Utilising point of care ultrasound for vascular access in haemodialysis

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Utilising point of care ultrasound for vascular access in haemodialysis

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Abstract

Learning outcomes:

On completion of this continuing professional development activity, participants will be able to:

- Discuss basic ultrasound principles;
- Define the roles and responsibilities of the nurse in point of care ultrasound;
- Identify strategies to utilise ultrasound to provide quality cannulation practice;
- Identify anatomic structures on an ultrasound picture;
- Identify anomalies in the anatomy such as thrombus, stenosis, aneurysm and pseudoaneurysm;
- Describe the advantages and disadvantages of using ultrasound for assessment and cannulation;
- Enable staff to reflect on their current approaches to assessment and cannulation.

Keywords

Vascular, ultrasound, access, haemodialysis, education.

Introduction

Cannulation of arteriovenous fistulae (AVF) and grafts (AVG) has long been a practice that has had its disadvantages. Placement of rigid metal needles into new arteriovenous fistulae can prove challenging in the presence of soft vessels with small diameters. These variables can lead to increased risk of vessel extravasation and haematoma formation. This then perpetuates the problem of cannulation for the next nurse cannulating through haematoma and clots. This situation may lead to the patient being sent home without dialysis, single-needle dialysis or, in worst-case scenarios, the insertion of a central venous catheter (CVC) (Lee, Barker & Allon, 2006). The use of point of care (POC) ultrasound for cannulation has the potential to decrease cannulation-related adverse events (van Hooland, Donck, Ameye & Aerden, 2010; Schoch & Smith, 2012; Marticorena *et al*. 2014).

Ultrasound use in vascular puncture is not a new concept. It has been used in general vascular practice for over 30 years,

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particularly in vessel identification in CVC insertion to avoid accidental arterial puncture where vessels are in close proximity (Lamperti *et al.* 2012). Ultrasound is utilised in emergency department peripheral cannula insertion, usually via basilic vein puncture (Blaivas & Lyon, 2006). A meta-analysis conducted in this area concluded that POC ultrasound increased the cannulation success and had no effect on cannulation time or the number of cannulations. However, with wide variation in cannulation and ultrasound practices within the studies analysed, further research is required in all areas that use POC ultrasound as studies are limited on this topic (Stolz *et al.* 2015).

Ultrasound use in renal vascular access is growing globally. This is largely due to the development of lighter, more portable POC equipment, which enables the clinician to perform more complex assessments at the bedside. The advantages and disadvantages of POC ultrasound in renal vascular access are outlined in Figure 1. To date, the implementation of POC ultrasound in Australia has been ad hoc, with varied levels of education provided to staff. The absence of quality education in POC ultrasound results in substandard practices or equipment being left unused. Anecdotally, some staff express concerns that the use of ultrasound will de-skill them in relation to vascular access physical assessment, specifically inspection, palpation and auscultation. POC ultrasound is an adjunct to this assessment, not a replacement, consequently these concerns are unfounded. International evidence-based recommendations suggest that ultrasound-guided cannulation should be the method of choice for any type of vascular cannulation due to the higher efficacy and safety of this method (Lamperti *et al.* 2012).

The role of the renal nurse

Renal nurses play an integral role in the use of POC ultrasound in haemodialysis. For many years, renal nurses have been cannulating 'blind', leading to miscannulation and infiltration of the vessels, particularly in new AVFs (Lee, Barker & Allon, 2006). Van Loon *et al.* (2009a) reported that in the first six months of an AVF's life there is a 31% chance of miscannulation, 33% chance of requiring single-needle dialysis and 22% chance of reverting to the use of CVC for dialysis. They concluded that the cannulation-related adverse events were eventually associated with vascular access failure. The use of ultrasound as part of POC vascular access assessment and cannulation should assist in decreasing these statistics.

Renal nurses should have a requisite baseline level of knowledge related to the basics of ultrasound. While no renal-specific, evidence-based guidelines regarding the use of POC ultrasound for assessment and cannulation in dialysis exist, those who have implemented POC ultrasound into their dialysis units have reported an improvement in vascular access-related outcomes (van Hooland, Donck, Ameye & Aerden 2010; Schoch & Smith 2012; Marticorena *et al.* 2014).

Advantages of ultrasound:

- Used as an adjunct to current clinical assessment.
- Avoid infiltration of the vessel by allowing staff to choose optimal cannulation sites and visualise insertion.
- Identify problems such as deep vessels, areas of previous infiltration, stenosis or thrombosis to avoid during cannulation.
- Aids in creating an AVF or AVG 'map' for subsequent cannulators.
- Images can be saved and uploaded to patient electronic records or shared among the medical team for case-based discussion.
- Decreases the number of patients requiring Doppler ultrasound in the imaging department.
- Decreases the amount of needle sticks (cannulations) for the patient.
- Decreases cost if CVC, single-needle, subsequent dialysis sessions and radiology visits are decreased or eliminated.

Disadvantages of ultrasound:

- Training required to acquire skills.
- Cost of training to acquire skills.
- Finding the time to use the ultrasound on the vascular access.
- Development of hand/eye coordination.
- Not enough ultrasounds in the unit to go around.
- Cost of ultrasound.

Figure 1: The advantages and disadvantages of POC ultrasound in renal vascular access

Adapted from: Schoch & Smith (2012); Marticorena et al. (2014); van Hooland et al. (2010); Lamperti et al. (2012)

Ultrasound basics

Ultrasound is the sound waves being beamed through a medium (such as fluid, tissue and bone) and back to a probe to elicit a picture. The probe has piezoelectric crystals that produce beams (or sound waves) that travel at different speeds through different mediums. The beam travels easily through fluid and therefore there is little reflection back to the probe, thus making blood appear black. Tissue allows for some of the beam to travel through and some to be reflected, showing up as shades of grey and white on the screen. Bone is the densest material in the body; therefore, it reflects most of the beam so bones appear white on the ultrasound screen with nothing reflected behind them (Abu-Zidan *et al.* 2011).

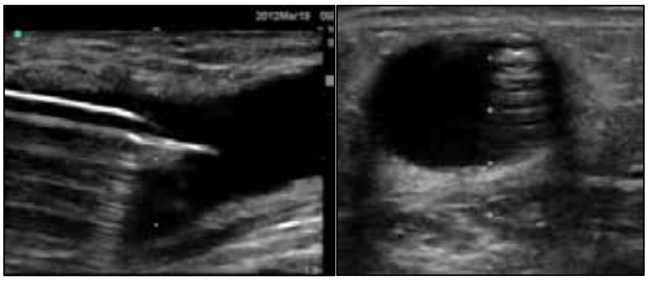
There are two types of ultrasound picture. The first is B-Mode (brightness mode), which is black and white and shades of grey (Abu-Zidan *et al.* 2011). This is the mode used most often for assessment and cannulation of AVF and AVG. Colour mode (not all POC ultrasound machines have this function) is useful if you are unsure of flow direction and colour power. Doppler is useful if you suspect a thrombosed vascular access or decreased flow in the access (van Hooland, Donck, Ameye & Aerden, 2010).

Artefact

An important aspect of ultrasound to be aware of is called artefact. Artefact is a shadowing effect that can trick the eye into thinking there is something there when there isn't.

There are three common types of artefact:

1. Reverberation artefact: is a repeated image of the same structure, typically seen with a dialysis needle (propagation).
2. Enhancement artefact: This is like a mirage on the ultrasound screen. Things may not be as they seem (attenuation).
3. Acoustic shadowing artefact: things such as calcification of a vessel will reflect brightly back to the beam and a shadow will be cast (attenuation) (Hoffman, Rumsey & Nixon, 2008).

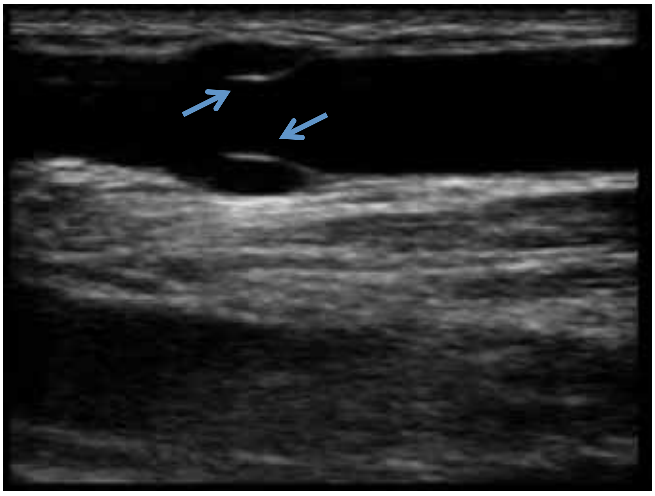


Picture 1: Reverberation artefact of a dialysis needle in (a) longitudinal and (b) transverse planes
Picture courtesy of Rosa Marticorena, Toronto, Canada

Identification of anomalies

Presence of valves

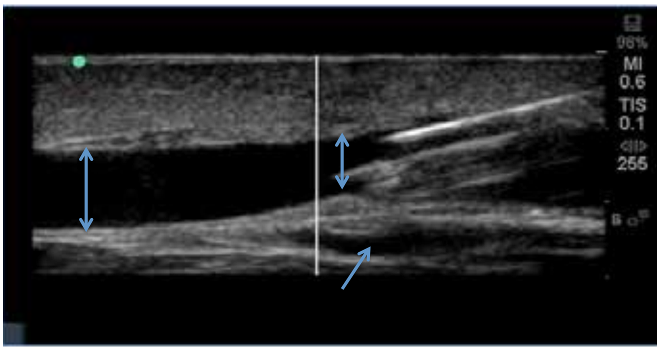
Venous valves are present to assist with the venous return to the heart. Generally when an arteriovenous fistula is created the surgeon will destroy the valves. The reason for this is that with the increased pressure, the outflow vein dilates, which causes stretching of the base of the valve, leading to valve dysfunction and inflammation, which can develop into fibrosis which causes stenosis formation from neo-intimal hyperplasia (Shenoy, 2009). Not only this, but nurses can also get the needle caught on the valves during cannulation, leading to intimal damage and stenosis. Picture 2 shows clearly how the venous valves sit within the vessel. This could easily cause the needle to get 'caught' under the valve, affecting arterial or venous flow (pressures). The use of ultrasound during cannulation or in precannulation assessment can eliminate the catching of these valves and the nurse can avoid this area.



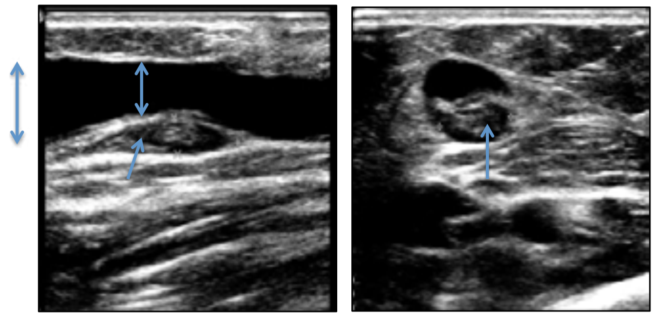
Picture 2: Shows the presence of valves in a newly created arteriovenous fistula
Picture courtesy of Monica Schoch, Victoria, Australia

'Backwalling' or coring of the vessel

One of the main issues with 'blind' cannulation is backwalling of the vessel. As the needle is inserted at the 45-degree angle, the tip of the needle scrapes the back of the vessel and as the needle is levelled out the wall of the vessel is cored with the tip of the needle. The cannulator can be completely unaware that this has occurred, until the next cannulation when the cannulator collects clot in the end of the needle from the damaged vessel. In the past this has led to patients being sent for expensive diagnostic testing to identify the reason for the clot presence (Schoch & Smith, 2012). With POC ultrasound in the dialysis unit the nursing staff can assess the cause of the clot and thus avoid that area for 4–6 weeks until the vessel has healed and the clot reabsorbed. Picture 3 is a classic view of backwalling of a vessel as seen on ultrasound. Picture 4 shows a previously cored vessel. Nursing staff could get the needle in



Picture 3: Classic picture of coring of the back wall of the vessel during cannulation — note the narrowing of the vessel at this point and the clot formation at the tip of the needle. There is fresh bleeding (at arrow) denoted by the clear black of the fluid in the space
Picture courtesy of Frank Grainer, Queensland, Australia

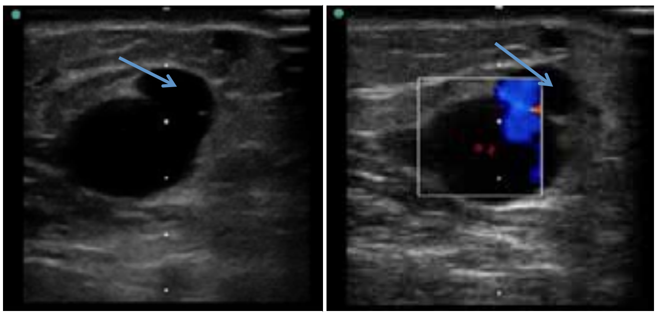


Picture 4: Previous backwalling episode in (a) longitudinal and (b) transverse plains. It is noted as old haematoma due to the presence of white in the damaged area, which is 'old clot'
Picture courtesy of Frank Grainer, Queensland, Australia

at this point but had great difficulty levelling the needle out and threading it in. This thrombotic area was not palpable during AVF assessment. Again this area would heal if avoided and the patient would not require any other diagnostic testing or interventions.

Pseudoaneurysm (false aneurysm)

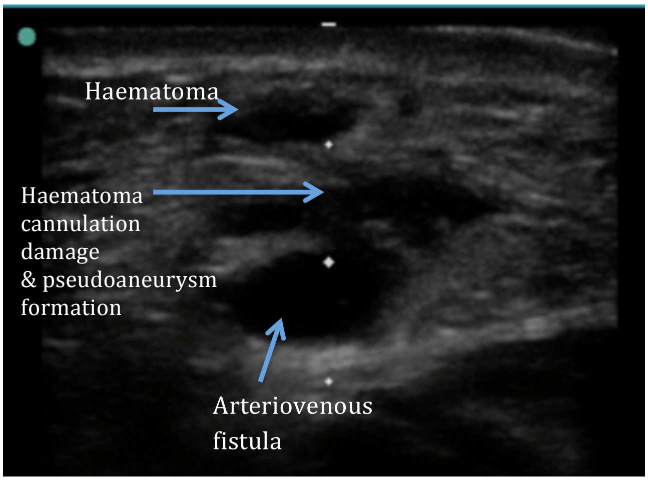
Pseudoaneurysm formation in a dialysis access occurs when the access wall is completely destroyed due to multiple cannulations in the same area (commonly seen in graft), when the needle pierces the back or side wall of the vessels, accidentally allowing blood to extravasate, and sometimes can also occur when the needle site is not held appropriately after needle removal — for example, the person is holding the skin insertion site but not putting pressure on the vessel insertion site. Blood leaking out into the tissues is encapsulated in a thin layer of connective tissue. Pseudoaneurysms communicate with the vessel and have blood flow. There is a risk of rupture as the film encasing the blood is very thin as opposed to the thickened vessel walls. Picture 5 shows a pseudoaneurysm on ultrasound.



Picture 5: Pseudoaneurysm present to the upper right of the vessel (a) in B-mode and (b) colour mode to show the communication with the main vessel
Picture courtesy of Dianne Du Toit, Queensland, Australia

Haematoma

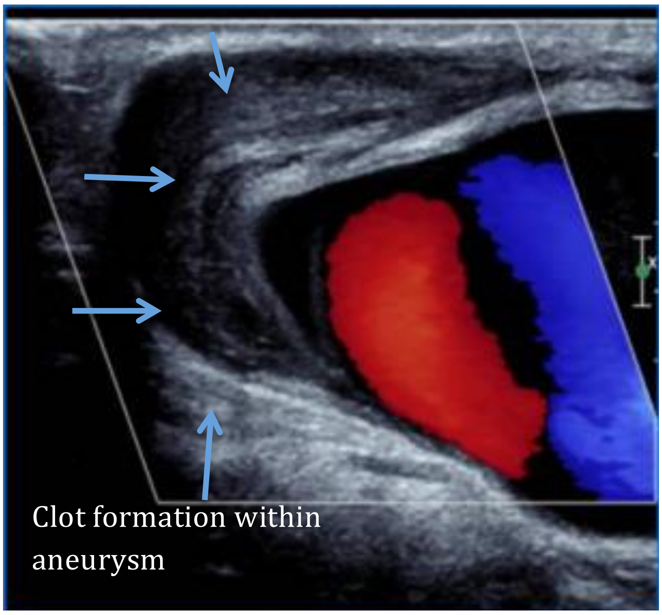
Haematoma can form above or around or underneath the vessel. It can occur in similar fashion to the pseudoaneurysm, with poor holding of the bleeding sites after needle removal or it can be trauma to the surrounding tissues from multiple cannulation attempts or extravasation or 'blow' of the vessel in a previous cannulation attempt. Picture 6 shows haematoma above the vessel. Staff were palpating this area, feeling the haematoma, thinking that it was the vessel for cannulation. As they went into this area the needle filled with clot and the patient was unable to be cannulated. As seen in this picture, the presence of haematoma on top of the vessel fills out the tissue and swells, pushing the vessel deeper than normal, making it almost impossible to cannulate at this point. Again, this area would need to be left for four–six weeks and the haematoma will reabsorb and swelling will subside, making it a cannulatable area again. A new area can be found using ultrasound in the interim weeks.



Picture 6: Haematoma formation from cannulation damage
Picture courtesy of Dianne Du Toit, Queensland, Australia

Aneurysm

A true aneurysm is an outpouching of the vessel wall, usually due to weakening of the wall. This can be due to cannulation, stenosis at an outflow point, genetics or previous damage to the vessel. An aneurysm is not really a concern of rupture unless it is continually cannulated, allowing large scabs to form, which may rupture under the pressure of the arterialised blood flow and/or presence of infection. Aneurysms generally only need to be removed for cosmetic reasons, or if the turbulent blood flow has thickened the intima and caused a build-up of clot within the aneurysm, making cannulation and successful dialysis troublesome. Picture 7 shows a true aneurysm on ultrasound with clot forming in the turbulent slower blood flow.



Picture 7: Clot formation within an aneurysm
Picture courtesy of Dianne Du Toit, Queensland, Australia

Handy tips

Tip 1: Make sure you set the ultrasound up in the correct position — screen behind the patient's shoulder so your line of vision is in line with the vascular access.

Tip 2: It can be much easier to use the ultrasound in the sitting position.

Tip 3: You can never use too much gel — you need lots and lots of gel!

Tip 4: Use small sachets of sterile ultrasound gel for cannulation and bottles of unsterile if only using for assessment.

Tip 5: Don't push too hard on the probe as it will distort the vessel. Use your little finger to anchor the probe away from the vessel so the pressure is through the little finger not the probe.

Tip 6: If you are cannulating with ultrasound guidance, make sure you have a cover on the probe to prevent blood getting on it.

Figure 2

Conclusion

POC ultrasound is available in more dialysis units globally than ever before; however, the daily use of the machine has been sporadic. The advantages of using ultrasound for assessment and cannulation outweigh the disadvantages. The ability to see into the vessels without invasive treatments to identify aneurysms, thrombus, backwalling and valves can assist in the success of cannulation. If thrombus from backwalling or presence of venous valves can be highlighted and mapped, it can decrease the amount of miscannulations and infiltration experienced. This can have an effect on patient comfort, patient and nurse satisfaction and the longevity of the life of the vascular access. The advantages of this inner sight can also reduce the referrals for expensive imaging for what is in essence a cannulation issue rather than a vascular access issue.

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