Best Practice Recommendations for the Safe use of Lung Ultrasound
Empfehlungen zur sicheren Anwendung des Ultraschalls an der Lunge

Authors
Frank Wolfram, Douglas Miller, Libertario Demi, Prashant Verma, Carmel M Moran, Marcel Walther, Gebhard Mathis, Helmut Prosch, Christian Kollmann, Klaus-Vitold Jenderka

Affiliations
1 Clinic of Thoracic and Vascular Surgery, SRH Wald-Clinic Gera, Germany
2 Department of Radiology, University of Michigan Health System, Ann Arbor, United States
3 Department of Information Engineering and Computer Science, University of Trento, Department of Information Engineering and Computer Science, Povo, Italy
4 Department of Medical Physics, Sheffield Teaching Hospitals NHS Foundation Trust, Sheffield, United Kingdom of Great Britain and Northern Ireland
5 Centre for Cardiovascular Science, University of Edinburgh, United Kingdom of Great Britain and Northern Ireland
6 Mindray Medical Imaging, MINDRAY Medical Germany GmbH, Darmstadt, Germany
7 Gastroenterologie, Internistische Praxis, Rankweil, Austria
8 Department of Biomedical Imaging and Image guided Therapy, Medical University of Vienna, Austria
9 Center for Medical Physics & Biomedical Engineering, Medical University Vienna, Austria
10 Department of Engineering and Natural Sciences, University of Applied Sciences Merseburg, Germany

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ABSTRACT
The safety of ultrasound is of particular importance when examining the lungs, due to specific bioeffects occurring at the alveolar air-tissue interface. Lung is significantly more sensitive than solid tissue to mechanical stress. The causal biological effects due to the total reflection of sound waves have also not been investigated comprehensively.

On the other hand, the clinical benefit of lung ultrasound is outstanding. It has gained considerable importance during the pandemic, showing comparable diagnostic value with other radiological imaging modalities.

Therefore, based on currently available literature, this work aims to determine possible effects caused by ultrasound on the lung parenchyma and evaluate existing recommendations for acoustic output power limits when performing lung sonography.

This work recommends a stepwise approach to obtain clinically relevant images while ensuring lung ultrasound safety. A special focus was set on the safety of new ultrasound modalities, which had not yet been introduced at the time of previous recommendations.

Finally, necessary research and training steps are recommended in order to close knowledge gaps in the field of lung ultrasound safety in the future.

These recommendations for practice were prepared by ECMUS, the safety committee of the EFSUMB, with participation of international experts in the field of lung sonography and ultrasound bioeffects.

ZUSAMMENFASSUNG

Andererseits ist der klinische Nutzen des Lungenultraschalls beträchtlich und hat aufgrund der Pandemiesituation einen erheblichen Stellenwert dazugewonnen. Dabei erweist sich dieser bisweilen dem anderer radiologischer Bildgebungsverfahren als ebenbürtig.

Deshalb widmet sich diese Arbeit, basierend auf derzeit verfügbaren Literaturquellen, dem Einfluss von Schalleffekten auf das Lungenparenchym und evaluiert bestehende Empfeh-
absorption and its extent [13, 14]. In obese patients, PCH is much less likely to occur during lung sonography due to the high attenuation of sound thresholds [22], however due to the use of higher intensities and lower frequencies than in diagnostic sonography, PCH may arise on a larger surface. Even though the lung is not directly targetable, pre-focal and post-focal intensities may expose the lung surface above the PCH threshold. Therefore, treatment planning should consider a sufficient safety margin between focal position and lung during application of therapeutic ultrasound in proximity to lung.

**Best Practice Recommendations**

**Scan Settings and Preparation**

A LUS specific Pre-Set should be used or scanner settings in line with the guidelines should be set up prior to any LUS examination [23, 24]. LUS specific Pre-Sets are nowadays available on modern scanners but cover a wide acoustic output range (0.4–1.4 MI). Therefore, the initial output should be adjusted (MI ≤ 0.4) independent of PreSet configuration before any lung examination.

**Safety Indices during applications**

Independent of mode, sonography of the lung with an MI value of less than or equal to 0.4 can be performed safely without limits on exposure time. Use overall gain and TGC (time gain compensation) for optimal imaging adjustments. For specific diagnostic
imaging requirements, the output can be increased up to an MI value of 0.7.

In clinical cases where adiposity may limit the field of view, or acoustic obstacles exist in the sonication path, a maximal MI value of 1.0 should not be exceeded in order to minimise the probability of cavitation. In such cases, justified by diagnostic needs, the operator should be aware of the likelihood of PCH falsifying diagnostic findings.

The use of the ALARA (As Low As Reasonable Achievable) principle is strongly recommended whenever LUS is performed. When exceeding the initial MI value and depending on the examination requirements, exposure times should be kept as short as possible (1–2 breath cycles).

The use of Doppler during LUS should be applied with an MI ≤ 0.5 and with exposure times as short as possible.

SWE and ARFI sonography techniques should be performed only if the region of interest (ROI—where the shear wave is generated) is located in consolidated, peripheral lung tissue, avoiding direct pleural exposure.

Lung sonography in the neonate should always be performed with the lowest MI value possible and not exceeding 0.4. The use of Doppler as well as SWE and ARFI should not be applied on neonatal subjects until further studies have shown that it is safe to use for this vulnerable patient class.

A summary of output setting recommendations is shown in Table 1.

### Education and Future directions

Specific teaching and education for lung sonography should include principles of safety indices and their recommended limits for lung sonography.

The safety profile of SWE and ARFI when applied to lung tissues requires more scientific evaluation to prove its diagnostic safety record before further recommendation.

No lung specific safety index has been introduced to date. However, most of the research literature shows good correlation of PCH thresholds with MI, even though current research would suggest that cavitation is not the cause of PCH [25]. A specific safety index for lung is justified which should include TI (Thermal Index), MI and pulse duration but requires evaluation in future studies [18, 26].

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**Conflict of Interest**

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**References**


