EFSUMB
Best Practice Guidance for the Safe use of Doppler Ultrasound
(last revision 2020)

Introduction

Quantitative pulsed Doppler measurements involve stationary beams of generally higher output levels than used in B-mode imaging (Spatial peak temporal average intensities (ISPTA) may be 2-140 times those used in B-mode imaging [1]). Colour flow and Power Doppler imaging employs swept beams and lower acoustic outputs, which are intermediate between those of pulsed Doppler and B-mode imaging. In clinical routine combinations of these imaging modes are often used (Duplex, Triplex) during scanning.

Continuous wave Doppler devices and Cardiotocograms (CTG) use intensities that are sufficiently low to give minimum concern about potential heating effects and present no significant hazard.

The differences between the various Doppler applications arise because high intensities are needed to obtain strong echoes from poorly reflecting blood cells for flow studies. Strongly reflecting moving structures, such as those found in the heart, return strong echoes from low intensity pulses [1,2].

Although not intended as such, the Thermal Index (TI) value displayed on-screen acts as a rough guide by which the user can recognise changes in output while using Doppler mode setups and allows the user to check if limits have been exceeded for specific applications [3,4].

These guidelines have been drawn up on the basis that there is the need to minimise any potential adverse thermal effects from Doppler applications. Although other effects (such as cavitation) may, in theory, occur, it is considered that these do not give serious cause for concern in diagnostic equipment used clinically at present.

The absorption of ultrasound by different tissues varies greatly, with fully calcified bone absorbing most. Thus, the temperatures that result from exposure to a given ultrasound beam will vary according to the tissue type exposed. It should be borne in mind that tissues with low perfusion rates may reach higher temperatures than their well perfused counterparts. When considering the thermal implications of a given exposure, it is necessary not only to consider temperature increases within tissue structures lying in the path of the ultrasonic beam, but also the exposure time, and their sensitivity to thermal damage.

On this basis, safe clinical practice, with regard to thermal effects, should be conducted according to the following guidelines:

- For each new patient investigation, set the machine output to a minimum, and receiver gain settings to a maximum, thus using lower TI values. This should ideally be achieved by the use of a default (start-up) setting with these conditions on the machine each time a new patient is examined. If this is not available, the manufacturer should be consulted. Monitor the displayed MI and TI indices. Start with low indices and adjust the settings as needed using the ALARA-principle (As Low As Reasonable Achievable).

- Keep Doppler exposure times and output levels to the minimum consistent with good clinical practice (ALARA principle). Choose the region for Doppler interrogation

using B- mode imaging. Where possible, set the Doppler gate to the required position under B-mode guidance before turning on the Doppler beam.

- The user must know whether there is continued acoustic output when the image is frozen. Although occurring rarely for modern scanners, if the acoustic output is not interrupted, then the probe should be removed from the patient during freeze frame conditions. Before it is replaced, its front surface temperature should be checked by contact with the user's hand, since some transducers may self heat when operating in air. A hot transducer will cool when the pulsed Doppler is switched off.

Bone

- Special care should be taken when bone falls within the pulsed Doppler field as rapid heating may result in biologically hazardous temperatures. Patients should be encouraged to report any discomfort during scanning. Particular care should be taken to minimize exposure times when examining patients with reduced pain sensitivity.

Paediatrics

- In paediatric applications, where tissues that may be especially sensitive to temperature elevations lie very close to, or within, bone, extra care must be taken to minimize pulsed Doppler exposures. The tissue of most concern here is the neonatal brain lying adjacent to the skull. Care should also be exercised when pulsed Doppler exposures are undertaken in the vicinity of the epiphyses of growing bone.

Obstetrics

- In view of the possibility of significant temperature elevation in tissues in the path of the pulsed Doppler beam, routine examination with Doppler ultrasound of the first trimester embryo should not be done [5,6]. Investigations for which the embryo does not lie in the path of the pulsed Doppler beam, such as studies of the vessels of the uterine wall, may be undertaken.

- Pulsed Doppler exposures become increasingly likely to produce biologically significant local heating as the pregnancy proceeds through the second and third trimesters because the acoustic absorption of fetal bone increases with its progressive mineralisation. This is of particular importance when brain or growing epiphyses lie in the path of the pulsed Doppler beam.

General

It should be remembered that sensitive structures lying in front of, or behind, the `measurement target´ will also be in the pulsed Doppler beam and thus will be exposed to ultrasound. This is of particular importance in obstetric applications.

References

[1] Martin K. The acoustic safety of new ultrasound technologies. Ultrasound 2010;18: 110–118.

[2] EFSUMB Tutorial : Doppler ultrasound devices –safety aspects; www.efsumb.org

[3] EFSUMB Tutorial : Thermal and Mechanical Indices; www.efsumb.org

[4] EFSUMB Guideline of the safe use of diagnostic ultrasound equipment; www.efsumb.org

[5] WFUMB/ISUOG Statement on the Safe Use of Doppler Ultrasound During 11-14 week scans (or earlier in pregnancy); UMB 39/3 (2013), 373ff. www.wfumb.org

[6] EFSUMB Clinical Safety Statement for Diagnostic Ultrasound. www.efsumb.org

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