



Guidelines

Recommended Maximum Exposure Times for Displayed Thermal Index (TI) Values



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Ultrasound has become an indispensable diagnostic tool in many areas of clinical medicine, finding numerous applications, and maintaining an excellent safety record for decades. It is important for its continued use that this safety record is maintained. With advances in ultrasound technology and the proliferation of new clinical applications, the past safety record does not guarantee future safety. For example, artificial intelligence is expanding the potential for ultrasound to be used in novel ways including in the presence of gas bodies, implants, and thermally sensitive tissues like bone and nerve, raising concerns about potential bioeffects. In addition, achieving uniform international guidance is important for reducing confusion and standardizing safe practices. WFUMB* therefore convened a Task Force, one of whose remits was to harmonize existing guidelines for recommended maximum exposure times when specific thermal indices (TIs) are displayed. In carrying out this task guidelines from BMUS**, AIUM*** and EFSUMB**** were compared. In practice the EFSUMB guidelines are identical to those of BMUS.

The use of the term “exposure time” has been adopted and is defined as the “total time that a specified anatomical structure is continuously exposed to the ultrasound beam during an ultrasound examination.” In the harmonization of previously recommended maximum exposure times, a number of changes have been implemented. Two categories of application (corresponding to Tables 1 and 2 in the

statement) have been defined, chosen by their potential for harm arising from temperature rise. The first (involving applications with potentially higher thermal risk) includes obstetric scanning, gynecological scanning where pregnancy might be possible, and scanning of the neonatal head and spine. Here, the maximum recommended exposure times are unchanged from those contained within existing guidelines. The scanning of premature infants, and of pediatric head and spine, which have not been separately specified in the past, are now included in this category.

The second category (involving applications with lower thermal risk) encompasses all other procedures, explicitly mentioning for the first time those pediatric scans not included above. Here, there were some slight differences in recommended maximum exposure times for different thermal index ranges between different organizations. The recommended exposure times listed below include some changes to those previously recommended by AIUM and BMUS but remain consistent with scientific literature on ultrasound bioeffects.

The statement and associated tables below which have been approved by WFUMB, reflect the consensus reached between members of the Task Force, whose members represent BMUS, AIUM, ASUM, EFSUMB, JSUM and ISUOG. The graphical charts, incorporating the original BMUS design [4], have now been updated consistent with the revised recommended exposure times in Tables 1 and 2.

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Table 1
Recommended maximum exposure time and TI ranges for the following examinations: 1. Obstetric (including gynecological when pregnancy is possible), 2. Premature infant scanning until estimated delivery date, 3. Neonatal transcranial and spinal, and 4. Pediatric transcranial and spinal

TI Range	Maximum exposure time (Minutes)
TI > 3.0	Not Recommended
2.5 < TI ≤ 3.0	<1
2.0 < TI ≤ 2.5	<4
1.5 < TI ≤ 2.0	<15
1.0 < TI ≤ 1.5	<30
0.7 < TI ≤ 1.0	<60
TI ≤ 0.7	No Limit

For obstetric examinations, monitoring the TIS is recommended up to 10 weeks from the last menstrual period (LMP) or a crown-rump length (CRL) of about 32 mm [1], and TIB thereafter. Exposure times should be reduced by 33% for ARFI and pulsed Doppler examinations when bone is near the transducer focus. TIC should be used for all post-natal transcranial scanning.

Recommended maximum exposure times for displayed thermal index (TI) values

The following 2 tables contain recommended maximum times for the duration of an ultrasound exposure at a given setting of the Thermal Index (TI) [4]. These recommendations for maximum exposure time* for different displayed TIs are intended to provide reasonable assurance that an ultrasound examination can be conducted without risk of producing an adverse effect due to undue heating under any scanning conditions. If it is necessary to exceed the recommended times, the occurrence of an adverse thermal effect is still unlikely under most scanning situations due to mitigating factors such as transducer movement and tissue perfusion. However, the principle of As Low as Reasonably

Table 2
Recommended maximum exposure time and TI ranges for the following examinations: 1. Adult transcranial, 2. General abdominal, 3. Peripheral vascular, 4. Neonatal (except head and spine), 5. Pediatric (except head and spine), and 6. Other examinations (except the eye [2])

TI Range	Maximum exposure time (Minutes)
TI > 6.0	Not recommended
5.0 < TI ≤ 6.0	<0.25 (15 seconds)
4.0 < TI ≤ 5.0	<1
3.0 < TI ≤ 4.0	<4
2.5 < TI ≤ 3.0	<15
2.0 < TI ≤ 2.5	<60
1.0 < TI ≤ 2.0	<120
TI ≤ 1.0	No Limit

TIB should be used when bone is near the transducer focus and exposure times should be reduced by 33% for ARFI and pulsed Doppler examinations under these conditions. TIC should be used for all post-natal transcranial scanning. *Exposure time—The total time that a specified anatomic structure is continuously exposed to the ultrasound beam during an ultrasound examination. Note that this definition of exposure time is the same as that referred to by some as dwell time [3].

Achievable (ALARA) should be followed, namely that output powers are minimized and examination times are only as long as necessary to produce a useful diagnostic result [5].

For acoustic radiation force impulse (ARFI) and pulsed Doppler modes, clinical ultrasound scanners may underestimate TIB (thermal index for bone near focus) due to limitations in standard methods for measuring acoustic output. Actual values of TIB are typically higher than those displayed [6–8]. Since thermal dose is directly proportional to exposure time, this effect may be countered by reducing maximum exposure times in Tables 1 and 2 by 33% for ARFI and pulsed Doppler examinations when bone is near the transducer focus [6–8]. As a precautionary measure, particular attention should be

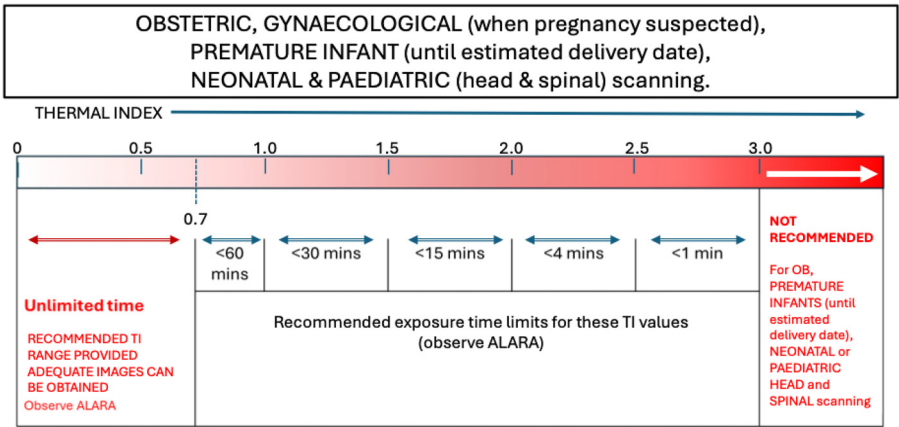


Figure 1. Visual representation of thermal index/exposure time thresholds shown in Table 1

NB: OBSTETRICS: Monitor TIS up to 10 weeks LMP (CRL ~ 32 mm); TIB thereafter
ARFI, WHEN BONE NEAR FOCUS : reduce exposure times by 33%
PULSED DOPPLER, WHEN BONE NEAR FOCUS: reduce exposure times by 33%

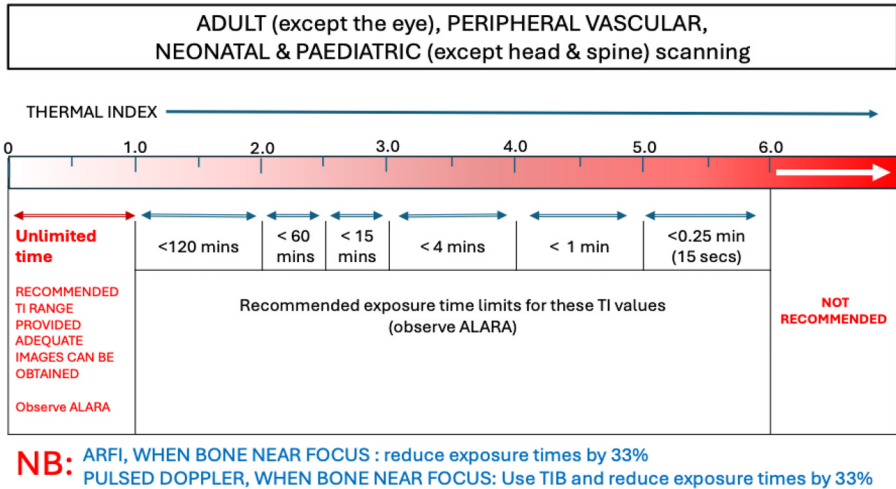


Figure 2. Visual representation of thermal index/exposure time thresholds shown in Table 2

paid to the ALARA principle when the mother has an elevated body temperature (Figs. 1 and 2).

References

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