

SHORT ABSTRACT

Basics of Paediatric Ultrasound: Tricks for Improved Feasibility and Image Quality

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Ultrasound (US) is the mainstay of paediatric imaging, not only because of radiation protection issues but also as children offer unique conditions for high-quality, high-resolution US that often provides a diagnosis without the need for further imaging. However, to be able to provide all the relevant information to reduce the need for other imaging techniques, particularly those with invasiveness and radiation burden, high-quality US must be provided that not only reveals reliable diagnoses but is also documented by superb images that enhance findings and make the situation understandable to the referring clinician.

What to consider for making an excellent US investigation with high image quality? First of all, the setting must provide a calm and child-friendly environment. For babies, a heater or radiator is helpful as well as swaddling facilities. Pacifiers and glucose drops should be available as well as helping and supporting persons, particularly if parents are not available or too stressed to calm and position the child. Comfortable positioning is essential – for example, providing a pillow below the knees for children with abdominal pain. The same apply for the investigator. For some detailed investigations prerequisites such as sufficient hydration, bladder filling or being fasted are very helpful if not necessary.

In terms of other requisites a profound education of the examiner concerning the child's anatomy and physiology including the specific conditions and diseases in childhood as well as the respective clinical implications is mandatory – the examination must not only offer a diagnosis but address all clinically relevant information necessary for further treatment decisions or for deciding on certain treatment procedures. The investigator should be (at least to some extent) experienced in how to handle children using a child-adapted approach, calming the child by talking in child-adapted language particularly when trying to perform positioning manoeuvres (e.g., *“make a big tummy as if you just ate at Mc Donald’s”, “hold your breath as if you want to take a long dive”* etc.).

Finally the examiner should be knowledgeable about the equipment and its handling as well as the technical and physical principals to be able to decide when to use

which method and how to improve the image and adapt to the child specific conditions in general. Higher frame rates and higher frequencies are used to offer sufficient spatial and temporal resolution also for the smaller (early) childhood structures with much more movement and higher respiratory and heart rate; often one will need to use different transducers with different apertures and frequencies during one single investigation to get the optimal yield from the examination. Below are some of the recently implemented US improving features:

- Harmonic Imaging is not only useful for obese adults but very helpful in many routine examinations during the entire even early childhood by reducing speckle and offering a better tissue differentiation – however, at the cost of some reduction of penetration and higher sound pressure in the tissue.
- Speckle Reduction or noise filtering has become standard – the proper level of speckle reduction, however, needs to be chosen to avoid artefacts (e.g., more nodular structure of the liver parenchyma at very high speckle reduction settings).
- Linear transducers provide the most homogenous image aspect with practically constant beam width throughout the field; they are very often used whenever penetration of those transducers suffices – such as for the intestine, the bladder, the kidney, small parts, musculoskeletal queries, or even the brain; furthermore, switching between linear and trapezoid mode will allow to widen the field of view even for large acquisitions similar to the field of a curved array.
- Image compounding is another modern option that improves image quality, however often at the cost of a slower frame rate; one needs to also know the respective implications (such as a potential loss of shadowing below or behind calcifications or concretions) to be able to decide when and how to apply this, and when to turn it off.
- (Colour) Doppler US has become routine for many queries – however, adequate child-adapted settings in terms of frame rate and velocities as well as filters are mandatory to achieve reliable results at good image quality.

- Extended field of view US is very helpful for documenting a convincing overview over large scale pathology or for measuring structures too large to be captured in a conventional US image.
- Contrast enhanced US is also increasingly advocated for certain conditions also in childhood; recently the Food and Drug Administration (FDA) has approved an US contrast agent for intravenous use and the European Medicines Agency (EMA) has approved the same US contrast agent for intraluminal use particularly in the child's bladder for assessing vesicoureteral reflux.
- Ultrasound elastography is also being investigated and preliminary results show the promising potential in assessing various conditions – also this modern approach should be made available to children if it proves to reveal clinically relevant information.

Using these, many paediatric body compartments and queries can be properly addressed. In addition, areas reputed inaccessible in adults can be accessed sonographically in childhood, such as the hip (e.g.,

developmental hip dysplasia), the brain (e.g., neonatal brain US), the spinal cord (using the non-ossified posterior arches as an option for access), or the mediastinum (with the large thymus as window to deeper structures). Applications and images of applications throughout the body demonstrating typical paediatric findings at all ages will be presented and discussed.

Finally, every radiological investigation does not only need a structured and understandable report, but also adequate image documentation. This simple approach to ensure a good image documentation quality should not only nicely demonstrate the investigated area or organ but also use recognisable landmarks and standardised projections with body markers or labelling to define the examined area. Suggestions for such standardised documentations and measurements are available. In summary, using fully the modern US potential, many paediatric conditions can be either diagnosed and or followed up, thus helping to reduce the need for irradiating imaging procedures.

Competing Interests

The author has no competing interests to declare.

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