Ultrasound Guided Peripheral IV Access

Objectives

The aim of this module is provide NCHDs rotating through the Department of Emergency Medicine in Crumlin with the theoretical and practical knowledge in order to safely and effectively perform ultrasound guided IV access (USGIV).

There are several components to this module. This manual provides a written summary and list of references and resources for USGIV. There are a plethora of resources, mainly video, referenced in this manual and you are strongly encouraged to view them to help develop your technique.

Accompanying this manual is a 20 minute video that provides the background detail on physics, preparation and technique.

There is a mandatory short quiz based on both this manual and the 20 minute video. You are required to obtain a passing mark on this before proceeding to the group practical session.

The practical session will allow you to scan live and practice cannulation on phantoms.

The final component will be an in person sign off on 2 cannulation attempts in the ED with one of the consultants.

We are grateful to Dr Adam O'Brien in the Royal Children's Hospital Melbourne and to Dr Patrick Fitzgerald in Temple Street Children's University Hospital for some of the images used in the teaching video.

Completion of this module should enable you to practice USGIV in the emergency department. It does not cover you for central venous access or for more general use of point of care ultrasound within the department.

Background

Peripheral venous access is a vital part of emergency care. It can be particularly challenging and distressing for children. Anything that can be done to improve first pass success rates will be in the child's interests.

While intraosseous access has greatly improved the options for vascular access in the critically ill child it is still limited in terms of blood testing and flow rates. It is also not appropriate for many children who are sick but not as yet critically ill.

Ultrasound guidance has been standard of care in central venous cannulation for some time.(1)

Several randomised trials and two separate systematic reviews and meta analyses have confirmed the benefit of USGIV in both children and adults (2-5) Different levels of providers have been shown to be proficient at USGIV with technicians (6)
and nurses included (7)

Patient selection

Any patient may be suitable for USGIV access but as it takes slightly longer than conventional techniques it is typically reserved for use in those with difficult intravenous access (DIVA). Reasonable indications for USGIV access may include

- 2 failed attempts at conventional access

- no visible or palpable veins
- patient or carer request

We all know the veins can come and go depending on environmental temperature and clinical state so just because a child required USGIV on a prior dependence does not mean that they will always need it. Clinicians will have to use judgement and their own skill levels to assess whether USGIV should be used as a primary or a rescue method of access.

Patients with DIVA include (but are not limited to) children with recurrent prior venous access. The sickle cell population in Crumlin would be an excellent example of this. Young babies from 6 months onwards may develop excessive amounts of adipose tissue that make visualization of excellent veins very difficult. USGIV can be extremely effective here even if only to visualise and mark a vein.

Neonates frequently have difficult venous access and while possible to place an USGIV in this population, ultrasound has significant limitations due to the size of the probes relative to the child.

Safety

The available data on USGIV shows that it is a very safe technique. However it is unclear if cannulas placed with ultrasound are at higher risk of infectious complications than those placed conventionally. The existing data uses a mixture of techniques including a simple clean technique with no sterile probe cover or gel all the way through to full sterile technique. Short conventional cannulas placed with ultrasound at the ante cubital fossa or below are unlikely to be any more at risk of infection than conventional cannulation. However ultrasound does allow you to place deeper and longer cannulas than you would otherwise and subsequently we recommend the sterile technique outlined in the video which includes sterile probe cover, sterile gloves and sterile gel.

As with all vascular access there is a risk of inadvertent arterial puncture but with correct vessel identification this should be very rare and even when it occurs complications seem extremely rare.

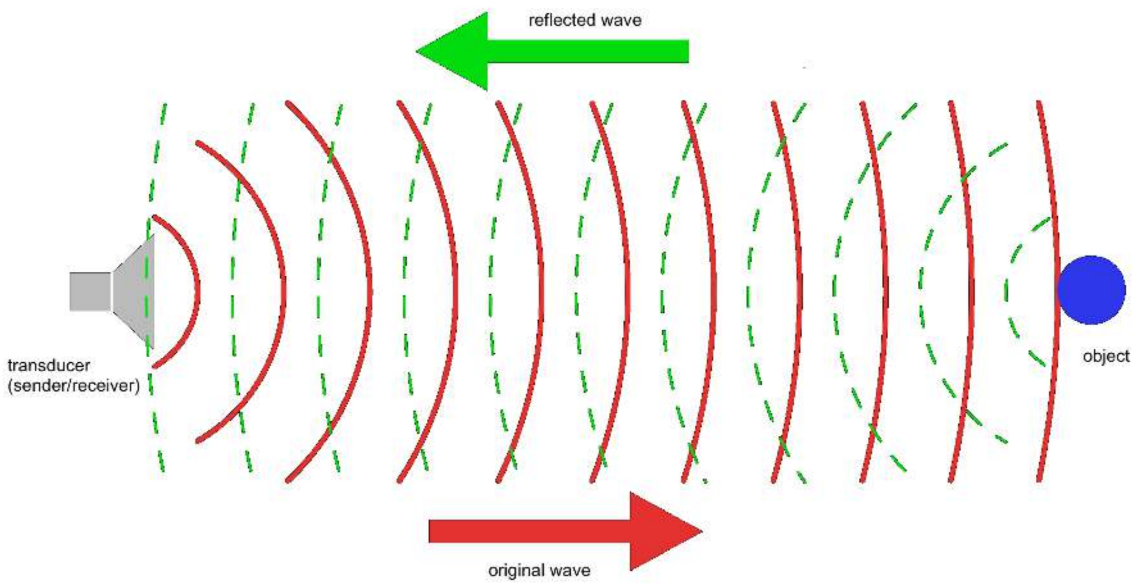
Ultrasound Physics

This is an important and quite complex topic and there are several videos and references available in the further reading section for those who wish to delve deeper. The summary provided here includes gross simplification of many of the principles.

Ultrasound works by sending high frequency waves through tissue to generate real time images inside the body. These waves are created using the piezo electric effect.

The probe you hold sends and receives the ultrasound waves. Because the probe has to send the wave and listen it works by sending pulses of ultrasound rather than a continuous wave. It cycles on and off millions of times a second, each time listening to hear waves bounced back to the probe. The length of time for a wave to bounce back to the procedure tells us how deep a given object is.

Different tissues have different characteristics in their speed of conduction, reflection and absorption of sound waves. This accounts for the different appearances of different tissues such as muscle, vessels and bones.



The frequency of the created sound waves determines in part how far within the body they will travel. This frequency is measured in Hz or cycles per second. Medical ultrasound exists in the MHz range or millions of cycles per second.

The probes found on bedside ultrasound machines have a variety of frequencies depending on their purpose. For example the curved abdominal probe is a low frequency probe (3-5 MHz) which has excellent penetration for deeper tissues but provides a poorer quality image. The linear high frequency probe used in USGIV (10-12 MHz) provides a much higher resolution image but much more superficial.

Objects in the ultrasound image that are described as echogenic appear bright white and occur at dense tissue types with strong reflective properties or at areas of transition from one tissue type to another where there is a large change in speed of transmission of the wave.

Anechoic areas allow ultrasound waves to pass through easily and appear black and produce few echoes. Typical examples would be free fluid or vascular structures.

The Doppler Effect (for our purposes we are referring to the “colour” mode) is used to determine if flow within a vessel is towards the probe or away from it. If low is away from the probe it will appear blue, if it is towards the probe it will appear red. This can be recalled with the mnemonic BART (Blue Away, Red Towards). It is important to note that the colours are not meant to indicate whether any given structure is arterial or venous and this is better determined with colour Doppler by looking at the characteristic of the flow – e.g. is it pulsatile in nature.

Preparation

USGIV does require a longer period of preparation than conventional cannulation but this is key to success

Equipment

- tourniquet
- alcohol swab
- cannula of appropriate size and length
- Steri-Strips™

- dressing
- brown tape
- gauze
- extension set, bung and flush
- syringe or bottles for blood collection
- sterile probe cover (we do not recommend using a “Tegaderm™” type sticky dressing as a substitute for a sterile probe cover given the risk of damage to the probe)
- sterile gel
- sterile gloves
- ultrasound machine

Patient positioning

- this will usually be on the bed with parent helping with reassurance and restraint if needed

Machine positioning

- almost always the machine should be on the opposite side of the bed to ensure that both screen and insertion site are lined up with minimal change in gaze

Cannulation

It is worth doing a non sterile “pre scan” of the area to establish where the optimal vein is for cannulation. The best site is probably on the forearm away from the wrist and elbow joints. This allows a substantial area to secure the cannula and also avoids joint movements which cause pressure alarms during infusions.

Ideally choose a vein that is within 5-10mm of the surface. Deeper veins can be cannulated but typical cannulas are too short to have enough of the cannula within the vessel.

Ensure that the vein is running reasonably straight proximal to the insertion site. If the vein takes a sharp turn immediately after your site of entry to the skin then it will be difficult to guide the needle or advance the cannula.

This is best described in the video and at the workshop.

The key principle is always being able to track the tip of the needle. This involves finding the vein then advancing the needle until the tip is just visible then moving the probe away from the needle tip and then again advancing the needle until the tip is visualized.

Once you have visualized the needle tip in the vessel and obtained a flashback in the hub it is important to advance the tip another 2-3 mm under ultrasound guidance to ensure that the cannula itself is within the vessel. Then the cannula can safely be advanced off the tip of the needle.

Decontamination

Before and after use it is important to clean the probe with Tristel™ duo and dry wipes that are attached to the machine. This process should be documented on the sheet also attached to the machine. This is an audit process that is required of us by HIQA.

References:

1. Bodenham Chair A, Babu S, Bennett J, Binks R, Fee P, Fox B, et al. Association of Anaesthetists of Great Britain and Ireland: Safe vascular access 2016. Anaesthesia. 2016 Feb 17;71(5):573–85.

2. Egan G, Healy D, O'Neill H, Clarke-Moloney M, Grace PA, Walsh SR. Ultrasound guidance for difficult peripheral venous access: systematic review and meta-analysis. Emergency Medicine Journal. 2013 Jun 13;30(7):521–6.

3. Heinrichs J, Fritze Z, Vandermeer B, Klassen T, Curtis S. Ultrasonographically Guided Peripheral Intravenous Cannulation of Children and Adults: A Systematic Review and Meta-analysis. Elsevier Inc; 2013 Apr 1;61(4):444–454.e1.

4. Stein J, George B, River G, Hebig A, McDermott D. Ultrasonographically Guided Peripheral Intravenous Cannulation in Emergency Department Patients With Difficult Intravenous Access: A Randomized Trial. American College of Emergency Physicians; 2009 Jul 1;54(1):33–40.

5. Bridey C, Thilly N, Lefevre T, Maire-Richard A, Morel M, Levy B, et al. Ultrasound-guided versus landmark approach for peripheral intravenous access by critical care nurses: a randomised controlled study. BMJ Open. 2018 Jun 9;8(6):e020220–8.

6. Schoenfeld E, Boniface K, Shokoohi H. ED technicians can successfully place ultrasound-guided intravenous catheters in patients with poor vascular access. Am J Emerg Med. 2011 Jun;29(5):496–501.

7. Fabiani A, Dreas L, Sanson G. Ultrasound-guided deep-arm veins insertion of long peripheral catheters in patients with difficult venous access after cardiac surgery. Heart Lung. 2016 Oct 22.

Further reading/resources:

iBooks

- Introduction to Bedside Ultrasound Volume 2, Chapter 8, Editors: Mallin & Dawson
  - Link (Free)
  - Volume 1 of this book also includes an excellent chapter on relevant ultrasound physics

Videos

- Traps in Ultrasound Guided Needling by Kylie Baker on YouTube.
  - Link
  - This is an excellent 21 minute video that highlights many of the common pitfalls in needle tracking and tips and tricks to overcome them. Worth watching after your first couple of live attempts

Papers

- Ultrasound-Guided Peripheral Intravenous Line Placement: A Narrative Review of Evidence-based Best Practices
  - Link
  - This a more comprehensive version of this manual and includes several excellent videos and tips on best practice