# Ultrasound guidance should be the standard of care for most invasive procedures performed by clinicians

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In this issue of the journal Rudas publishes a review describing the utility and efficacy of ultrasound when used to guide the performance of percutaneous tracheostomy placement. An Australasian Society for Ultrasound in Medicine (ASUM) grant funded research completed by the same authors, and presented at the recent 2012 ASUM meeting in Sydney. This demonstrated that ultrasound improves first-pass success rate and improves accuracy when compared to the landmark technique in performing percutaneous tracheostomy. This is not a surprising finding given the plethora of recent literature supporting the use of ultrasound by clinicians to guide a wide variety of procedures previously done "blindly". In many areas advantages have been demonstrated in patient safety, time taken for the procedure, as well as in cost savings.

Fortunately for our patients, the days of blindly performed procedures, using traditional anatomical landmarks are numbered. Imagine the outcry if an amniocentesis were performed without ultrasound guidance. The same standard should be set for all invasive procedures where ultrasound guidance is practical, and there is risk if the desired target is not hit and adjacent structures are damaged.

This does not mean that the widespread use of ultrasound for procedural guidance is without difficulty. Acquiring the necessary cognitive and psychomotor skills to perform ultrasound-guided procedures takes time and practice. There remains controversy over the exact amount of training required, and how to ensure competence. In addition using ultrasound, even in competent hands, does not completely eliminate complications.

Radiologists have used ultrasound to guide procedures for years, including most of those listed in Table 1 (this list is not exhaustive). Many of these procedures will remain within the domain of the imaging specialist quite appropriately. In recent years however, particularly in the emergency setting, clinicians are increasingly performing their own specialty-specific ultrasound-guided procedures. In addition to this, advanced nurse practitioners (such as those dedicated to the PICC line service in many hospitals) are also developing these skills.

## Technique

Most ultrasound-guided procedures are performed with a linear high frequency transducer. This is particularly the case where the target is accessible and superficial. A curvilinear probe with a lower frequency range is appropriate where the target is deeper. Finally, in difficult to access areas a high-frequency endocavity probe is most appropriate (such as for peritonsillar abscess localisation and aspiration and transvaginal and transrectal procedures).

A sterile technique should be used for most procedures. This involves placing a sterile probe cover, generally of non-latex material over the transducer. Acoustic coupling gel is placed inside the cover. Sterile gel is then also placed between the outside of the cover and the patient's skin. This can create a slippery working field and an alternative is to use sterile liquid (such as chlorhexidine or water) as the external coupling medium; this can make feeding a wire less difficult. Some advocate using a sterile glove or Tegaderm (3M, North Ryde NSW, Australia) like dressing over the transducer to create a sterile field. A sterile transducer sleeve long enough to ensure both the operator's gloved hands and the working field remains sterile is essential, and for this reason these techniques should be discouraged. A sticky dressing placed directly onto the transducer face can leave residue that is difficult to remove and ultimately may damage the delicate matching layer.

Prior to performing the procedure the target is generally scanned in two perpendicular planes to ensure comprehension of its depth, orientation and to establish the optimal needle trajectory.

Orientation is established, a working area established, and ideally the target, the probe, the needle and the ultrasound monitor are all placed within the same line, directly in front of the operator.

For large static targets such as a substantial knee effusion or large pleural effusion the character, depth and position of the target can be ascertained, the trajectory of the needle planned, the skin marked and then the procedure performed without real-time ultrasound guidance. This is known as the static technique.

For smaller targets, targets that are moving, or targets directly adjacent to vulnerable structures, a dynamic technique is preferred. This involves watching the needle, and most importantly its tip, as it is advanced through the tissues toward and into the target.

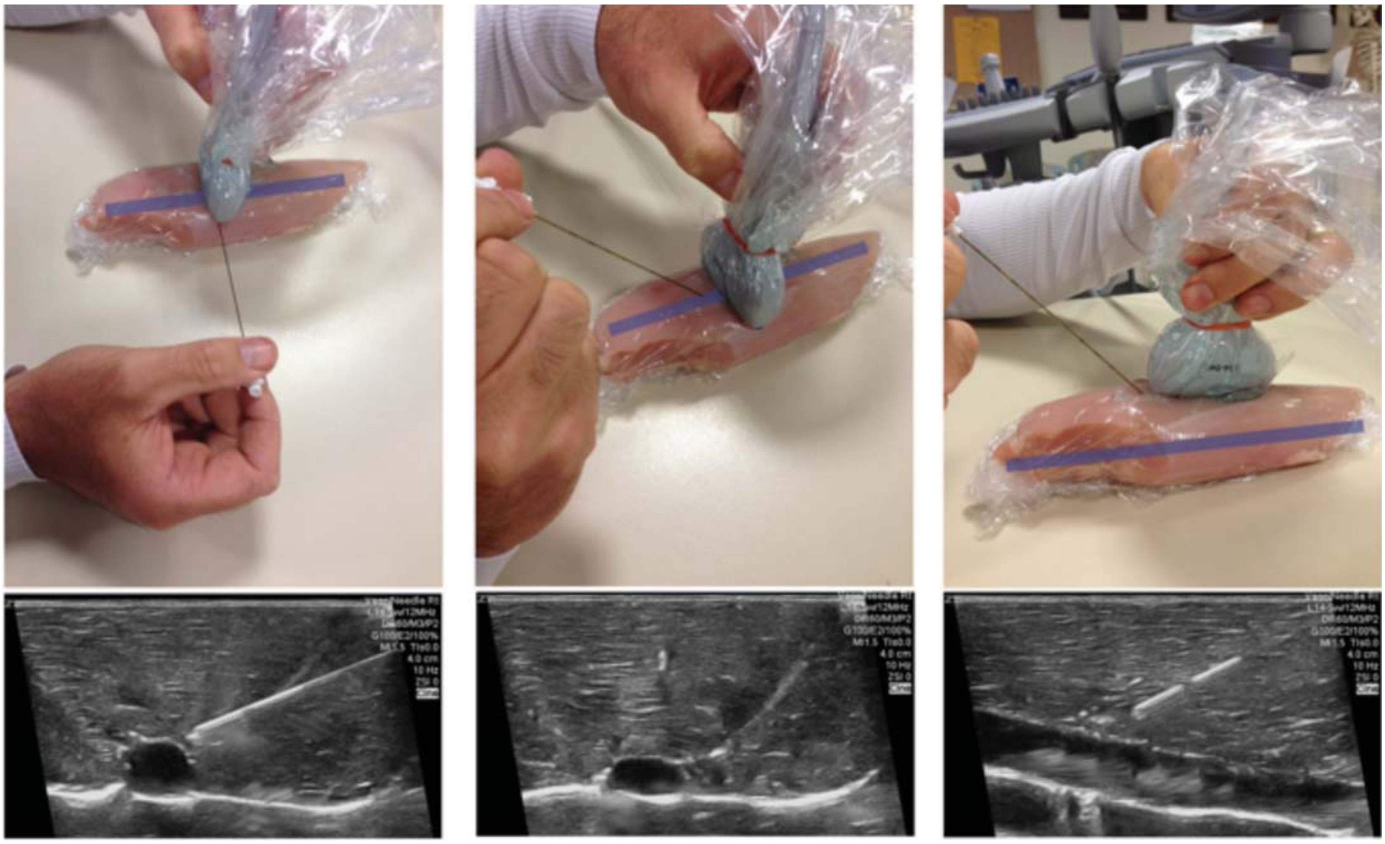
The in-plane and out-of-plane techniques describe the relationship of the needle to the plane of ultrasound interrogation. Each has its advantages and most operators vary from one technique to another depending on the procedure they are performing (Table 2).

The terms "long-axis" and "short-axis" are used to refer to the relationship between the transducer and the tubular structure being interrogated. A long-axis, in-plane technique is commonly used for vascular access where the vessel is imaged longitudinally (long-axis) and the needle approach is in the same plane (in-plane). A short-axis, in-plane technique is often used for nerve blocks where the nerve is imaged transversely (short-axis) and the needle advanced in the plane of the ultrasound beam (in-plane).

**Table 1:** Systems and procedures by profession.

| System and Procedure | Specialties who may perform these procedures |
|---|---|
| **Vascular system** | |
| Central venous cannulation | Critical care physicians (anaesthetists, intensivists and emergency physicians (adult and paediatric)) |
| Peripheral venous cannulation | Most hospital based clinicians, pre-hospital medical staff |
| Arterial cannulation | Critical care physicians |
| **Nervous system** | |
| Nerve blocks and catheter placement | Anaesthetists and emergency physicians |
| Epidural placement | Anaesthetists |
| Lumbar puncture performance | Critical care physicians, neurologists, general physicians |
| **Respiratory system** | |
| Endotracheal intubation | Critical care physicians |
| Percutaneous tracheostomy placement | ENT, intensivists |
| Emergency cricothyroidotomy | Critical care physicians |
| Thoracostomy placement | Respiratory physicians, critical care physicians, general physicians |
| Pleural biopsy | Respiratory physicians |
| **Genitourinary system** | |
| Renal biopsy | Nephrologists |
| Nephrostomy tube placement | Urologists, nephrologists |
| Suprapubic aspirate or catheter placement | Urologists, emergency physicians |
| Urinary catheterisation | Most hospital based clinicians |
| **Cardiovascular system** | |
| Pericardiocentesis | Cardiologists, critical care physicians |
| Pacemaker wire placement | Cardiologists, critical care physicians |
| **Musculoskeletal system** | |
| Joint aspiration and injection | Rheumatologists, orthopaedic surgeons, general physicians, emergency physicians |
| Fracture and dislocation detection and reduction | Emergency physicians |
| Foreign body detection and removal | Emergency physicians |
| Abscess detection and drainage | General surgeons, emergency physicians |
| Intraosseous needle placement | Paediatricians, critical care physicians |
| **Obstetrics and gynaecology** | |
| Dilation and curette guidance | Gynaecologists |
| Oocyte retrieval | Gynaecologists |
| Amniocentesis and chorionic villous sampling | Materno-fetal medicine specialists |
| **Gastrointestinal** | |
| Liver biopsy | Hepatologists |
| Ascites detection and drainage | Many hospital based clinicians |
| **Breast** | |
| Mass localisation and biopsy | Breast surgeons and breast imaging specialists |
| Collection aspiration | Breast surgeons |

**Table 2:** Comparison of in-plane and out-of-plane techniques. For these images a needle with distal surface micro-irregularities (Pajunk) was used to enhance the ultrasound appearance of the needle.



| In-plane, short-axis | Out-of-plane, short-axis | In-plane, long-axis |
|---|---|---|
| See entire needle as it advances | Only see tip of needle | See entire needle as it advances |
| See transverse section of target | See transverse section of target | See longitudinal section of target |
| Can easily adjust position of transducer to ensure needle is aligned | Must slide or fan transducer to follow the tip as it advances | Require transducer, needle and target to be aligned perfectly |
| Needle can be directed precisely to deliver local anaesthetic directly adjacent to nerves | Cross section image of the needle shaft looks the same as the needle tip – the needle may be deeper than anticipated | Slice thickness artefact can make the needle appear within the target vessel when it is in fact beside it |
| Never inject any air, artefact obsures the image | Can see adjacent and parallel structures and ensure they are away from the needle | Can inadvertently slide onto adjacent similar appearing structure (e.g. artery instead of vein) |
| Best for nerve blocks | Good for vascular access | Good for vascular access |
| http://youtu.be/QRWi7W900sQ | http://youtu.be/GCB2tPWDi8Q | http://youtu.be/uCzJ5mciRYA |

### Technology

Numerous recent advances have been made to assist the user in performing ultrasound-guided procedures. Machine presets that enhance the appearance of both the tissues and the needle have been developed.

Compound imaging has been used to ensure the ultrasound beam interrogates both the needle and target vessel perpendicularly, optimising reflection and improving the needle and target's visibility. A dotted line is often projected over the image to act as a guide to the user advancing the needle in-plane. Two series of beams are sent, one perpendicular to the transducer face and target vessel and the other at an angle, but perpendicular to the needle. Both sets of images are integrated and displayed to assist in optimal imaging.

Needles have been developed with micro-irreularities or abrasions at the tip or along the shaft to enhance their reflectivity and appearance on ultrasound.

Finally needle guides can be placed over the transducer head and sterile cover and ensure the needle trajectory is along a predefined pathway.

### Credentialing and training

There remains controversy about the exact requirements for training in procedural ultrasound. Whilst various organisations have developed guidelines for requirements in teaching diagnostic ultrasound, precise guidelines for training requirements in procedural ultrasound have not been so well publicised. Clinicians already perform many of these procedures "competently" without ultrasound and perhaps this is why there has been hesitance in promoting appropriate guidelines.

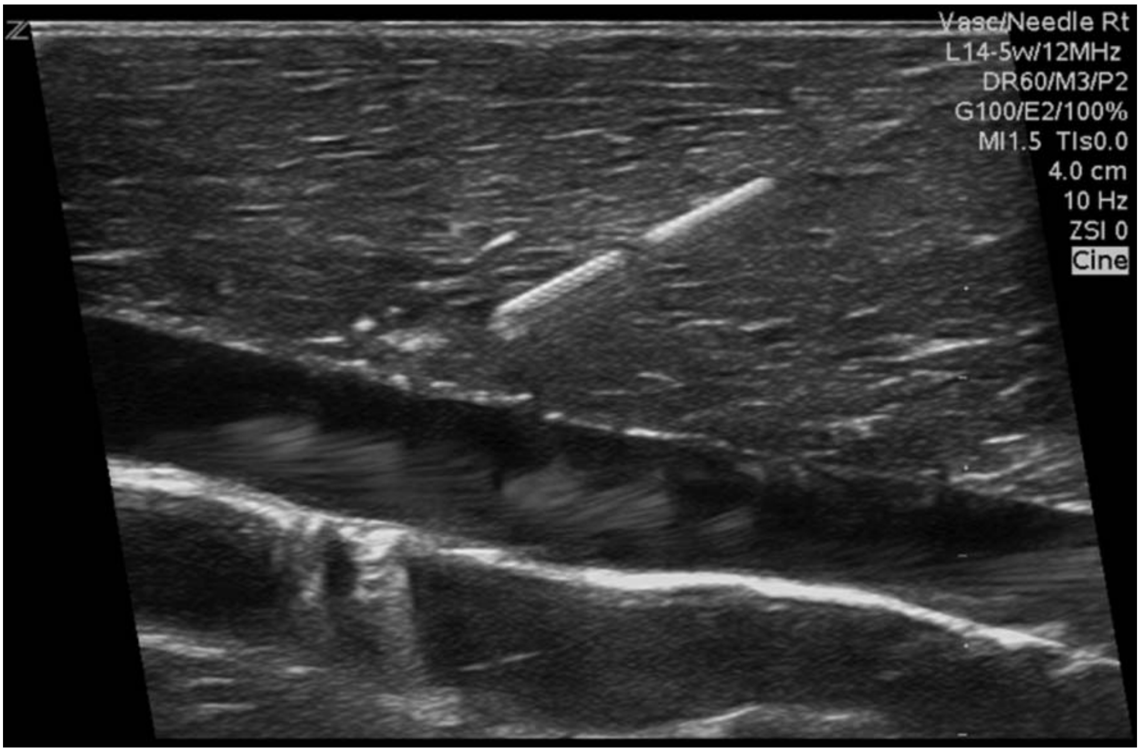



**Figure 1:** This is an in-plane long axis image. Note the angled beam to ensure better reflection from the needle's surface, and the micro irregularities that highlight the distal 1 and 2 cm of the needle.

It has now been recognised that people develop ultrasound and procedural skills at differing rates. A required minimum number of scans or procedures does not necessarily make one competent. Formal competence based assessments are being developed and introduced to ensure a minimum level of ultrasound and procedural understanding is present rather than just a minimum number of scans performed.

Simulation on phantoms provides a zero-risk environment for both patient and practitioner and are an ideal initial learning opportunity. Numerous phantoms have been developed for training in procedural ultrasound. These range from simple phantoms made from jelly, agar or meat, to more complex silicon and latex phantoms mimicking human tissues, to dynamic computer guided phantoms simulating genuine pathology.

Once competence has been assured on phantoms, a number of supervised procedures, performed with an experienced "sono-proceduralist" is advised. The number of these proctored studies would depend on the complexity of the procedure, the risks involved, and the perceived competence of the trainee.

A final formal competence based assessment covering both knowledge and procedural skill, prior to unsupervised practice would be the gold standard.

A generic procedural ultrasound module could include:

1. Knowledge acquisition
    - Clinical knowledge in relation to the procedure
    - Anatomy, common variations, pathology
    - Indications, contraindications, potential complications
    - How to perform the procedure (without ultrasound)
        - Consent, preparation, sterile technique, Seldinger technique, etc.
    - Ultrasound knowledge
    - How to use the machine
    - How to achieve and optimise an image
    - Image interpretation of normal anatomy, common variations and pathology
    - How to assess the target in all planes and determine the optimal approach
    - How to guide the needle into the target using various techniques
    - Ultrasound related pitfalls and problem solving.
2. Skill acquisition
    - Simulation on phantoms
    - Proctored procedures on genuine patients with standardised assessment and feedback (formative assessment).
3. Final standardised competence based assessment (summative assessment).
4. Recommendations regarding maintenance of professional standards.

## Further reading

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