2009) vol. 103 (4) pp. 606

Further Reading:

An introduction to ultrasonic guided axillary brachial plexus neuroblockade. II Hawkinberry, W Denzil, LM Broadman. Techniques in Regional Anesthesia and Pain Management (2004) vol. 8 (4) pp. 149-154

Is the Musculocutaneous Nerve Really in the Coracobrachialis Muscle When Performing an Axillary Block? An Ultrasound Study. F Remerand, J Laulan, C Couvret, M Palud, A Baud, S Velut, M Laffon, J Fusciardi. Anesthesia & Analgesia (2010) vol. 110 (6) pp. 1729

Upper extremity regional anesthesia: essentials of our current understanding. JM Neal, JC Gerancher, JR Hebl, BM Ilfeld, CJL McCartney, CD Franco, QH Hogan. Regional Anesthesia and Pain Medicine (2009) vol. 34 (2) pp. 134

Exercises:

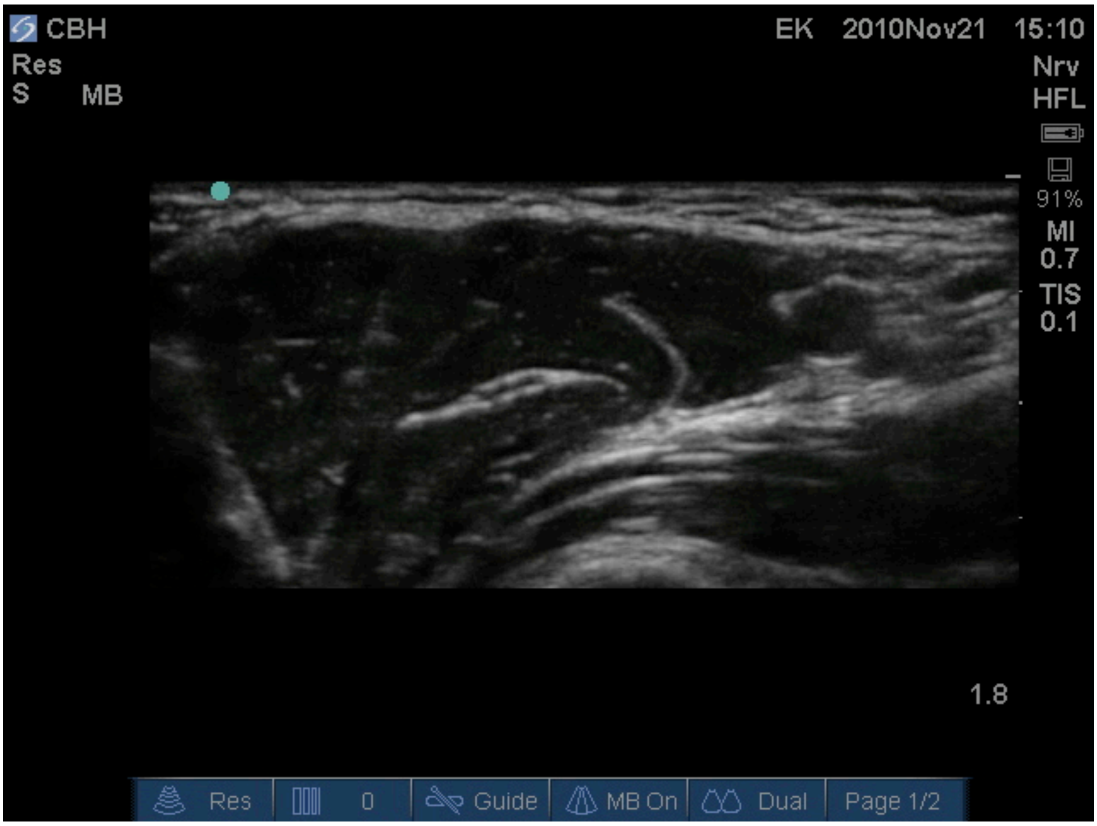
1. Scan an axilla, identify the axillary artery, trace it distally and use colour Doppler to confirm it. Remove all probe pressure and observe the axillary veins. There are usually multiple veins which you will not be aware of if you do not specifically look for them by taking off probe pressure. It is important to know where the veins are to minimise the risk of intravascular injection.
2. Identify median nerve. Median nerve usually sits around 11 o clock to the artery. Sometime it can be seen to slide back and forth over the artery with probe pressure. Trace the median nerve distally. It tends to run superficially with the brachial artery down the medial side of the arm and sits superficially adjacent to the medial side of the brachial artery in the ACF.

3. Identify the ulnar nerve. The Ulnar nerve usually sits around 2 O'clock relative to the artery. There are usually veins close to this. Tracing the ulnar nerve distally results in the nerve running superficially down the medial side of the arm and then coursing posteriorly to pass through the ulnar groove of the medial epicondyle at the elbow.

4. Identify the radial nerve. The radial nerve is often the most difficult to identify. It usually sits between about 3 and 6 O'clock relative to the artery. Do not be misled by the bright area of post cystic enhancement immediately deep to the artery. Tracing the radial nerve distally results in the nerve descending deep in the fascial plane anterior to triceps. It then winds posteriorly around the humerus in the spiral groove before leaving the humerus and becoming more superficial as it approaches the lateral side (radial) of the ACF. Here it usually divides into superficial and deep branches.

5. Identify the musculocutaneous nerve. Unlike the above 3 nerves the musculocutaneous nerve has usually left the neurovascular bundle and is sited in the coracobrachialis muscle or between coracobrachialis and biceps muscles, at this level.
Up to 20% may be atypical and located near the Axillary artery or joined to the median nerve.
6. Once you have identified the vessels (including all veins) and nerves in an axilla consider what needle approach will allow the easiest access to the nerves.

Scan of axilla showing axillary artery and brachial plexus



Scan of the axilla showing musculocutaneous nerve

Module 17. Distal arm blocks

Essential Reading:

Distal arm blocks are great blocks to do. The imaging is easy as the nerves are relatively superficial. Needle access is easy due to superficial location and easy access around arm, and safety is high due to lack of other significant structures like large vessels or lung. They are ideal for beginners.
Indications are usually hand surgery or occasionally as "rescue" blocks if a brachial plexus block has failed to block a single terminal nerve.
Due to the common requirement for a tourniquet by the surgeons they are often combined with a GA or a shorter acting brachial plexus block.

The L25 high frequency probe is usually chosen. Although these nerves can be blocked with only 1 or 2 mls of LA accurately placed around the nerve, commonly 5 mls or even up to 10 mls is used depending on spread.

Ultrasound for regional anaesthesia website - Mid Humeral Block

Ultrasound for regional anaesthesia website - Peripheral Nerve Block - Median Region

Nerve imaging atlas median nerve– Andrew Gray

Ultrasound for regional anaesthesia website - Peripheral Nerve Block - Musculocutaneous Region

Ultrasound for regional anaesthesia website - Peripheral Nerve Block - Ulna Region

Nerve imaging atlas ulna nerve– Andrew Gray

Ultrasound for regional anaesthesia website - Peripheral Nerve Block - Radial Region

Nerve imaging atlas radial nerve – Andrew Gray

Recommended Reading:

Ultrasound guidance for ulnar nerve block in the forearm. AT Gray, I Schafhalter-Zoppoth. Regional Anesthesia and Pain Medicine (2003) vol. 28 (4) pp. 335-339

Ultrasound identification of the radial nerve and its divisions. Is rescue nerve block at or below the elbow possible? S Anagnostopoulou, T Saranteas. Anaesth Intensive Care. 2008 May;36(3):457-9.

Ultrasound anatomy of the radial nerve in the distal upper arm. GL Foxall, D Skinner, JG Hardman, NM Bedforth. Regional Anesthesia and Pain Medicine (2007) vol. 32 (3) pp. 217-220

Exercises:

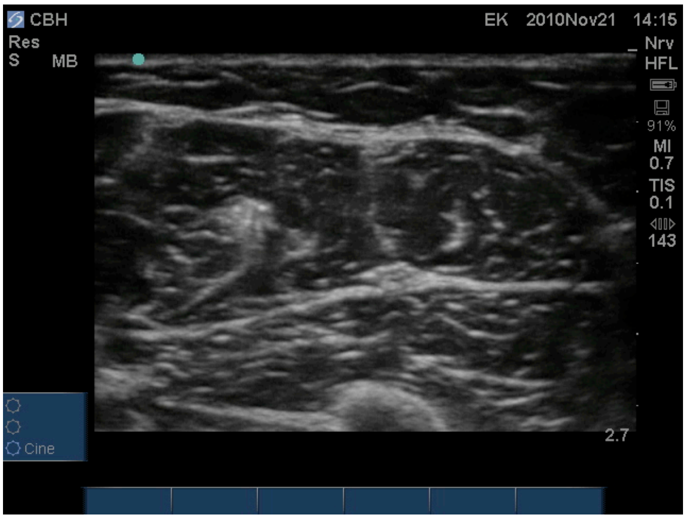
1. Scan the median nerve from axilla (usually around the 11O'clock position relative to the artery) to the carpel tunnel (usually on the anterior wall of carpel tunnel). Note the locations where it is superficial and easy to block i.e. axilla, medial boarder upper arm where it accompanies the brachial artery, ACF where it is very superficial on the medial side of the brachial artery, mid to distal forearm where it lies between Flexor Digitorum Superficialis and Flexor Digitorom Profundus muscles. Ensure you can differentiate it from tendons by tracing proximal and distal.

Transverse scan of the median nerve at the elbow

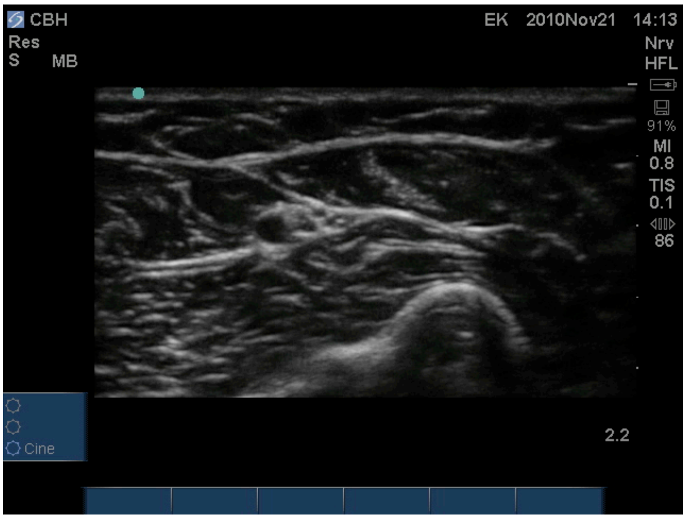
Transverse scan of the median nerve mid forearm

2. Scan the ulnar nerve from axilla to wrist. Note the locations where it is easy to block i.e. axilla (usually around 1 to 3 O'clock position relative to artery), medial side of upper arm anywhere between axilla and ulnar groove. The ulnar groove/tunnel is usually avoided due to the confined space and risk of excessive pressure on the nerve from the large volume of LA. You will note the ulnar artery joins the nerve about mid forearm and accompanies it to the wrist. A common approach is mid forearm when it just separates from the ulnar artery. The

dorsal and palmar cutaneous branches of the ulnar nerve arise 5 – 10 cm proximal to the adult wrist. Blocking proximal to this therefore provides a more complete block.



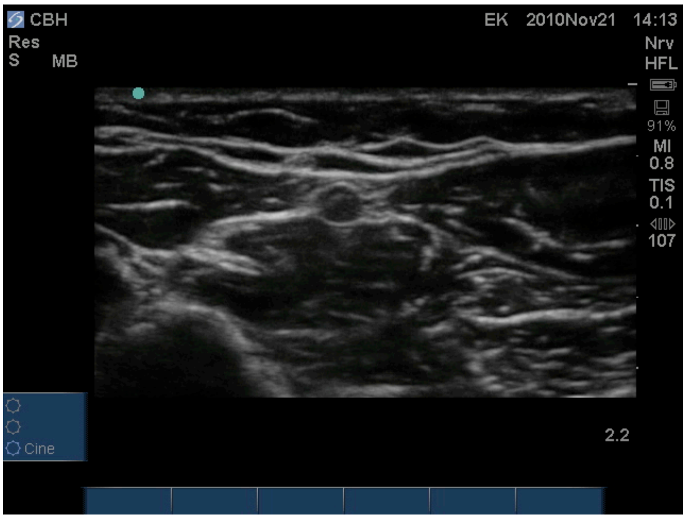
Transverse scan of the ulna nerve at the elbow



Transverse scan of the ulna nerve mid forearm

3. Scan the radial nerve from axilla to below the ACF. Its position in the axilla is more variable than the other nerves but commonly around 3 to 7 O'clock relative to the artery. The radial nerve leaves the axilla and descends to the humerus where it winds around the posterior aspect in the spiral groove to emerge on the lateral side, commonly in conjunction with the profunda brachii artery. It then enters the anterior compartment of the arm and runs between brachialis and brachioradialis muscles. Around this level it divides into superficial and deep branches. This division is usually imaged and can result in a "snakes eyes" appearance. Following these branches below the ACF becomes difficult. The radial nerve is therefore commonly blocked before it divides just proximal to the ACF on the lateral aspect of the upper arm, in the axilla and sometimes from the posterior aspect of the upper arm as it emerges from the spiral groove.

Transverse scan of the radial nerve at the elbow



Transverse scan of the radial nerve mid forearm

Module 18. Femoral Nerve& Fascia Iliaca Blocks

Essential Reading:

The Femoral nerve is one of the principle nerves of the lower limb. It innervates the hip joint, the anterior thigh, knee joint and medial aspect of the lower leg down to and including the medial ankle. It is composed of nerves from L2, 3 and 4. Blockade of the femoral nerve is useful for many lower limb procedures for both anaesthesia and analgesia. It can be blocked with single shot techniques or catheters may be inserted for on-going blockade.

The femoral nerve can be difficult to visualise on ultrasound. This is because when it emerges from under the Inguinal ligament it is usually flattened between Iliopsoas muscle and the Fascia Iliaca. It is also starting to divide into its many branches and has a similar echogenicity as the fascial tissues immediately above it. Despite this it is an easy nerve to block with ultrasound. To visualise the Femoral nerve the patient is positioned supine and flat. A 38mm linear transducer is ideal for this block. The Femoral artery can be palpated in the Femoral crease and then used to identify the Femoral nerve. The Femoral crease is usually the best level to visualise the nerve. If you are distal to this the nerve has often divided and may not be seen. If you visualise two arteries (Femoral and Profunda Femoral) try moving more proximal until only one artery is seen. The nerve is found lateral to the artery and below the Fascia Iliaca. The Fascia Iliaca is seen as a hyperechoic fascial plane that emerges from deep to the artery to curve more superficially and laterally over the hypoechoic belly of Iliopsoas muscle. There are often other fascial planes and tissues above the Fascia Iliaca but only hypoechoic muscle below. The Fascia Iliaca is a critical landmark and is easily identified with ultrasound. The Fascia Lata is a more superficial fascial plane that runs superficial to the artery. The Femoral nerve is usually seen immediately underneath the Fascia Iliaca. It can vary in shape from very broad and flat to more oval or triangular. It can be close to the artery or up to a couple of cm lateral to it. It has the characteristic nerve “honeycomb” appearance with hypoechoic fascicles and hyperechoic connective tissue. Because it is immediately underneath the Fascia Iliaca, with similar echogenicity, it often appears to be a swelling continuous with the fascial plane. With LA injection the nerve separates from the fascia and becomes more clearly seen.

To target the femoral nerve either the out-of-plane or in-plane approach can be used. Introducing the needle from the lateral end of the transducer (in-plane) optimises the view of the needle throughout its passage towards the nerve. A long needle (e.g. 8cm) is usually used for this block. The initial target site for the needle tip should be to penetrate the Fascia Iliaca just lateral to the lateral edge of the nerve. You will see the Fascia Iliaca tent and feel a pop as you penetrate it. If the nerve cannot be confidently seen then penetrate the Fascia Iliaca approximately 2cm lateral to the artery. Once underneath the Fascia Iliaca inject some LA. You should see it tracking along underneath the fascia. In contrast to this sharp upper boarder to your LA pool the deep boarder will be less distinct due to the hypoechoic muscle. If you see a clearly defined fascial plane deep to your LA pool you probably have not penetrated the

Fascia Iliaca and need to advance your needle further. If you are under Fascia Iliaca the pool of LA will track around the nerve separating it from the fascia and making it much easier to image. You may then choose to reposition you needle tip, above or below the nerve, to ensure a good spread of LA around the nerve.

The Fascia Iliaca block is a modified form of the Femoral 3-in-1 block. It relies on a large volume of local anaesthetic injected below the Fascia Iliaca spreading in this plane proximally. This plane contains, as one moves proximally into the pelvis, the Femoral, Obturator and Lateral Cutaneous Nerve of the Thigh. The block is performed lateral to both the Femoral nerve and artery thereby reducing the risk of intraneural and intravascular injection. It is an ideal block for hip surgery analgesia (including analgesia for fractures of the neck of femur) as the Femoral and Obturator nerves are innervators of the hip joint and the Lateral Cutaneous Nerve of the Thigh innervates the usual incision site for hip surgery.

To perform a Fascia Iliaca block under ultrasound guidance the fascial plane must be first identified. This is best done by first identifying the femoral artery as described above. The fascial plane is followed laterally as it curves over the superficial margin of Iliopsoas muscle. An injection point is chosen lateral to the nerve and away from vascular structures. As the aim of the injection is to encourage proximal spread of local anaesthetic over the Iliacus muscle into the pelvis. The needle should be introduced from distal to proximal. The block can therefore be done with the probe remaining in a transverse orientation and the needle inserted out-of-plane. Alternatively once the fascial plane is identified the probe can be rotated through 90º keeping the fascial plane in view at all times. The plane remains visible as a hyperechoic stripe. The needle can then be introduced in-plane. The needle should penetrate the Fascia Iliaca and a characteristic ‘pop’ is felt. After aspiration the local anaesthetic should be injected at this point. Injection should be easy and the local anaesthetic should be visualised spreading proximally on top of the Iliacus muscle and ideally seen disappearing along this plane deep into the pelvis.

Both the Femoral nerve and Fascia Iliaca blocks are amenable to catheter placement. If placing a Femoral nerve catheter it is recommended that the catheter is only inserted 1-2cm past the needle tip to minimise the tip leaving the nerve proximity. For the Fascia Iliaca however it is ideal to insert the catheter towards the pelvis along the surface of the Iliacus muscle and a catheter depth of 5 to 10cm beyond the needle tip may deliver the LA more proximally aiding block success.

Ultrasound for regional anaesthesia website - Femoral Nerve Block

Nerve imaging atlas femoral nerve – Andrew Gray

Recommended Reading:

An introduction to femoral nerve and associated lumbar plexus nerve blocks under ultrasonic guidance. AT Gray, AB Collins, I Schafhalter-Zoppoth. Techniques in Regional Anesthesia and Pain Management (2004) vol. 8 (4) pp. 155-163

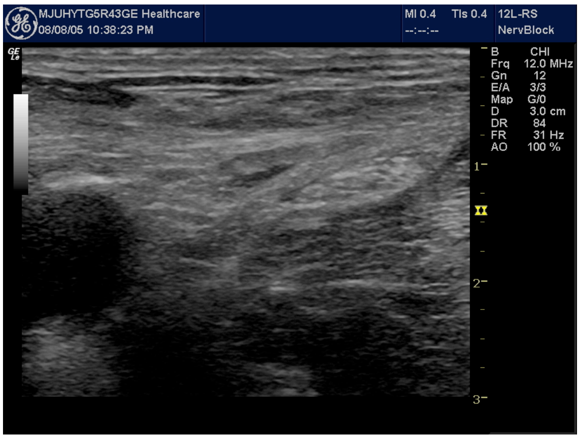
Ultrasound guided fascia iliaca block: a comparison with the loss of resistance technique. J Dolan, A Williams, E Murney, M Smith, GNC Kenny. Regional Anesthesia and Pain Medicine (2008) vol. 33 (6) pp. 526-531

Further Reading:

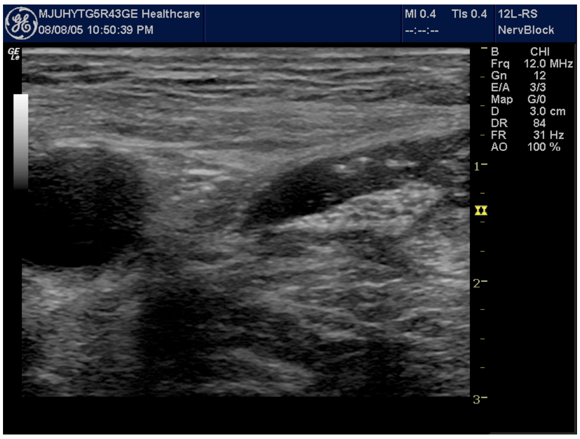
The ultrasonographic appearance of the femoral nerve and cases of iatrogenic impairment. H Gruber, S Peer, P Kovacs, R Marth, G Bodner. Journal of Ultrasound in Medicine (2003) vol. 22 (2) pp. 163

Exercises:

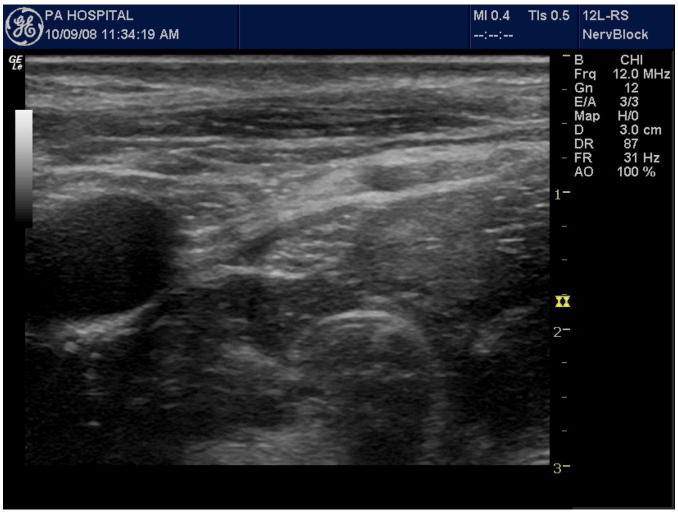
1. Palpate the patient's groin at the femoral crease and identify the femoral artery. Place a 38mm transducer over the artery and identify the artery in short axis. The artery should be pulsatile and non-compressible. The femoral vein should be identified medial to the artery as a compressible, non-pulsatile hypoechoic structure. Scan distally and identify the branching of the femoral artery with profunda femoris tracking deeper. Return proximally to a single femoral artery.
2. Scan laterally from the artery and identify the hyperechoic Fascia Iliaca and the femoral nerve. Scan proximally and distally on the nerve to identify the level at which it is best identified. Tilting the probe will change the nerves appearance due to anisotropy.
3. Continue scanning laterally from the nerve and follow the Fascia Iliaca. At a point 2-3 cm from the nerve keep the Fascia Iliaca in view and rotate the transducer through 90º maintaining your view of the Fascia Iliaca throughout.



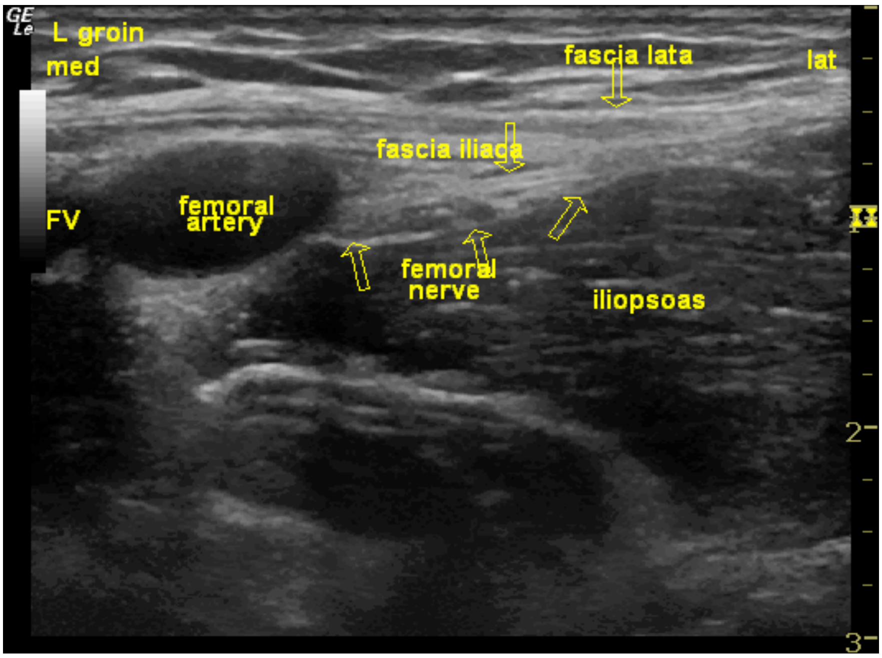
Transverse scan of the femoral nerve



Femoral nerve post LA injection



Fascia iliaca running under femoral artery



The Femoral nerve often appears as a flat structure sandwiched between Iliopsoas

Module 19. Lateral Femoral Cutaneous Nerve Block

Essential Reading:

The Lateral Femoral Cutaneous Nerve supplies the skin over the anterior and lateral parts of the thigh. It can be useful to target this nerve for procedures involving the lateral thigh, especially skin harvesting for grafting. It can also be used diagnostically in meralgia parasthetica.

It is a very small nerve and often not visualised on US. However a 'plane' block can be performed. The lateral cutaneous nerve of the thigh is usually found immediately superficial to the Sartorius muscle just distal to the anterior superior iliac spine.

To perform the block a linear (25 or 38mm) probe is usually used. The probe is placed transversely over the anterior superior iliac spine and the hyperechoic bone is identified. This is very superficial and creates a complete acoustic shadow. The probe, still in a transverse orientation, is moved distally onto the proximal thigh. The Sartorius muscle can be then identified as a wedge or cylinder of muscle. The block is performed by introducing a block needle, in plane, from lateral to medial and local anaesthetic infiltrated in the plane immediately superficial to Sartorius. 5 to 10 ml is required. The nerve may become visible as a small hyperechoic structure in the local anaesthetic. If the nerve is not visualised the end-point should be infiltration of local anaesthetic across the whole of the superficial aspect of Sartorius.

Ultrasound for regional anaesthesia website - Lateral Femoral Cutaneous Nerve Block

Recommended Reading:

Ultrasound of the lateral femoral cutaneous nerve: normal findings in a cadaver and in volunteers. G Bodner, M Bernathova, K Galiano, D Putz, C Martinoli, M Felfernig. Regional Anesthesia and Pain Medicine (2009) vol. 34 (3) pp. 265-268

Sonographic assessment of the lateral femoral cutaneous nerve. B Damarey, X Demondion, N Boutry, HJ Kim, G Wavreille, A Cotten. Journal of Clinical Ultrasound (2009) vol. 37 (2) pp. 89-95

Further Reading:

Ultrasound imaging accurately identifies the lateral femoral cutaneous nerve. I Ng, H Vaghadia, PT Choi, N Helmy. Anesthesia & Analgesia (2008) vol. 107 (3) pp. 1070

Exercises:

1. Scan over the anterior superior iliac spine and identify the hyperechoic bone.
2. Move the probe distally and identify the *Sartorius* muscle. This muscle has its origin at the anterior superior iliac spine should be readily identified immediately distal to the spine as the most superficial muscle.
3. Identify the plane immediately superficial to the *Sartorius* muscle.

Module 20. Obturator Nerve Block

We currently have no experience with this block.

Recommended Reading:

Ultrasound for regional anaesthesia website -Obturator Nerve Block

Ultrasound-guided obturator nerve block: an interfascial injection approach without nerve stimulation. SK Sinha, JH Abrams, TT Houle, RS Weller. Regional Anesthesia and Pain Medicine (2009) vol. 34 (3) pp. 261

Ultrasound-guided obturator nerve block: a sonoanatomic study of a new methodologic approach. T Akkaya, E Ozturk, A Comert, Y Ates, H Gumus, H Ozturk, I Tekdemir, A Elhan. Anesthesia & Analgesia (2009) vol. 108 (3) pp. 1037

Assessment 3

In this assessment you will have to demonstrate that you can:

1) Discuss general principles of UGRA, local anaesthetic toxicity and catheter techniques.
2) Image the brachial plexus in the axilla, distal arm nerves, Femoral nerve and Fascia Iliaca. Be able to identify surrounding relevant sonoanatomy.
3) Demonstrate where you would expect to find the Lateral Femoral Cutaneous nerve and the Obturator nerve.

Module 21. Cervical Plexus Block

We currently have no experience with this block

Recommended Reading:

An Anatomical Basis for Blocking of the Deep Cervical Plexus and Cervical Sympathetic Tract Using an Ultrasound-Guided Technique. Y Usui, T Kobayashi, H Kakinuma, K Watanabe, T Kitajima, K Matsuno. Anesthesia & Analgesia (2010) vol. 110 (3) pp. 964

Ultrasound guided deep cervical plexus block. DJ Sandeman, MJ Griffiths, AF Lennox. Anaesthesia and intensive care (2006) vol. 34 (2) pp. 240

Further reading:

Anatomical considerations for ultrasound guidance for regional anesthesia of the neck and upper limb. P Soeding, N Eizenberg. Can J Anesth/J Can Anesth (2009) vol. 56 (7) pp. 518-533

Module 22. Interscalene Block

Essential Reading:

The brachial plexus above the clavicle consists of the nerve roots of C5-T1, which join to form the trunks (upper, middle and lower). These roots/trunks pass between the anterior scalene and middle scalene muscles, where they are targeted for the interscalene brachial plexus block. As they continue down the neck, these trunks start to form the divisions of the brachial plexus at the level of the clavicle, and can be blocked at this location when performing a supraclavicular block.

There is considerable anatomical variation in the structure and course of the brachial plexus between individuals, as well as variations in vascular anatomy. This results in difficulty in identifying some or all brachial plexus elements under ultrasound, as well as contributing to incomplete regional blockade if not all elements have been exposed to local anaesthetic.

When planning a brachial plexus block above the clavicle, a thorough ultrasound assessment of the region should be conducted to identify brachial plexus components, other nerves (e.g. phrenic), vascular structures and pleura. This allows the operator to confirm that the anatomy is suitable for performing a nerve block at the desired location.

Interscalene block under ultrasound is performed at a lower level in the brachial plexus than with landmark based techniques. The distinction between interscalene block and supraclavicular block is blurred when using ultrasound due to their proximity (1-2cm). If the brachial plexus is blocked when it lies between the two scalene muscles then it is referred to as an interscalene block. If it has emerged superficially from the groove into subcutaneous fascia it is a supraclavicular block.

Regional anaesthesia for shoulder surgery is only consistently achieved when local anaesthetic blockade of the suprascapular and axillary nerves (innervate the shoulder joint), as well as the supraclavicular and axillary nerves (innervate the overlying soft tissues and skin) is achieved. The suprascapular nerve leaves the brachial plexus high in the interscalene groove, and is not anaesthetised in a supraclavicular brachial plexus block. The supraclavicular nerve is a branch of the cervical plexus, and is anaesthetised during interscalene block by local anaesthetic spread. (Note the terms supraclavicular brachial plexus and supraclavicular nerve can be confused).

There are two approaches to finding the interscalene brachial plexus, and it is recommended that both techniques are used on each patient, to accurately assess the individual's anatomy. The patient should be positioned supine or head up, with the head rotated to the opposite side (not excessively).
The first and easiest approach is to identify the brachial plexus in the supraclavicular fossa as described in Module 23. Once identified, the plexus is followed proximally up the neck, where it become deeper and enters the interscalene groove.

The alternative approach is to place the transducer over the carotid artery and internal jugular vein at the level of the cricoid. Sliding the transducer laterally and identifying the lateral tapered border of sternocleidomastoid, which is just superficial to the two scalene muscles. 2-4 hypoechoic trunks should be visualised between the two scalene muscles. Again, caudal angulation of the probe so that it is perpendicular to the course of the nerves is required. Occasionally, one or more of the trunks may travel within or over the anterior scalene muscle. The phrenic nerve can often be identified between anterior scalene and sternocleidomastoid, and it appears to run medially towards the midline as it descends into the chest. It's proximity to the interscalene groove explains the very high incidence of ipsilateral diaphragmatic paresis with the interscalene block. This is generally accepted as a known side effect. There has been some success in reducing phrenic nerve palsy by targeting the brachial plexus as far away as practical from the phrenic nerve, as well as the use of reduced local anaesthetic volumes. (See recommended reading).

Many needle approaches for the interscalene block are described; in-plane (lateral, medial, posterior) or out-of-plane (superior or inferior), with the most appropriate being the one that allows placement of the needle tip with minimal disruption to structures. The out of plane superior approach is useful for catheter placement. The in-plane posterior approach requires having the patient in the lateral position for placement, and again is useful for catheter placement, although the longer subcutaneous and intramuscular course is more painful. Variations in anatomic relationships are common, so structures should be identified with certainty. The hypoechoic appearance of the plexus should be distinguished from vessels if there is any doubt (eg compressible, pulsatile, flow on colour Doppler). The vertebral artery is located deep to the interscalene groove below C6.

A multiple injection technique, placing local anaesthetic between the two deepest trunks initially, and then between the more superficial trunks, ensures success and early onset of block. If local anaesthetic is injected superficially first, it pushes the plexus deeper making the approach more difficult. If local anaesthetic is not visualised on both sides of the plexus, the needle can be passed between the trunks, using hydro-dissection to get to the other side. This can also be used to place block catheters. It is imperative that the full shaft and tip of the block needle is visualised at all times, and an in-plane approach is strongly advised. Intraneural injection is contraindicated, due to the low connective tissue content of the trunks at the interscalene level. The usual dose is 20-30ml of local anaesthetic.

Ultrasound-guided interscalene brachial plexus block. A Perlas, VWS Chan. Techniques in Regional Anesthesia and Pain Management. 2004 vol. 8 (4) pp. 143-148

Ultrasound for regional anaesthesia website - Interscalene Block

Recommended Reading:

Upper extremity regional anesthesia: essentials of our current understanding, 2008. JM Neal, JC Gerancher, JR Hebl, BM Ilfeld, CJL McCartney, CD Franco, QH Hogan. Regional Anesthesia and Pain Medicine (2009) vol. 34 (2) pp. 134

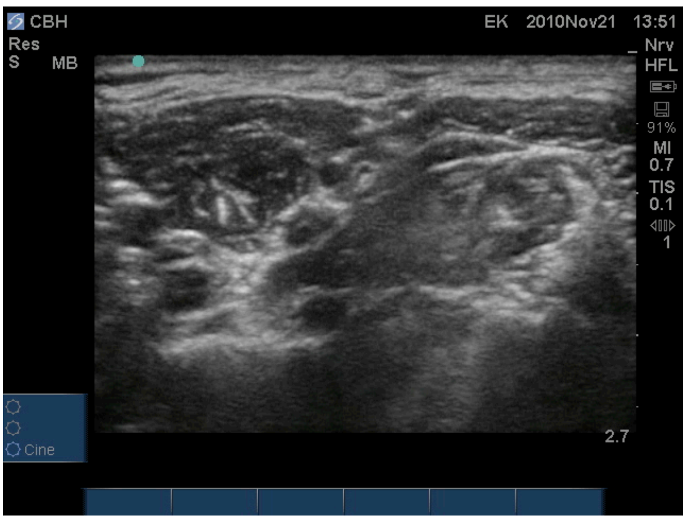
Applied anatomy of the upper extremity. CD Franco, L Clark. Techniques in Regional Anesthesia and Pain Management. 2008 vol. 12 (3) pp. 134-139

Ultrasound-guided posterior approach for the placement of a continuous interscalene catheter. John G Antonakakis, Brian D Sites, Jeffrey Shiffrin. Regional Anesthesia and Pain Medicine. 2009 vol. 34 (1) pp. 64-8

Effect of local anaesthetic volume (20 vs 5 ml) on the efficacy and respiratory consequences of ultrasound-guided interscalene brachial plexus block. S Riazi, N Carmichael, I Awad, RM Holtby, CJL McCartney. British Journal of Anaesthesia. 2008 vol. 101 (4) pp. 549

Exercises:

1. A suitable subject and an ultrasound machine, with a high frequency linear probe (25 or 38mm) are required.
2. Turn the US machine on. The following settings should be selected; Nerve preset, General or Resolution, depth 4cm initially.
3. Have the subject supine, or sitting at 45 degrees, with a thin or no pillow. Have the head rotated about 45 degrees away from the side to be scanned.
4. After applying Gel to the probe, place the probe in the supraclavicular area above the clavicle. Ensure you familiarise yourself with the orientation of the transducer and the display. Slide the probe medially until the subclavian artery is seen. Try to identify the supraclavicular brachial plexus which is adjacent to the artery and just lateral to it. At this level, the divisions of the brachial plexus appear as one or more hyperechoic bundles, containing smaller hyperechoic connective tissue elements, and hypoechoic neural elements. Changing the angulation of the face of the transducer to a more caudal orientation should improve the appearance of the plexus.



Transverse scan of the interscalene brachial plexus

5. With the plexus well visualised, optimise the US image depth and gain. Now slowly slide the transducer up the neck while maintaining a good image of the plexus. Small adjustments to the angle of the transducer are necessary to maintain a good image, with the US beam at right angles of the trunks. The plexus will be seen to enter the interscalene groove between the anterior scalene muscle medially, and the middle scalene muscle laterally. Continue to scan in a cephalad direction until the deepest of the nerve roots is seen to travel medially and under the hyperechoic transverse process.
6. Scan up and down the trunks as they travel between the scalene muscles. Identify the level most favourable for a block – where the trunks are packed together and on top of each other, just before they emerge from the interscalene groove.
7. Try to identify the phrenic nerve on the superficial surface of the anterior scalene muscle. Also identify any vessels deep and superficial to the plexus. Try to imagine the path of a needle when performing a block, and position you transducer so that there are no structures obscuring the path.
8. Now remove the probe from the subjects neck, reapply some gel, and place the transducer on the neck at the level of the cricoid cartilage just lateral to midline. Identify the trachea, and the thyroid gland overlying the airway. Slide the transducer laterally and identify the carotid artery and internal jugular vein. Also identify sternocleidomastoid, and its lateral border which is tapered. Just below this point the scalene muscles can be identified. Adjust the angle of the probe in a caudal direction until the trunks of the brachial plexus are identified.

Module 23. Supraclavicular Block

Essential Reading:

The introduction of ultrasound into regional anaesthetic practice has allowed the supraclavicular block to become a popular and common technique for anaesthesia and analgesia of the upper limb distal to the shoulder. The compact structure of the plexus as it approaches the clavicle, and its superficial location, make the supraclavicular block an easy and reliable technique when performed in-plane under ultrasound guidance. Although originally described in 1911, the proximity of the pleura resulted in a high incidence of pneumothorax when performed by the landmark technique, and the supraclavicular block fell out of favour. Also, the close relationship of the plexus with the subclavian artery, as well as common vascular anomalies passing through the plexus, such as the transverse cervical artery and suprascapular artery, increase the risk of vascular puncture and local anaesthetic toxicity.

The trunks of the brachial plexus emerge from the interscalene groove as they approach the clavicle, start to form divisions and are enveloped in a connective tissue sheath of variable continuity. The plexus is close and lateral to the subclavian artery, with the inferior trunk positioned just above the first rib. Ulna sparing occurs when this inferior trunk is not surrounded by local anaesthetic. It is postulated that the pulsatile nature of the subclavian artery impedes the flow of local anaesthetic injected nearby but not adjacent to the inferior trunk. Local anaesthetic injection into the "corner pocket" at the junction of the 1st rib and the subclavian artery attempts to place local anaesthetic directly next to the inferior trunk to avoid ulna sparing.

The patient should be positioned supine or head up, with the head rotated to the opposite side (not excessively). The transducer is placed on the skin in the supraclavicular fossa just above and parallel to the clavicle, scanning medially until the subclavian artery is identified. The supraclavicular plexus can be identified immediately lateral to the artery, with the majority of the plexus at the same depth or slightly more superficial, and the inferior trunk components slightly deeper as described above. One or more large bundles with hyperechoic texture can be identified. The brachial plexus is anisotropic and requires caudal angulation of the probe. The first rib should be identified as a bright line with a dark shadow behind it (may require sliding the probe up the neck until the 1st rib is in view). It may be possible to identify parts of the inferior trunk just superficial to the rib. The pleura should be visualised slightly deeper than the 1st rib as a white line, with movement on respiration and possibly a comet tail artefact. Alternatively, the supraclavicular plexus can be located by visualising the interscalene brachial plexus and following it down to the supraclavicular fossa.

A range of anatomical variability is observed between patients, with vascular anomalies being most common. The transverse cervical artery can pass through the plexus, and in some individuals some or all of the plexus can be located on the medial side of the subclavian artery. The brachial plexus should be scanned from the level of the clavicle and up the neck until it enters the interscalene groove, paying close attention to any vessels that may pass

through the plexus. Vessels can be confirmed by compression, pulsation and colour Doppler. The most favourable location for the block can then be selected.
If the probe is placed too medial in the supraclavicular fossa, the base of the common carotid artery is visualised, and often confused for the subclavian artery. The subclavian artery lies under the middle third of the clavicle.

An in-plane approach is necessary to maintain the needle tip in view at all times, to avoid inadvertent vascular or pleural puncture. Performing the block at the level of the 1st rib allows a margin of safety, as the block needle is prevented from going deep by the rib, thus avoiding the pleura. The first needle pass should be directed toward the deepest part of the plexus close to the first rib, and local anaesthetic injected to surround this part of the plexus. The needle can then be redirected to surround the remainder of the plexus with local. Initial injection of LA to superficial structures can make subsequent injection around the deep structures more difficult, as they are pushed deeper by the LA. It may be necessary to redirect the needle medially over the plexus to surround the medial aspect of the plexus with LA. A local anaesthetic volume of up to 40ml may be required to adequately surround all parts of the plexus, but the usual volume is 30ml.

Introduction of the needle into the plexus sheath has been described, and is routine practice in some centres. It may result in faster block onset and reduced LA volume requirement. The risk of intraneural injection and plexus injury may be increased using this technique, and should not be used unless performed or directly supervised by a specialist.

Continuous supraclavicular plexus block can be achieved by placing a catheter in close proximity to the plexus, usually just under the plexus next to the subclavian artery, using the in-plane approach described above. Catheters have a tendency to fall out due to the short subcutaneous course and the highly mobile area. Subcutaneous tunnelling and fixation using Dermabond may help. An infraclavicular plexus catheter may provide a more reliable continuous block.

Ultrasound for regional anaesthesia website - Supraclavicular Block

Recommended Reading:

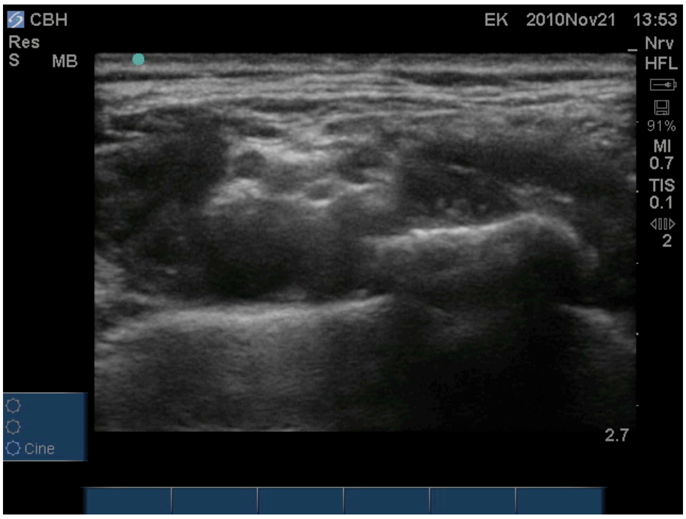
Upper extremity regional anesthesia: essentials of our current understanding, 2008. JM Neal, JC Gerancher, JR Hebl, BM Ilfeld, CJL McCartney, CD Franco, QH Hogan. Regional Anesthesia and Pain Medicine (2009) vol. 34 (2) pp. 134

Ultrasound-Guided Supraclavicular Brachial Plexus Block. Chan, Vincent, Perlas, Anahi, Rawson, Regan, Odukoya, Olusegun Anesthesia & Analgesia. 97(5):1514-1517, November 2003.

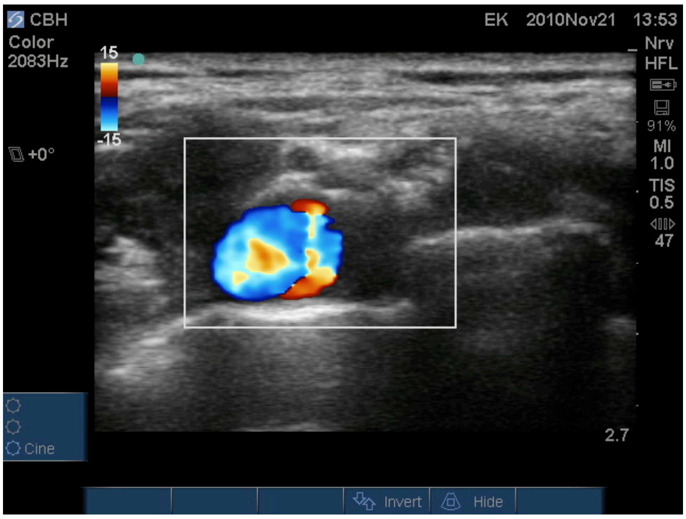
Ultrasound-Guided Supraclavicular Block Outcome of 510 Consecutive Cases. Anahi Perlas, Giovanni Lobo, Nick Lo, Richard Brull, Vincent W.S. Chan and Reena Karkhanis. Regional Anesthesia and Pain Medicine. 34 (2): 171-176, April 2009.

Exercise:

1. A suitable subject and an ultrasound machine, with a high frequency linear probe (25 or 38mm) are required.
2. Turn the US machine on. The following settings should be selected; Nerve preset, General or Resolution, depth 4cm initially.
3. Have the subject supine, or sitting at 45 degrees, with a thin or no pillow. Have the head rotated about 45 degrees away from the side to be scanned.
4. After applying Gel to the probe, place the probe in the supraclavicular area above the clavicle. Ensure you familiarise yourself with the orientation of the transducer and the display. Slide the probe medially until the subclavian artery is seen. Identify the supraclavicular brachial plexus which is adjacent to the artery and just lateral to it. At this level, the divisions of the brachial plexus appear as one or more hyperechoic bundles, containing smaller hyperechoic connective tissue elements, and hypoechoic neural elements. Changing the angulation of the face of the transducer to a more caudal orientation should improve the appearance of the plexus.
5. With the plexus well visualised, optimise the US image depth and gain.



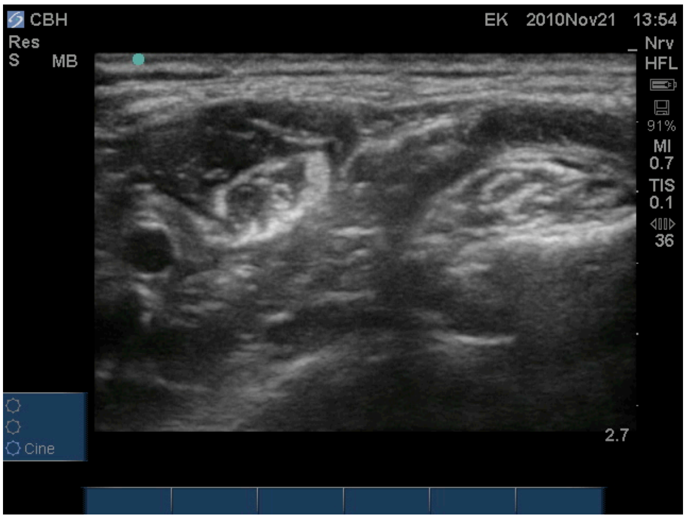
Supraclavicular brachial plexus



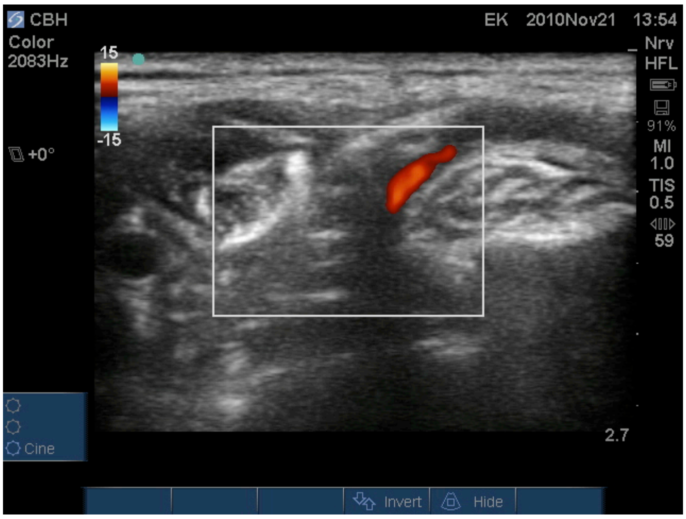
Same view with Colour Flow Doppler

6. Now slowly slide the transducer up the neck while maintaining a good image of the plexus. Small adjustments to the angle of the transducer are necessary to maintain a good image, with the US beam at right angles of the plexus. Identify the first rib deep to the artery and plexus, which appears as a bright line with a bony shadow deep to it. Also identify the pleura, which are slightly deeper than the first rib, and also appear as a bright line, with a halo or haze deep to it; the comet tale artefact. Ask the subject to vary their breathing, observing the movement of the pleura.
7. Closely inspect the region between the artery and the 1st rib to identify any plexus components.
8. Slide the transducer further up the neck. The plexus will be seen to enter the interscalene groove between the anterior scalene muscle medially, and the middle scalene muscle laterally.

9. Note any vascular anomalies passing through the plexus. A block in the vicinity of these is avoided by selecting a suitable level just higher or lower in the neck.



Supraclavicular brachial plexus with possible vascular anomaly



Same view of supraclavicular brachial plexus with transverse cervical artery visible on colour flow doppler

Module 24. Infraclavicular Block

Essential Reading:

The infraclavicular block, at the level of the cords of the brachial plexus, provides reliable anaesthesia and analgesia distal to the mid-humeral level of the upper limb. This approach has many advantages to other brachial plexus blocks; The incidence of hemi-diaphragmatic paresis is negligible because of the distance from the phrenic nerve. The risk of pneumothorax is reduced when the block is performed laterally, as the chest wall falls away from the neurovascular structures. The block can be performed with the arm in any position. Multiple injections are not required, as the cords are close together. Catheter placement for continuous blockade may be more reliable, as the block is deeper and the shoulder less mobile, reducing the chance of the catheter being dislodged. The main disadvantage is the deep location of the cords, which makes imaging challenging; The individual cords may not be easy to identify, the needle insertion angle in most approaches makes needle visibility poor, and there may be significant US signal attenuation from the overlying pectoral muscles.

The brachial plexus cords are closely associated with, and rotate around, the axillary artery. Around the acromion they take their positions lateral, posterior and medial to the artery, from where they derive their names. This terminology is confusing, the position is better described as superior, posterior and inferior respectively. Anatomical variability is common. More medially, they tend to be situated on the same side superior (cranial) to artery, facilitating a single shot block without having to redirect the needle, thus increasing success rate. The close association of the cords with the artery facilitates performing this block, as identifying the individual cords is not critical to block success, and local anaesthetic is placed on the postero cranial aspect of the artery. Anterior to the artery lie skin, subcutaneous tissue, pectoralis major and minor. Inferior and slightly deeper to the artery lie the axillary vein, connective tissue, ribs, pleura and lung. The clavicle is superior to the artery, while the scapula lies posteriorly.

The patient is positioned supine, with the head on a pillow. Infraclavicular block can be performed with the arm adducted by the side of the patient. If the arm is abducted to 110°, externally rotated with the elbow flexed, the neurovascular bundle becomes more superficial and positioned further away from the lung. The operator stands at the head of the bed, with the US machine positioned on the side to be blocked. Some practitioners perform this block from the side, with the US machine positioned the other side of the patient. The artery is usually found at 3.5-4.5cm depth, so a wide (38 or 50mm) high frequency linear transducer is used, set to maximum depth and GEN or PEN frequency settings selected. In obese, or very muscular subjects, a low frequency curved transducer may be required, and set to appropriate depth and RES or GEN frequency selected. Muscle causes significant signal attenuation, and increasing far and/or overall Gain will improve image quality.

To assess the sonoanatomy before performing the block, the transducer is placed on the skin at the desired location (approaches described below). The subcutaneous fascia, pectoralis major and pectoralis minor muscles are identified. At maximum depth, ribs, pleura and lung may be visualised, and the depth and distance to the vessels should be noted. The vessels are identified, which might require angulation of the US beam superiorly, with the vein being inferior and varying in size with respiration and on valsalva, while the artery is superior, pulsatile with no variation in size. The vein is difficult to collapse with pressure, so this is not a reliable sign. Colour Flow Doppler should be used to confirm the identity of the vessels. Occasionally, the cephalic vein is seen superior to the artery. Note the post cystic enhancement posterior to the artery, which should not be confused with one of the cords, although this is the described position of the posterior cord. The cords will appear hyperechoic in this region, and are anisotropic so slight variations in transducer angulation and tilt may improve their visibility. If the cords are identified, they can be blocked individually, although evidence suggests a single large volume injection of local anaesthetic posterior to the artery and slightly cranial to be equally effective.

Local anaesthetic infiltration of the block needle track should be performed for all blocks, to avoid pain and movement while inserting the block needle.

Lateral, medial and posterior infraclavicular blocks will be described:

A lateral infraclavicular block can be performed with the transducer just inferior to the acromion, where the artery is more superficial and where the separation from the ribs and pleura is greatest. Disadvantages of performing the block in this position are the acute needle angle, separation of the cords around the artery requiring repositioning of the needle to ensure adequate LA spread, and increased incidence of missing the axillary and musculocutaneous nerves as they may have already separated from the plexus, resulting in poor tolerance of an upper arm tourniquet. The common needle approach is in-plane entering the skin from the superior end of the transducer. The needle is advanced under direct vision until the tip lies next to the artery on the posterior aspect just superior to the artery (at the 7 o'clock mark when viewing the cross section of the artery from the lateral side). Local anaesthetic is injected, and should be seen flowing around and under the artery. The needle can be advanced under the artery to ensure adequate spread. If individual cords are visible, the needle can be redirected to surround them with local anaesthetic. Block success is increased when local anaesthetic is spread in a U shape around the cross section of the artery, and when individual cords are identified and surrounded by local.

Lateral infraclavicular block can also be performed with an inferior to superior in-plane approach, but is more painful due to the needle passing through the pectoralis muscles, and negotiating the needle around the vascular structures is more difficult. An out-of-plane approach with needle insertion medial to the transducer and guided in a lateral direction, with the needle tip placed superior to the artery, follows traditional blind approaches to this block.

A medial infraclavicular block is performed with the transducer in the delto-pectoral groove. Here the artery is deeper, but the cords are usually arranged closer together on the cranial side of the artery. Blockade here results in a higher success rate with a single injection point, and better tourniquet tolerance. An in-plane approach from the superior edge of the transducer is made, directing the needle tip to the 7 o'clock position posterior to the artery on the superior side, and injecting the local anaesthetic at this point. Local anaesthetic should be seen to spread posterior and superior to the artery, if not, the needle is repositioned appropriately. Needle visibility is poor due to the steep insertion angle, and care should be taken advancing the needle tip strictly in-plane, as the pleura are closer to the neurovascular bundle than the lateral approach.

The posterior infraclavicular block is an alternative approach to the medial infraclavicular block, which is technically challenging, but allows better needle visibility because the needle is orientated parallel to the transducer head. The transducer is placed in the delto-pectoral groove so that its superior edge is just overlying the clavicle (confirmed by a shadow cast under the bone). This may not be the optimal position for imaging the axillary artery and cords; the transducer will be relocated later. The needle is inserted on the superior aspect of the shoulder, between the clavicle and scapula, guided in a direction that aligns it with the plane of the US beam. The needle initially passes through trapezius muscle, then under the clavicle, to emerge into the plane of the US. The transducer may be used to locate the needle by sliding medially or laterally. Once the needle is identified in-plane, the transducer and needle can be slowly manipulated together to focus on the block target area. The needle is advanced so that the tip is at the 7 o'clock position described above, and local anaesthetic is injected.

To compensate for the difficulty in needle visualisation, a large needle should be selected (eg 18-20 gauge), with a length of 8-10 cm. Stiff needles that don't bend are easier to direct in deeper blocks. Echogenic needles and/or Enhanced Needle Visualisation/MBe (Sonosite M-turbo) mode are ideal for situations where the insertion angle is steep.

The usual volume of local anaesthetic required for this block is 30-40ml. High concentration long acting LA produces a block that lasts 12-36h.

For continuous blocks, a 16 or 18 gauge Tuohy with catheter kit is used. With the needle in position, 10-20ml of LA is injected to dissect a space posterior to the artery, then the catheter is passed 3-5 cm past the needle tip. A further 20-30 ml is injected through the catheter under US vision, to ensure adequate spread posterior and superior to the artery, and establish the block, with the catheter position revised if required. The block is maintained using low concentration LA, by intermittent bolus (20-30 ml PRN two hourly) or continuous infusion plus PCRA.

Ultrasound for regional anaesthesia website - Infraclavicular Block

A comparison of two techniques for ultrasound guided infraclavicular block. P Bigeleisen, M Wilson. British Journal of Anaesthesia (2006) vol. 96 (4) pp. 502-7

Use of magnetic resonance imaging to define the anatomical location closest to all three cords of the infraclavicular brachial plexus. AR Sauter, HJ Smith, A Stubhaug, MS Dodgson, O Klaastad. Anesthesia & Analgesia (2006) vol. 103 (6) pp. 1574

Recommended Reading:

Upper extremity regional anesthesia: essentials of our current understanding, 2008. JM Neal, JC Gerancher, JR Hebl, BM Ilfeld, CJL McCartney, CD Franco, QH Hogan. Regional Anesthesia and Pain Medicine (2009) vol. 34 (2) pp. 134

Ultrasound guided posterior approach to the infraclavicular brachial plexus. P Hebbard, C Royse. Anaesthesia (2007) vol. 62 (5) pp. 539

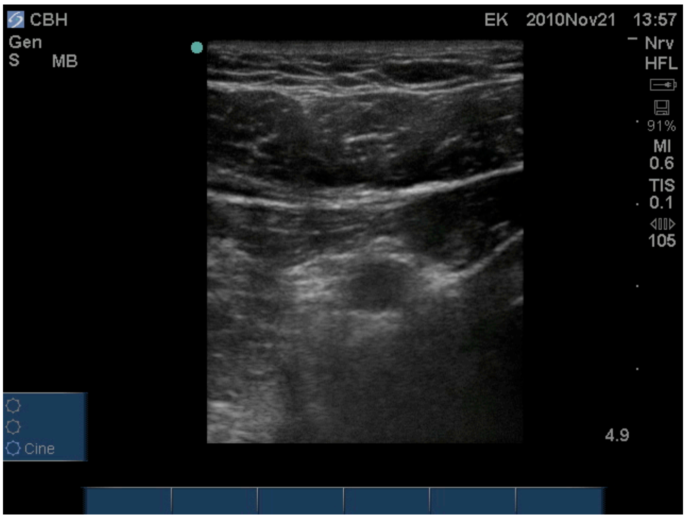
A Prospective, Randomized Comparison Between Single-and Double-Injection Ultrasound-Guided Infraclavicular Brachial Plexus Block. DQH Tran, P Bertini, C Zaouter, L Muñoz, RJ Finlayson. Regional Anesthesia and Pain Medicine (2010) vol. 35 (1) pp. 16

Exercises:

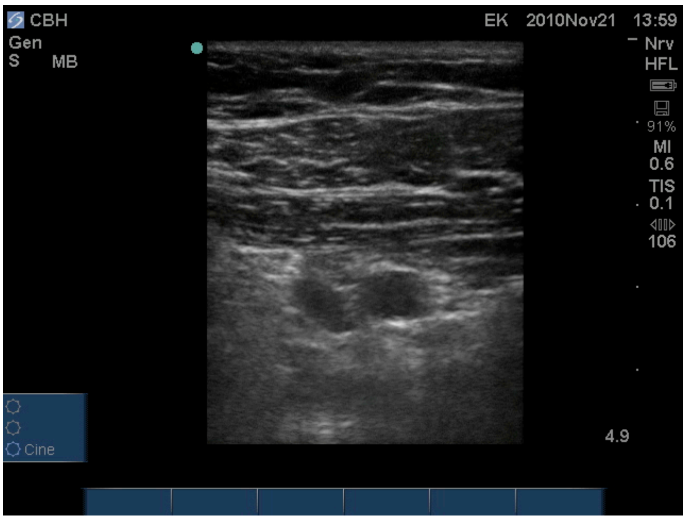
1. A suitable subject and an ultrasound machine, with a high frequency linear (HFL) probe 38mm and low frequency curved probes are required.
2. Turn the US machine on. The following settings should be selected; HFL probe, Nerve preset, General or Penetration, depth 6cm initially.
3. Have the subject supine, with their head on a pillow that is pulled to the contralateral side to be imaged. Have the arm abducted to 110°, externally rotated with the elbow flexed.
4. Apply gel to the transducer. Identify the coracoid process by palpating the shoulder, and place the probe inferior to it in a parasagittal plane (superior-inferior orientation).
5. Identify the subcutaneous tissue, pectoralis major and minor muscles superficially. Next try to identify structures at the bottom of the screen; are ribs visible ? (hyperechoic lines casting a shadow), is pleura and lungs visible between the ribs ? Ask the subject to take a breath in and observe movement of the ribs and pleura. Identify the vessels and note the distance between them and the ribs and pleura.
6. If vessels are not visible, or only the vein is visible, angulation of the ultrasound beam upwards will bring the vessels into view. Adjust the image so that the vessels are in the middle of the screen by angling the transducer and adjusting the depth. Optimise the image by ensuring the vessels are seen in cross section, which might require slight rotation.
7. With the vessels in view, ask the subject to adduct their arm to the side of their torso, and note changes in the position and depth of the vessels. Return the arm to the abducted position.
8. Adjust the depth so that the vessels are in the middle of the screen (optimum focal point for Sonosite machines).
9. Observe the features of the inferior vein. It is thin walled. Ask the subject to perform a valsalva manoeuvre, and observe the change in size. Increase the transducer pressure to collapse the vein. In contrast the superior artery has a thicker wall, is pulsatile, and does not change in size with valsalva. Now apply Colour Flow Doppler. Observe the direction of flow in both vessels – remember to relate this to the position of the

transducer. The pulsatile nature of the artery is easily seen. Squeeze the subject's upper arm to augment the venous flow and observe the effect.

10. Inspect the area superior to the artery and attempt to identify the hyperechoic lateral cord. Tilt the transducer slightly in either direction as the nerve is anisotropic. Other cords may be in this vicinity as well.
11. Identify the area of post cystic enhancement posterior to the artery, and appreciate that this can be confused with the posterior cord. Are the posterior or medial cords visible ?.
12. Inspect the area between the artery and vein – this is the textbook position of the medial cord.
13. Increase the scanning depth to 6cm, and slide the transducer medially until it sits in the delto pectoral groove. Repeat steps 5-12 noting any differences.
14. Now slide the transducer superiorly until the clavicle casts a shadow in the image. This is the position used for the posterior approach to this block.
15. Repeat the above exercises using the curved low frequency probe. High frequency RES setting can be used when scanning with this probe because it has a lower frequency, and the area of interest is in the shallow end of this transducer's depth capability (can scan up to 30cm depth).



Lateral infraclavicular brachial plexus



Medial infraclavicular brachial plexus

Module 25. Intercostal Nerve Block

Essential Reading:

Intercostal nerve block can be used for analgesia following rib fracture, intercostal drain insertion, thoracotomy, breast surgery, and upper abdominal wall surgery. It is an alternative to the thoracic paravertebral block, with the advantage of being more superficial and easier to image, with no risk of epidural or contralateral local anaesthetic spread, and similar risk of pneumothorax. It only provides analgesia to a single thoracic level, unlike thoracic paravertebral block which can cover a number of levels depending on volume injected. Local anaesthetic absorption into the circulation is high, so attention to drug dosing is essential. This also limits the duration of blocks.

Three layers of muscle are present between the ribs, although it may not be easy to distinguish them. The neurovascular bundle of intercostal nerve, artery and vein are located between the innermost 2^{nd} and 3^{rd} layers, and usually lie deep to the inferior border of the rib. Intercostal nerves are small, and not imaged by US. To perform a block, local anaesthetic is injected into the plane between the inner two muscle layers, where it will track to surround the nerve.

The block can be performed with the patient sitting, or lying in the lateral or prone position. A high frequency linear transducer is used (25 or 38mm), with RES or GEN frequency settings. The transducer is placed in a parasagittal (superior-inferior) orientation, at the posterior angulation of the ribs (area of maximal rib curvature 5-10 cm lateral to midline). Here minimal branching of the intercostal nerve has occurred and the ribs are shallow. Below the subcutaneous tissue latissimus dorsi, trapezius or infraspinatus may be seen depending on the level and lateral position scanned. At levels higher than T6, the shoulder needs to be abducted to move the scapula out of the way. Ribs can be identified as hyperechoic lines casting a shadow deep to their image. Between the ribs, muscle is seen, and occasionally 2 or 3 layers can be identified. A pulsating artery may be present, which can be confirmed with Colour Flow or Power Doppler. Deep to the intercostal muscles, a hyperechoic pleural line can be identified, with movement seen on respiration. Note the comet tail and reverberation artefacts that often occur below the pleural line. These are absent in the presence of a pneumothorax.

In-plane intercostal block is preferred, allowing imaging of the needle approaching the pleura. After local infiltration, the block needle is inserted into the skin over the superior aspect of the rib below the level to be blocked, in an inferior to superior direction and angulated towards the innermost muscle layer, or towards the intercostal artery if seen. The needle should not be advanced unless the tip is perfectly in-plane. Once in position, fluid should be observed dissecting the two muscle layers on injection of LA. If intramuscular injection is observed, with swelling of the muscle layer, the needle should be repositioned.

Out-of-plane approaches from medial or lateral are also practiced. Alternatively, the transducer can be positioned parallel to the ribs and over the intercostal space, and the needle passed in-plane, again with a lateral or medial approach.

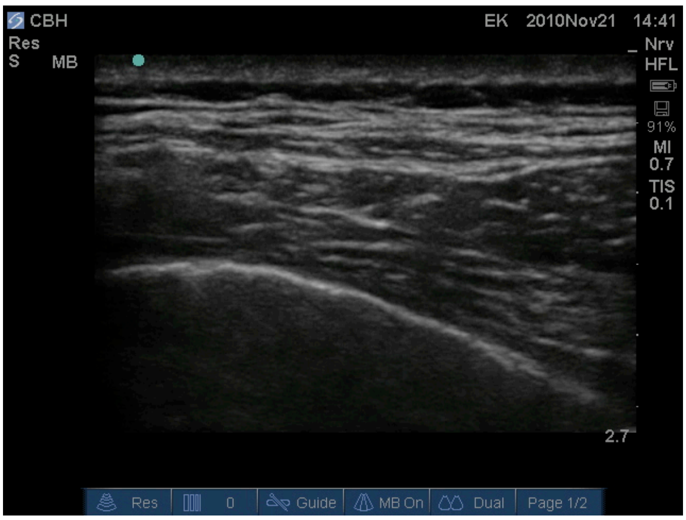
The needle of choice is a short bevelled 22 gauge block needle. Echogenic needles offer enhanced tip visibility at the insertion angle. 2-5ml of LA is sufficient for this block. Adrenalin containing solutions may slow systemic absorption and prolong block duration.

Ultrasound-Guided Interventional Procedures in Pain Medicine: A Review of Anatomy, Sonoanatomy, and Procedures: Part I: Nonaxial Structures. PWH Peng, S Narouze. Regional Anesthesia and Pain Medicine (2009) vol. 34 (5) pp. 458

Exercise:

1. A suitable subject and an ultrasound machine, with a high frequency linear (HFL) probe 25 or 38mm in length.
2. Turn the US machine on. The following settings should be selected; Nerve preset, GEN or RES, depth 4cm initially.
3. Position the subject prone, with an arm abducted. Add gel to the transducer and place it on the posterior rib angle 5-10cm lateral to the midline, and parallel to the spine.
4. Identify the subcutaneous tissues and superficial muscles, and the ribs below them. The depth can be adjusted to place the ribs in the centre of the screen. Identify the intercostal muscles between the ribs. Varying the tilt of the transducer may allow the individual muscle layers to be seen more clearly.
5. An attempt to find the intercostal artery should be made, by placing a Colour Flow or Power Doppler box over the intercostal muscles.
6. The pleural line can be visualised as a hyperechoic line just deep to the intercostal muscles. Ask the subject to take a deep breath in and out, observing the movement of the pleura. Can you see a reverberation artefact deep to the pleural line (better seen by increasing the gain) ? A comet tail sign may also be visible.
7. Rotate the transducer so it lies parallel to the ribs and over the intercostal space, and identify the structures in steps 4-6 again.

Intercostal longitudinal



Intercostal transverse (slightly oblique)

Module 26. Rectus Sheath Block

Essential Reading:

Rectus sheath block provides anaesthesia and analgesia for midline anterior abdominal wall surgery, such as umbilical and incisional hernia repair. The cutaneous innervation to this region is from the terminal branches of 9th-11th intercostal nerves. It does not provide any analgesia for visceral components that may have herniated through the abdominal wall. The block is performed bilaterally, and for umbilical procedures is often performed above and below the umbilicus bilaterally, requiring 4 injections.

A high frequency linear ultrasound probe is used, with RES or GEN resolution setting and Nerve preset. With the patient supine, the probe is placed in the transverse plane lateral to the midline. Subcutaneous tissue, anterior rectus sheath, rectus abdominis muscle, and posterior rectus sheath are identified. Note the abdominal contents below the posterior rectus sheath, which is associated with peritoneum. Vessels and fascial layers may be identified within the rectus muscle.

To perform the block, a 22 gauge short bevelled needle is inserted in-plane from either side of the transducer, and passed through the rectus muscle to its posterior border. A loss of resistance may be felt, as well as a “scratching” sensation when moving the needle along the posterior rectus sheath. Injection of local anaesthetic should result in spread along the fascial plane, and the needle tip position should be adjusted to achieve this. 5-10ml local anaesthetic is injected at each spot.

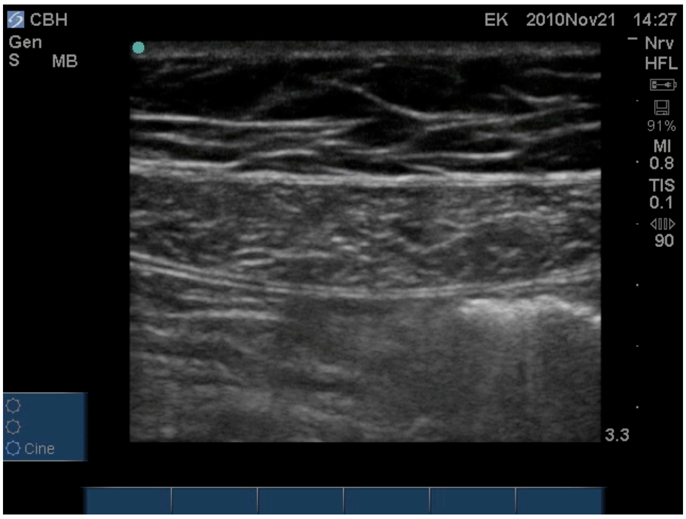
Recommended Reading:

Ultrasonography-guided rectus sheath block in paediatric anaesthesia-a new approach to an old technique. H Willschke, A Bosenberg, P Marhofer, S Johnston, SC Kettner, O Wanzel, S Kapral. British Journal of Anaesthesia (2006) vol. 97 (2) pp. 244

Exercise:

1. An ultrasound machine with a high frequency linear probe (25-50mm) is required. Setting; Nerve preset, RES or GEN, 4cm.
2. Position the subject supine, with the US machine on the opposite side of the bed.
3. Place the transducer on the abdominal wall in the transverse orientation just lateral to midline.
4. Identify subcutaneous tissue, rectus abdominis muscle underneath, with the hyperechoic anterior and posterior rectus sheaths. Also identify any moving intra-abdominal contents.
5. Adjust depth and gain to optimise your image.
6. Identify the posterior border of the rectus muscle where the needle is placed to perform a block – do not do this to your volunteer.

7. Change the tilt of the transducer and observe how the appearance of the muscle changes.
8. Slide the transducer laterally and identify external oblique, internal oblique and transversus abdominis as they gradually come into view, and observe how rectus disappears.



Rectus transverse

Module 27. Transversus Abdominis Plane (TAP) Block

Essential Reading:

The skin of the anterior abdominal wall is innervated by the cutaneous thoracic nerves (T6 to T12). These nerves run in the Transversus Abdominis Plane (TAP) as they pass anterior from the intercostal spaces as terminal branches of the intercostal nerves running towards the midline of the abdomen where they pass superficially to innervate the skin. The nerves can be blocked with local anaesthetic in the TAP to aid in the provision of analgesia. It is important to note that the TAP block provides no visceral analgesia and as such cannot be relied upon for anaesthesia for procedures within the abdomen and has a role as a part of a multimodal analgesic approach.

The TAP can be approached at 2 sites on each side dependent on the area needing to be blocked. A rough 'rule' of thumb is that an incision above the umbilicus requires a **subcostal** approach and an incision extending below the umbilicus requires a **lateral** approach. If the incision is in the midline the TAP must be performed on both sides. This means an extensive abdominal incision may require 4 separate injection sites.

The Transversus Abdominis muscle is the deepest muscle in the anterior abdominal wall lying immediately superficial to the peritoneum. The TAP is the tissue plane immediately superficial to the Transversus Abdominis muscle and it is this plane that is targeted during a TAP block. It is unusual to visualise the nerve prior to injection of local anaesthetic but once a pool of hypoechoic local anaesthetic is deposited hyperechoic structures may be seen within the local anaesthetic pool which may represent the nerves.

Lateral approach – A 38mm linear or a curvilinear probe may be used for this block. Dependent on the patient body habitus the injection point may be anywhere from 2cm to >10cm depth. The patient is positioned supine. The operator stands at the side of the patient with the ultrasound machine on the opposite side. The ultrasound probe is placed on the lateral abdominal wall in the space between the inferior costal margin and the iliac crest in a vertical orientation relative to the bed. 3 distinct muscle layers should be identified with a variable amount of subcutaneous and adipose tissue superficial to the muscle layers. The peritoneum should be visualised and bowel peristalsis may be seen. To aid identification of the muscle layers the 2 superficial most (external and internal oblique) often appear to have a 'chevron' like appearance – the fibre orientation of these muscles are perpendicular to each other. The Transversus Abdominis muscle often has very little in the way of internal structure visible appearing hypoechoic. If the operator moves the probe even more laterally into the flank the Transversus Abdominis may be seen to taper to a point. The depth of the TAP is identified, bearing in mind that the probe may be indenting the skin quite significantly. The needle insertion point should reflect this distance to allow the needle passage to be perpendicular to the ultrasound beam to optimise the view of the needle. Once the TAP is entered the local anaesthetic may be used to hydrodissect the plane further. The injection should have little resistance and the TAP should be seen to 'unzip' and a biconcave pool of local anaesthetic is often seen. 20 to 30 ml of local anaesthetic is required.

Subcostal approach – The upper thoracic nerves (T6-9) are usually not blocked by the lateral approach as they emerge from the intercostal spaces too medially. To block these nerves for supra-umbilical incisions a subcostal approach must be used, again bilaterally if the incision involves the midline. The same probe can be used for the lateral & subcostal approach with the operator & ultrasound machine positioned as described above. The probe should be placed obliquely on the abdominal wall parallel and inferior to the costal margin. The abdominal wall musculature changes here. As one moves from lateral to medial the internal and external oblique muscles taper and the Rectus muscle becomes visible overlying the Transversus Abdominis muscle that continues as the deepest muscle towards the midline. The Transverse Abdominis muscle will taper to a point as one continues to move the probe medially. The needle is inserted distal to the xiphisternum and orientated in the long axis to the probe to enter the TAP. The TAP is opened up with hydrodissection and the block is performed with 20 to 30 ml of local anaesthetic. The superior epigastric artery may be visualised in the TAP with the Subcostal approach and care must be taken to avoid an intra-arterial injection.

It must be remembered that often large volumes of local anaesthetic are required for the TAP block especially if a 4 quadrant (bilateral lateral & subcostal approaches) block is performed. Care must be taken to calculate a safe local anaesthetic dose.

Ultrasound for regional anaesthesia website - Transversus Abdominis Plane (TAP) Block

Ultrasound-guided transversus abdominis plane block: description of a new technique and comparison with conventional systemic analgesia during laparoscopic cholecystectomy. AA El-Dawlatly, A Turkistani, SC Kettner, AM Machata, MB Delvi, A Thallaj, S Kapral, P Marhofer. British Journal of Anaesthesia (2009)

Recommended Reading:

NYSORA - Transverse Abdominis Block

Ultrasound-Guided Continuous Oblique Subcostal Transversus Abdominis Plane Blockade: Description of Anatomy and Clinical Technique. PD Hebbard, MJ Barrington, C Vasey. Regional Anesthesia and Pain Medicine (2010) vol. 35 (5) pp. 436

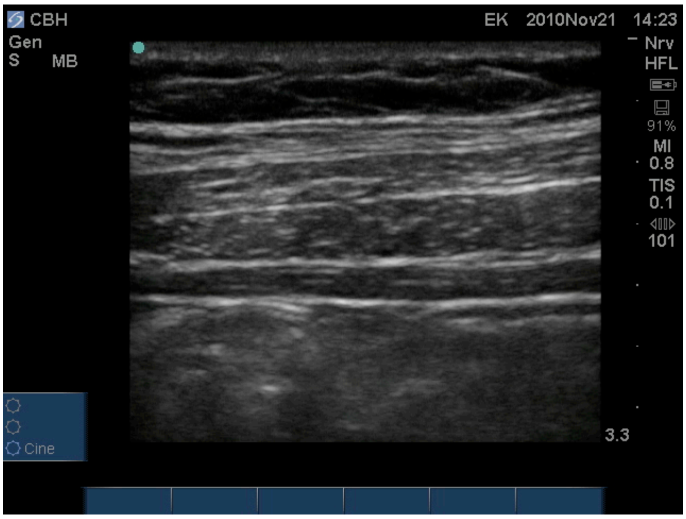
Further Reading:

Ultrasound-guided transversus abdominis plane block for analgesia after Caesarean delivery. D Belavy, P J Cowlishaw, M Howes, F Phillips. British Journal of Anaesthesia (2009) vol. 103 (5) pp. 726-30

Plasma Ropivacaine concentrations after ultrasound-guided transversus abdominis plane block. J Griffiths, F Barron, S Gran. Br J Anaesth. 2010 Sep 22. [Epub ahead of print]

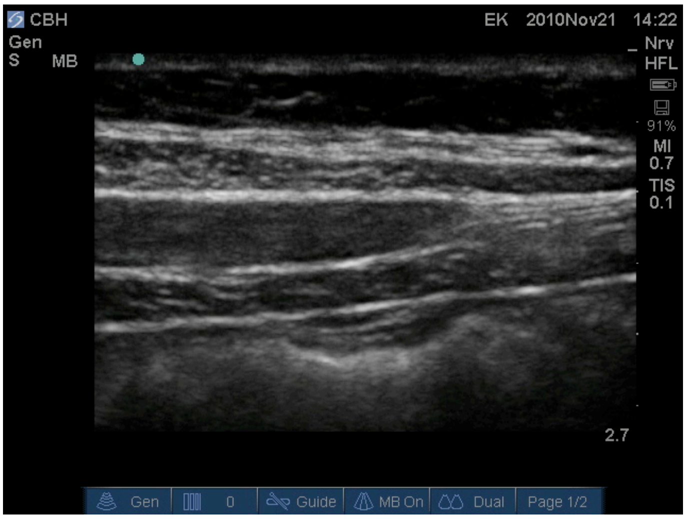
Exercises

1. Place the ultrasound probe on the patient's lateral abdominal wall between the inferior costal margin and the iliac crest orientated vertically. Identify the following structures; subcutaneous & adipose tissue, external oblique, internal oblique, transverse abdominis and transverse abdominis plane (TAP). Identify peristalsis of bowel deep to transverse abdominis muscle.

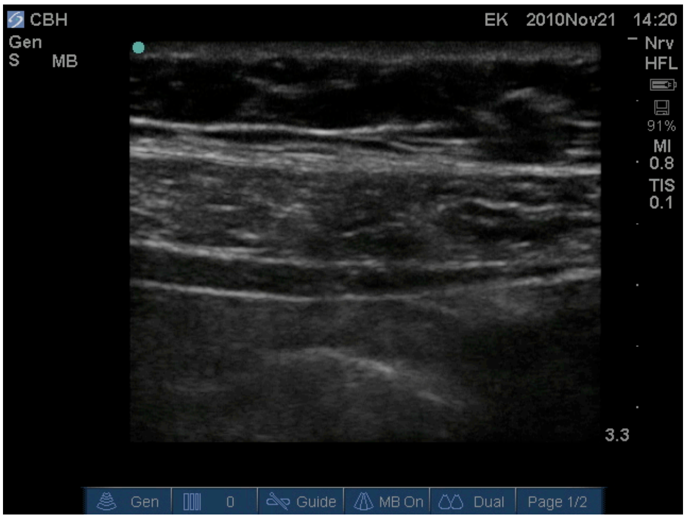


TAP view lateral abdominal wall

2. Place the ultrasound probe in the subcostal region parallel to the costal margin. Identify the medial edge of the external & internal obliques and then the rectus muscle. Identify the TAP superficial to the hypoechoic transverse abdominis muscle. Try to identify the superior epigastric artery.



Lateral subcostal view, transition to 3 muscle layers (external & internal oblique and transversus abdominis)



Medial subcostal view of rectus and transversus abdominis

Module 28. Ilioinguinal/ Iliohypogastric Nerve Block

Essential Reading:

The Ilioinguinal & Iliohypogastric nerves are terminal branches of the L1 root of the lumbar plexus. They innervate the skin of the groin and upper medial thigh and also, along with the Genitofemoral nerve, variable areas of the external genitalia. Blockade of these nerves may be used for analgesia for inguinal hernia surgery. Anaesthesia may be provided by blockade of these nerves though complete anaesthesia for inguinal hernia is difficult to achieve with nerve block alone & often requires supplemental local anaesthetic infiltration.

The nerves can usually be identified in the Transverse Abdominis Plane (TAP - see Module 27 – TAP) but a more inferior approach is required than for the usual lateral approach to the TAP block. To perform this block a 38mm linear probe is ideal though if being performed on a child a 25mm linear probe may be more appropriate. The patient should be positioned supine with the operator standing on the side to be blocked and the ultrasound machine on the other side of the patient. The probe is placed on the lower abdominal wall in line with a line joining the umbilicus to the anterior superior iliac spine. The 3 muscle layers of the anterior abdominal wall are identified; external oblique, internal oblique and transverse abdominis as described in Module 27. The 2 nerves should be sought & will appear as 2 small hyperechoic structures in the TAP. The nerves may also be identified as a thickening of the TAP and not as discrete nerves. There may be some variability in patients and the 2 structures may be seen within the transverse abdominis muscle itself. The needle should be positioned so as to inject local around the 2 structures with injection of sufficient local anaesthetic to surround the nerves. If no nerves are visualised a modified TAP block may be performed with the end-point being 'unzipping' of the TAP at this level with 20 ml of local anaesthetic.

Small vessels often run in this plane at this level & it is important to visualise local anaesthetic spread on injection after negative aspiration to minimise the risk of an intravascular injection. Colour Doppler may also be used if available to help identify blood flow.

Ultrasound for regional anaesthesia website - Ilioinguinal/Iliohypogastric Nerve Block

Recommended Reading:

Ultrasonography for ilioinguinal/iliohypogastric nerve blocks in children. H Willschke, P Marhofer, A Bosenberg, S Johnston, O Wanzel, SG Cox, C Sitzwohl, S Kapral. British Journal of Anaesthesia (2005) vol. 95 (2) pp. 226

Exercises:

1. Mark a line joining the umbilicus to the anterior superior iliac spine.

2. Place the ultrasound probe on the line identified above and confirm probe / screen orientation. Identify the following structures; subcutaneous & adipose tissue, external oblique, internal oblique, transverse abdominis and transverse abdominis plane (TAP).

3. Identify the 2 hyperechoic structures lying within the TAP or in the Transverse Abdominis muscle beneath. If the nerves are not visible try to identify a thickening of the TAP.

4. Apply Doppler and identify any blood vessels in and around the region of the block.

View of ilioinguinal/iliohypogastric nerves

Module 29. Proximal Sciatic Nerve Block

Essential Reading:

The sciatic nerve is the largest nerve in the body. It innervates the posterior aspect of the thigh, and most of the lower leg and foot, apart from the medial aspect which is supplied by the saphenous nerve. Sciatic nerve block provides anaesthesia and analgesia for ankle and foot surgery, and when combined with femoral, lateral femoral cutaneous and obturator nerve blocks, or a 3-in-1 block, anaesthesia and analgesia of the entire lower limb can be achieved.

Traditional landmark and nerve stimulator techniques were quite tricky, with variable success rates, possibly a result of anatomical variation. Ultrasound guided approaches are modified from traditional approaches, and are considered advanced techniques. The sciatic nerve can be difficult to see using ultrasound because it is located deep in the thigh, and surrounded by muscles which attenuate the signal. The steep angle of needle insertion also makes needle visualisation difficult.

Many approaches to sciatic nerve block have been described; anterior, parasacral, transgluteal, infragluteal, lateral, posterior subgluteal, infragluteal–parabiceps, proximal thigh, and popliteal. Block characteristics are similar for these approaches, with the more proximal blocks (subgluteal and higher) anaesthetising the posterior femoral cutaneous nerve which supplies the posterior aspect of the thigh. Using ultrasound, the sciatic nerve can be followed up the thigh starting in the popliteal fossa. It becomes difficult to visualise in the buttock, where the gluteus maximus is at its greatest thickness. The sciatic nerve block can be performed anywhere along this path.

Two approaches for the proximal sciatic nerve block will be described; the subgluteal approach has obvious landmarks and the sciatic nerve is easier to visualise than higher levels, and the anterior approach as it can be performed in the supine position. The popliteal sciatic block is described in module 31.

In the subgluteal approach, the patient is placed in the lateral position, with the side to be blocked uppermost, and the hip and knee flexed. The ultrasound machine is placed on the other side of the bed, and should be set to nerve preset, GEN frequency, and a depth of 10cm. A curved low frequency transducer is placed along a line that joins the greater trochanter laterally, with the ischial tuberosity medially. Below the subcutaneous tissue, gluteus maximus is identified. The greater trochanter can be identified laterally, and the ischial tuberosity medially. The hypoechoic subgluteal space is visualised deep to gluteus maximus and between the boney landmarks, with quadratus femoris forming the anterior border to this space. Image depth and gain should be adjusted appropriately. The sciatic nerve is seen as a hyperechoic oval structure 1.5-2cm in diameter. Slight changes in tilt may improve nerve visibility.

Subgluteal sciatic nerve block is performed in-plane from the lateral edge of the transducer, using a 18-21 gauge 100mm short bevel needle. An echogenic needle should be used if available. Visualisation of the needle is poor due to the steep angle of insertion. Hydrolocation can be used to confirm needle tip position. Some practitioners aim for needle-nerve contact and observe sciatic nerve movement induced by the needle. Neurostimulation is unreliable, sometimes requiring needle entry into the nerve before stimulation takes place. 20-30ml of local anaesthetic is injected into the subgluteal space adjacent to the sciatic nerve, with a portion of the dose injected slightly deep to the nerve to flow along its anterior border, and the remainder injected slightly more superficially to flow along the posterior border. The subgluteal space is seen to expand during injection.

The anterior approach is performed with the patient in the supine position, hip and knee flexed, and externally rotated. A curved low frequency probe is used, with nerve preset, GEN frequency and a depth of 11cm. The probe is placed perpendicular to the skin, on the antero medial aspect of the thigh 8cm distal to the inguinal crease. Subcutaneous tissues, the femoral artery and vein, and anterior thigh muscles are identified. From lateral to medial, pectineus, adductor longus (more superficial), adductor brevis (in between) and adductor magnus (deeper) can be seen. The anterior branch of obturator nerve lies in the fascia between adductor longus and brevis, and the posterior branch lies between adductor brevis and adductor magnus. Both may be accompanied by an arterial branch. The lesser trochanter of the femur is visualised on the lateral edge of the image. The sciatic nerve is identified as a hyperechoic structure at the level of and medial to the lesser trochanter. Ultrasound settings should be adjusted to optimize the image. Changing the tilt of the transducer may help increase visibility of the nerve. Gluteus maximus can be identified posterior to the sciatic nerve.

To perform the block using the anterior approach, the needle (same as for subgluteal approach) is inserted from the anterior edge of the transducer in-plane, avoiding the femoral vessels, and directed to lie just next to the sciatic nerve. 20-30ml local anaesthetic is injected, ensuring spread around the nerve. The needle can be repositioned if spread is inadequate.

The sciatic nerve is easily susceptible to injury through ischaemia, as it is a large nerve with marginal blood supply. Adrenalin containing local anaesthetics, and increased tissue pressure induced from local anaesthetic injection, patient positioning, preexisting disease and tourniquet use, may all contribute to inadequate blood supply. High concentrations of local anaesthetic may also contribute to neurotoxicity. Some practitioners avoid adrenalin containing solutions and high concentrations of local anaesthetic.

Ultrasound for regional anaesthesia website - Sciatic Nerve Block - Gluteal Region

Ultrasound for regional anaesthesia website - Sciatic Nerve Block - Subgluteal Region

Ultrasound for regional anaesthesia website - Sciatic Nerve Block - Proximal Thigh Region

Recommended Reading:

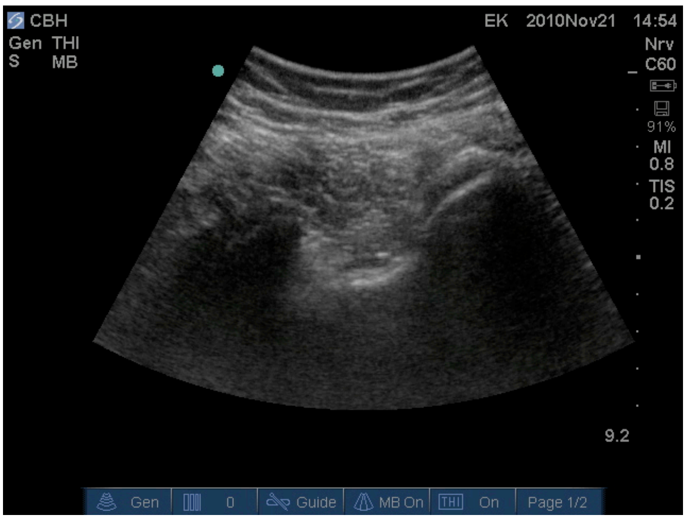
Ultrasound examination and localization of the sciatic nerve: a volunteer study. VWS Chan, H Nova, S Abbas, CJL McCartney, A Perlas, D Quan Xu. Anesthesiology (2006) vol. 104 (2) pp. 309

Ultrasound-guided anterior approach to sciatic nerve block: a comparison with the posterior approach. J Ota, S Sakura, K Hara, Y Saito. Anesthesia & Analgesia (2009) vol. 108 (2) pp. 660

Ultrasound-guided sciatic nerve block: description of a new approach at the subgluteal space. MK Karmakar, WH Kwok, AM Ho, K Tsang, PT Chui, T Gin. British Journal of Anaesthesia (2007) vol. 98 (3) pp. 390

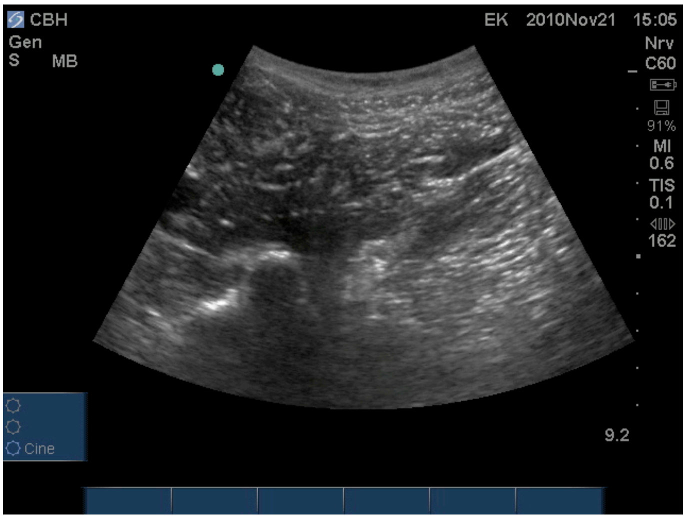
Exercises:

1. A suitable subject and an ultrasound machine, with a curved low frequency probe is required.
2. Turn the US machine on. The following settings should be selected; Nerve preset, GEN , depth 11cm initially.
3. For the subgluteal approach, the patient is placed in the lateral position, with the side to be blocked uppermost, and the hip and knee flexed.
4. Position the ultrasound machine on the other side of the bed.
5. Place the transducer along a line that joins the greater trochanter laterally, with the ischial tuberosity medially.
6. Identify the subcutaneous tissue and gluteus maximus. The greater trochanter can be identified laterally, and the ischial tuberosity medially.
7. The hypoechoic subgluteal space is visualised deep to gluteus maximus and between the boney landmarks, with quadratus femoris forming the anterior border to this space.
8. Image depth and gain should be adjusted appropriately. Slight changes in tilt may improve nerve visibility.
9. Identify the sciatic nerve; a hyperechoic oval structure 1.5-2cm in diameter.



View of sciatic nerve in subgluteal space

10. For the anterior approach position the subject in the supine position, hip and knee flexed, and externally rotated.
11. Place the probe perpendicular to the skin, on the antero medial aspect of the thigh 8cm distal to the inguinal crease.
12. Identify subcutaneous tissues, the femoral artery and vein, and the anterior thigh muscles; lateral to medial, pectineus, adductor longus (more superficial), adductor brevis (in between) and adductor magnus (deeper) can be seen. The fascia separating these muscles may be poorly defined in some subjects making it difficult to distinguish the different muscles. Changing the angulation of the transducer may help.
13. Now try to identify the anterior branch of obturator nerve, which lies in the fascia between adductor longus and brevis.
14. Try to identify the posterior branch of the obturator nerve, which lies between adductor brevis and adductor magnus.
15. Place a color flow Doppler box over both obturator nerves, which may be accompanied by an arterial branch.
16. Identify the lesser trochanter of the femur on the lateral edge of the image.
17. Can you see the sciatic nerve ? It is a hyperechoic structure at the level of and medial to the lesser trochanter.
18. Ultrasound settings should be adjusted to optimize the image. Changing the tilt of the transducer may help increase visibility of the nerve
19. Identify gluteus maximus posterior to the sciatic nerve.



View of anterior approach to sciatic nerve

Module 30. Saphenous Nerve Block

Essential Reading:

The Saphenous nerve is a terminal branch of the femoral nerve providing sensory innervation to the medial side of the lower leg to the medial aspect of the ankle and proximal foot. The significance of this nerve to regional anaesthesia is that to complete a block of the lower limb below the knee, both sciatic nerve and saphenous nerve blocks must be performed.

There are 3 main locations that the saphenous nerve can be blocked using ultrasound guidance
1. Mid-thigh adjacent to femoral artery in the subsartorial plane
2. Above the knee in the subsartorial plane
3. Below the knee adjacent to the saphenous vein on the medial aspect of the tibia

The depth of the nerve from the skin varies according to the site chosen and the body habitus of the patient. In all but the most obese patient a linear transducer (38 or 25mm) is chosen. The nerve is often difficult to visualise at all locations due to it's small size but if seen is a hyperechoic structure in the relevant location. Often a plane or peri-vascular block is required if the nerve is not directly seen.

Specific sonoanatomy and techniques:

1. Mid-thigh: The probe is placed on the anterior aspect of the thigh distal to the groin and perpendicular to the long axis of the femur. The femoral artery is identified and followed down the thigh. At approximately mid-thigh level the femoral artery is seen to be in a plane immediately deep to a 'wedge-shaped' muscle (the apex of the wedge laterally). This is the *Sartorius* muscle. The saphenous nerve lies **lateral** to the artery in the sub-sartorial plane. As the saphenous nerve is rarely seen the aim of this technique is placement of the local anaesthetic in this plane immediately **deep** to the *Sartorius* muscle and **lateral** to the femoral artery. A 10cm needle is inserted in a long axis orientation from lateral to the probe towards the femoral artery and 5-10ml of local anaesthetic is injected in the sub-sartorial plane lateral to the artery.

2. Above knee: The probe is placed on the anterior aspect of the thigh approximately 8-12cm above the patella perpendicular to the long axis of the femur. The hyperechoic 'stripe' of the femur is identified and immediately superficial to this is the muscle *Vastus medialis*. The probe is moved postero-**medially** keeping the muscles in view. The *Sartorius* muscle is found immediately postero-medially to the *Vastus medialis* with the saphenous nerve usually lying in the plane immediately deep to the *Sartorius* muscle. As the saphenous nerve is rarely seen the aim of this technique is placement of the local anaesthetic in the plane immediately **deep** to the *Sartorius* muscle. A 10cm needle is inserted in a long axis orientation from lateral to the probe, passing through the *Vastus medialis* muscle and depositing 5-10 ml of local anaesthetic in the plane immediately deep to *Sartorius*.

3. Below knee: From the level of the knee joint down as far as the medial malleolus of the ankle the saphenous nerve runs immediately adjacent to the saphenous vein. This

collapsible vascular structure is identified in the short axis. The block needle is inserted in the long axis and a perivascular injection of 5ml of local anaesthetic is performed. As the saphenous nerve and saphenous vein run together from knee to ankle the block performed at any level in this range bearing in mind the area the operator wishes to block.

Ultrasound for regional anaesthesia website - Saphenous Nerve Block

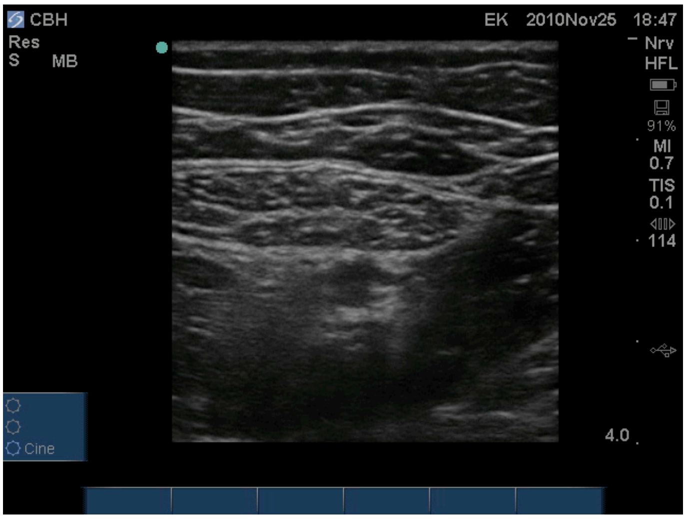
Recommended Reading:

Preliminary experience with a new approach to performing an ultrasound-guided saphenous nerve block in the mid to proximal femur. Jennifer D Kirkpatrick, Brian D Sites, John G Antonakakis. Regional Anesthesia and Pain Medicine. 2010 vol. 35 (2) pp. 222-3

Anatomic basis to the ultrasound-guided approach for saphenous nerve blockade. JL Horn, T Pitsch, F Salinas, B Benninger. Regional Anesthesia and Pain Medicine. 2009 vol. 34 (5) pp. 486

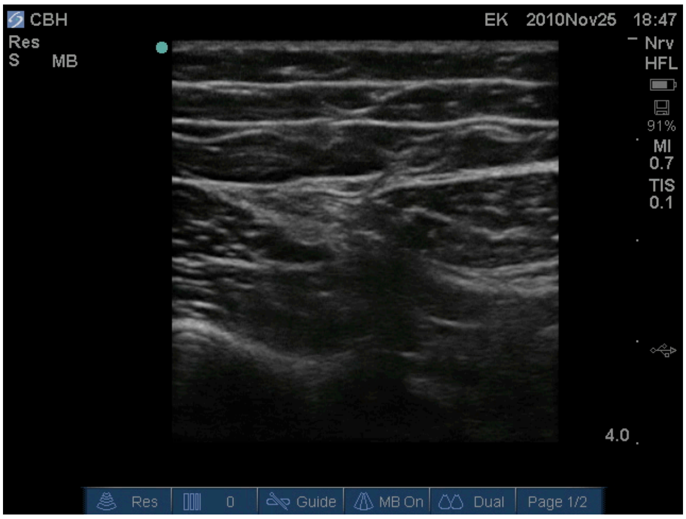
Exercises:

1. Scan the anterior thigh from the groin distally and identify the femoral artery, confirming with colour Doppler. Observe the wedge shaped *Sartorius* muscle immediately superifical to the artery and the subsartorial plane which contains the artery. If possible identify the hyperechoeic saphenous nerve.



Saphenous nerve and femoral artery mid-thigh

2. Scan the anterior thigh 8-12cm proximal to the patella. Identify the curved hyperechoeic anterior surface of the femur and the overlying *Vastus medialis* muscle. As the probe is moved medially identify the *Sartorius* muscle and the subsartorial plane. If possible identify the hyperechoeic saphenous nerve.
3. Scan the medial aspect of the proximal tibia and identify the very superficial saphenous vein. Too pressure with the probe at this point may collapse the vein and make identification impossible.



Saphenous nerve sub-sartorial plane

Module 31. Popliteal Sciatic Block

Essential Reading:

The Sciatic nerve can be blocked at many levels in the posterior thigh from the gluteal region down to the level at which it bifurcates into the tibial and common peroneal nerves immediately superior to the popliteal fossa.

The terminal branches of the sciatic nerve innervate the entirety of the lower leg with the exception of the medial aspect of the lower leg & ankle (see Module 30. Saphenous). It is a very useful and important block to utilise on its own or in combination with a Saphenous nerve block for peripheral leg surgery both for anaesthesia and perioperative analgesia .

In general a linear probe is utilised to perform the block. In order to access the popliteal region the patient needs to be appropriately positioned according to the operators preference and the patient's comfort. Suggested positions include:

- Supine with lower leg elevated with hip and knee both flexed to approximately 45°
- Lateral with leg to blocked superior and supported on a pillow
- Prone

Specific sonoanatomy and techniques:
The probe is placed transversely at the popliteal crease so the popliteal artery is visualised in the short axis as a hypoechoic pulsatile circle. As the probe is traced proximally the tibial and common peroneal nerves will be visible superficial to the artery as heterogeneously hyperechoic regions, medial and lateral respectively, which as the probe continues to move proximally converge. The convergence indicates the bifurcation of the sciatic nerve. To ensure complete blockade of the sciatic nerve, an injection point at or proximal to the bifurcation should be chosen unless the operator wishes to specifically block one of the 2 branches. The sciatic nerve is a large nerve that has a characteristically anisotropic appearance and as such small alterations in the orientation of the probe can produce dramatic differences in the appearance of the nerve.

Once the nerve is identified, the skin is appropriately prepared and local anaesthetic infiltrated. The block needle should be inserted from the lateral aspect of the thigh, perpendicular to the skin and parallel to the US probe so that the needle intersects the ultrasound beam in-plane. Needle insertion is usually anterior to the biceps femoris tendon. The needle should be advanced to a position immediately deep to the nerve and a 'pop' is often seen & felt as it pierces the fascia surrounding the nerve. After careful aspiration the local anaesthetic should be injected slowly and seen to spread around the nerve. If incomplete spread is seen with the single injection the needle should be repositioned immediately superficial to the nerve and a subsequent injection made. Should the injection be performed at the level of the bifurcation a 'figure 8' of local anaesthetic may be seen around the tibial and common peroneal nerves.

As the sciatic nerve is bulky this block may take up to 30 minutes to evolve depending on the choice of local anaesthetic so adequate time must be given for the block to develop.

Ultrasound for regional anaesthesia website - Sciatic Nerve Block - Popliteal Region

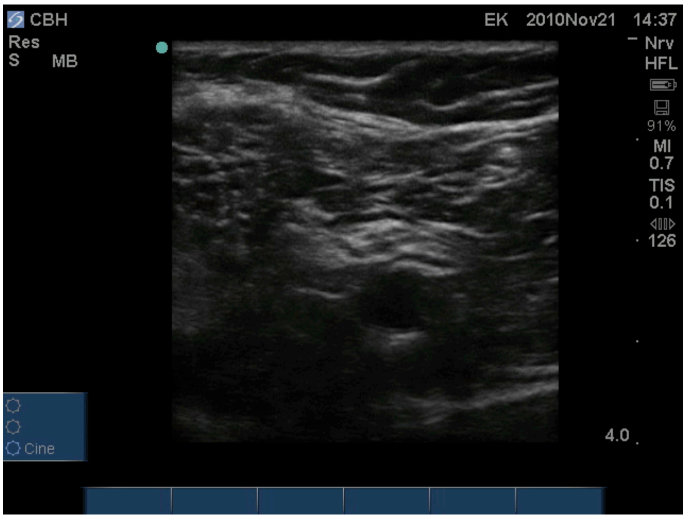
Recommended Reading:

Popliteal fossa block. D Girdharry, P McQuillan. Techniques in Regional Anesthesia and Pain Management (2004) vol. 8 (4) pp. 164-166

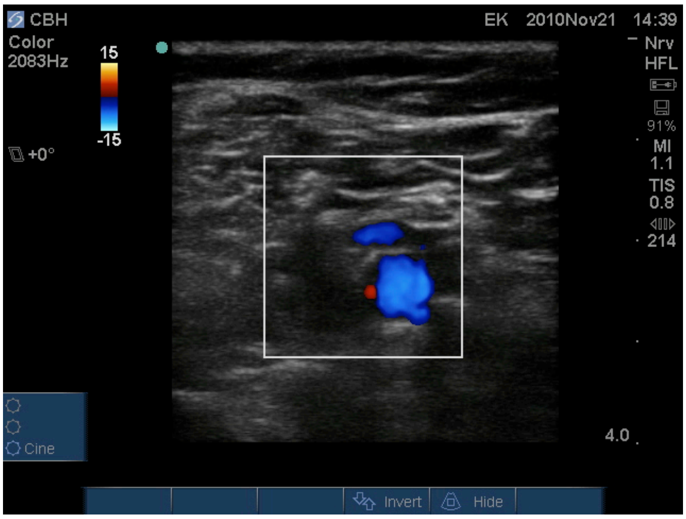
Ultrasound-Guided Popliteal Block Distal to Sciatic Nerve Bifurcation Shortens Onset Time: A Prospective Randomized Double-Blind Study. A Prasad, A Perlas, R Ramlogan, R Brull, V Chan. Regional Anesthesia and Pain Medicine (2010) vol. 35 (3) pp. 267

Exercises:

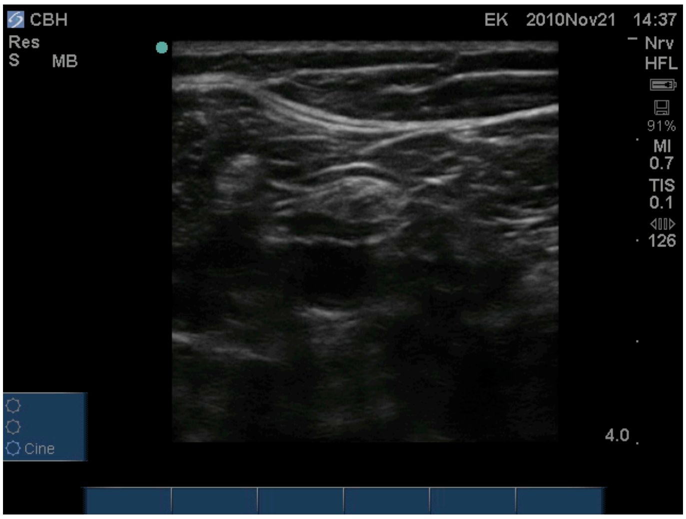
1. Scan the popliteal fossa at the level of the popliteal crease and identify the Popliteal artery, confirming it with colour Doppler.
2. Move the probe proximally and identify the hyperechoeic structures of the common peroneal nerve laterally and the tibial nerve medially. The tibial nerve is likely to be larger than the common peroneal nerve.
3. Continue to move the probe proximally and identify the level of bifurcation of the sciatic nerve into the common peroneal and tibial nerves. Alter the angle of probe to visualise the anisotropic nature of the sciatic nerve.



Sciatic nerve in popliteal fossa



Same image with colour flow doppler



Sciatic nerve dividing into posterior tibial and common peroneal nerves

Assessment 4

In this assessment you will have to demonstrate that you can:

1) image and identify the sonoanatomy relevant for the following blocks:
- Interscalene
- Supraclavicular
- Infraclavicular
- Transversus Abdominus Plane
- Proximal Sciatic – Sub Gluteal Approach
- Distal Sciatic – Popliteal Approach
- Saphenous

Module 32. Thoracic paravertebral block

Essential Reading:

Thoracic paravertebral block can be used instead of intercostal nerve block for thoracic, breast and abdominal surgery, and has the benefit of providing anaesthesia or analgesia to multiple dermatomal levels. Pain relief from this block is comparable to thoracic epidural analgesia, with a lower incidence of side effects.

The thoracic paravertebral space is described as a triangular space; the vertebral bodies, intervertebral discs and vertebral foramina form the medial borders to the base of the triangle. The parietal pleura form the anterior border, while the anterior costotransverse ligament (which joins the transverse processes of adjacent vertebra) forms the posterior border. The paravertebral space contains intercostal nerves, the dorsal rami, the intercostal vessels, and the sympathetic chain, all of which are surrounded by adipose tissue. There is communication between paravertebral spaces on both sides of the spine, and with the epidural space, which rarely results in bilateral or sympathetic block. Indeed, some of the therapeutic effect of paravertebral block is though to be due to a small degree of epidural extension.

The block can be performed with the patient in the sitting, prone or lateral position. In very thin subjects, a high frequency linear probe may be used, but the majority of patients will require a lower frequency curved probe. The paravertebral region can be scanned in the longitudinal and transverse orientations, both of which will be described. After identifying the appropriate level for the block, the transducer is placed in a longitudinal orientation 2-3cm lateral and parallel to the spine, and depth adjusted (4-6cm) to allow visualization of subcutaneous tissue, paravertebral muscles and transverse processes (these appear as hyperechoic round structure casting a shadow). Between the shadows of the transverse processes, a more echogenic area is observed containing connective tissue. Deep to this an echogenic pleural line is observed, which can be confirmed by the presence of movement with respiration. The above image is difficult to acquire, and will require adjustment of transducer position by sliding laterally or medially, and varying the tilt of the transducer.

The transverse view can be obtained by placing the transducer transversely at the desired level, with the medial edge of the transducer 2-3cm lateral to the midline overlying the transverse process. Subcutaneous tissue and paravertebral muscles lie superficially to the transverse process, while the paravertebral space lies lateral and slightly deeper, with the pleural line visible below that. If a shadow is cast by the presence of the rib in the image, the lateral edge of the transducer can be moved slightly obliquely.

The needle approaches to this block are dependent on the view obtained. In the longitudinal view, the in-plane approach is difficult because of the steep needle approach and close proximity of the adjacent transverse process. The block needle is advanced until the tip is 2-3mm posterior to the pleural line, with hydrolocation to confirm tip position. In the out-of plain approach, the needle is advanced from the lateral side of the transducer to the same point, again utilizing hydrolocation to confirm needle tip position.

In the transverse view, the block needle is inserted at the lateral edge of the probe in-plane, and directed medially through the paravertebral muscles so that the needle tip is just posterior to the pleura. Hydrolocation is used to confirm the position of the needle tip. The needle is easier to visualise due to the shallow insertion angle.

A loss of resistance when advancing the needle, loss of resistance to injection of local anaesthetic, or visualisation of local anaesthetic spread in a plane just posterior to the pleura, indicate entry to the paravertebral space, but may not be elicited in all procedures.

The procedure is quite painful due to the number of muscles traversed by the needle. Local anaesthetic infiltration, together with some Fentanyl/Alfentanil and Midazolam are required.

Needle visibility is critical to avoid accidental pleural puncture. Larger size needles (16-20G), echogenic needles, and Enhanced Needle Visualisation where available should be used.

The usual dose for a single shot paravertebral block is 10-15ml for a single level, or 5-10ml when multi-level blocks are performed. Higher volumes increase the number of dermatomes blocked, but also increase the risk of epidural or contralateral spread.

For continuous blockade, a 16 or 18 gauge Tuohy needle is used to enter the paravertebral space, and after injection of 5-10ml local anaesthetic or saline, the catheter is passed 2-3cm from the tip. The needle is withdrawn and local anaesthetic is injected observing the spread, and the position adjusted if necessary by retracting the catheter. Analgesia is maintained by intermittent bolus injection, or continuous plus PCRA infusion of dilute local anaesthetic.

Continuous thoracic paravertebral block can also be achieved from a more lateral intercostal approach. In a transverse view of the intercostal space, a Tuohy needle is used to access the intercostal space as described in Module 25. After injection of 10ml local anaesthetic, the block catheter is inserted 7cm from the tip of the needle, placing the tip in the paravertebral space. The reduced depth of the intercostal space results in easier needle visualisation.

Ultrasound for regional anaesthesia website - Thoracic Paravertebral Block

Ultrasound-guided thoracic paravertebral block. MK Karmakar. Techniques in Regional Anesthesia and Pain Management (2009) vol. 13 (3) pp. 142-149

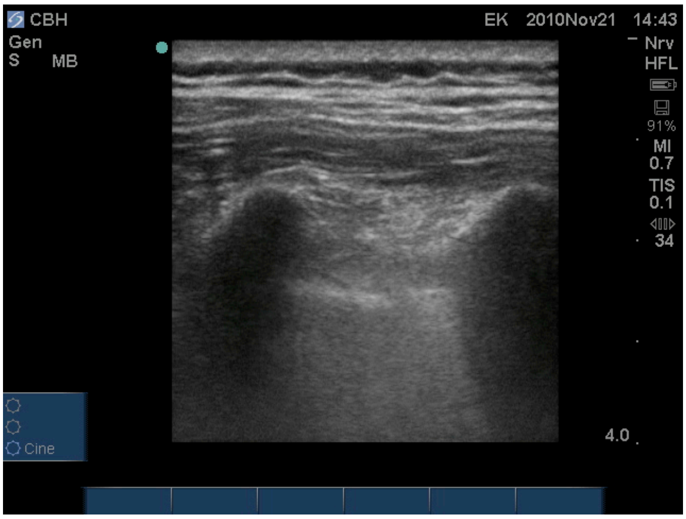
Recommended Reading:

Ultrasound-guided paravertebral block using an intercostal approach. A Ben-Ari, M Moreno, JE Chelly, PE Bigeleisen. Anesthesia & Analgesia (2009) vol. 109 (5) pp. 1691

Exercises:

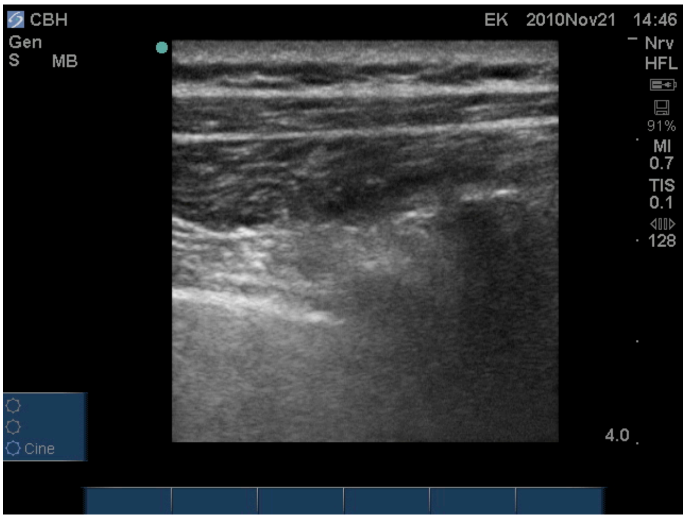
1. A suitable subject and an ultrasound machine, with a high frequency linear (HFL) probe 38mm in length or curved low frequency probe.
2. Turn the US machine on. The following settings should be selected; Nerve preset, GEN , depth 6cm initially.
3. Position the subject sitting as for spinal insertion. Add gel to the transducer and place it on the spine 2-3cm lateral to the midline, and parallel to the spine.
4. Identify the subcutaneous tissues and paravertebral muscles, and the transverse processes below them. The depth can be adjusted to place the transverse process in the centre of the screen. Identify the pleural line deep to the transverse process, and observe movement during respiration. Varying the tilt of the transducer, or sliding laterally or medially may allow structures to be seen more clearly.

Longitudinal paravertebral view with C60 low frequency curved probe



Longitudinal paravertebral view with 38mm high frequency linear probe

5. Rotate the transducer so that the medial edge lies over the transverse process, and the rest of the face of the transducer overlies the intercostal space. Identify the subcutaneous tissue, the paravertebral muscles, and the pleural line.
6. Now slide the transducer laterally while keeping it in the intercostal space, so that the lateral edge of the transducer lies about 7cm lateral from the midline. This is now an intercostal view.



Transverse paravertebral view (slightly oblique)

Module 33. Epidural Imaging

We currently have limited experience with this technique

Recommended Reading:

Ultrasound for regional anaesthesia website - Neuraxial Block

Ultrasound for central neuraxial blocks. MK Karmakar. Techniques in Regional Anesthesia and Pain Management (2009) vol. 13 (3) pp. 161-170

Ultrasound using the transverse approach to the lumbar spine provides reliable landmarks for labor epidurals. C Arzola, S Davies, A Rofaeel, JCA Carvalho. Anesthesia & Analgesia (2007) vol. 104 (5) pp. 1188

Ultrasound guidance for epidural steroid injections. H Shankar, CM Zainer. Techniques in Regional Anesthesia and Pain Management (2009) vol. 13 (4) pp. 229-235

Sonoanatomy of the lumbar spine of pregnant women at term. BCR Borges, P Wieczoreck, M Balki, JCA Carvalho. Regional Anesthesia and Pain Medicine (2009) vol. 34 (6) pp. 581

Module 34. Lumbar Plexus Block

We currently have no experience with this technique

Recommended Reading:

Ultrasound for regional anaesthesia website - Psoas Compartment Block

Ultrasound-guided lumbar plexus block through the acoustic window of the lumbar ultrasound trident. M K Karmakar, A M-H Ho, X Li, W H Kwok, K Tsang, W D Ngan Kee. British Journal of Anaesthesia (2008) vol. 100 (4) pp. 533-7

Module 35. Penile

We currently have no experience with this technique

Recommended Reading:

Ultrasound guided dorsal penile nerve block in children. D J Sandeman, A V Dilley. Anaesth Intensive Care (2007) vol. 35 (2) pp. 266-9

Assessment 5

In this assessment you will have to demonstrate that you can:

1) image and identify the sonoanatomy relevant for the following blocks:
   - Paravertebral
   - Lumbar Plexus
   - Penile
   - Proximal Sciatic – Anterior Approach

2) image and identify the sonoanatomy relevant for neuraxial blocks.