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Neurosonology Survey in Europe and Beyond

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ABSTRACT

Purpose To provide an overview on education, training, practice requirements, and fields of application of neurosonology in Europe and beyond.

Materials and Methods National representatives and experts in neurosonology were surveyed regarding neurosonology requirements and practice in their countries. Descriptive statistics were used to report the data.

Results Between February 1 and March 31, 2023, 42/46 (91.3 %) national representatives responded to our questionnaire and the completion rate was 100 %. Most countries (71.4 %) offer a neurosonology training program during neurology residency, but it is part of the undergraduate medical program only in 30.9 %. National certification is available in 47.6 % of the countries surveyed and most countries (76.2 %) require certification to practice. In 50 % of the countries, candidates are assessed by a board examination, while in 26.2 % they just need to document their practice. There is no formal accreditation of neurosonology centers in 78.6 % of the countries surveyed. Only a few require certified personnel and appropriate equipment. Adequate teaching and research activities are only rarely necessary elements for laboratory accreditation.

Conclusion Our results indicate that there is a substantial need for transnational harmonization of neurosonological standards to guarantee uniformity and quality of performance. This survey will also provide guidance to promote an international accrediting council and create a quality-controlled laboratory network for implementing neurosonology in clinical trials.

Introduction

Neurosonology is an outstanding diagnostic instrument in the hands of clinical neurologists with unique selling points such as specific imaging technology, high spatial resolution, online observation, non-invasiveness as well as broad and easy availability in the clinical routine all over Europe.

Beside traditional vascular neurology, currently new fields of application such as muscle and nerve imaging, brain parenchyma imaging, orbital ultrasound, and online monitoring techniques in intensive care are booming.

We decided to conduct a survey to collect data on the current state of neurosonology in Europe and beyond, as there is a definite need for a well-structured clinical network to promote further technical progress, to offer an in-depth education and training program, to test the usefulness of ultrasound in new fields, to implement it in clinical trials, and to foster the application of sonography in daily practice.

Methodology

A short 8-question survey (▶ **Fig. 1**) covering education, training, practice requirements, fields of application, and laboratory organization was developed by the authors and distributed via e-mail to 46 countries. Each country representative is a respected expert and active promotor of neurosonology in her/his country. The survey was launched on February 1 and the end date was March 31, 2023. Descriptive statistics were used to report the data.

Results

Between February 1 and March 31, 2023, 42 out of 46 (91.3 %) countries responded to our questionnaire (▶ **Fig. 2**). The completion rate was 100 % (8/8 questions answered) among respondents.

Question 1: Is neurosonology part of the medical program in your country?
In the majority of the countries surveyed (69.1 %), neurosonology is not part of the medical program. A few countries (11.9 %) have it as an elective course, while neurosonology is compulsory in less than one fifth (19 %) (▶ **Fig. 3**).

Question 2: Is neurosonology part of the neurology residency program?
In most countries (71.4 %), neurosonology is part of the neurology residency training program and is mandatory in almost half (47.6 %) of the countries (▶ **Fig. 3**).

Question 3: Do you have a national neurosonology society?
In 50 % of the countries, neurosonology is organized in a society, either on its own (19 %) or as part of a larger society, such as the National Neurological Society (31 %) (▶ **Fig. 3**).

Question 4: Who certifies neurosonologists?
In the majority of the countries surveyed (52.4 %), there is no national certification. In 42.8 % of the countries, certification in neurosonology is offered by a larger society, such as the National Neurological Society. Certification is under the direct supervision of a national neurosonology society only in a few countries (4.8 %) (▶ **Fig. 4**).

Question 5: What are the certification requirements?
In 23.8 % of the surveyed countries, there are no requirements to practice neurosonology. Candidates are assessed by a board examination (theoretical and practical assessment) in 50 % of the countries, while they just need to document their practice in 26.2 % (▶ **Fig. 4**).

Question 6: Who accredits neurosonology centers?
Neurosonology centers are formally accredited only in a few countries (21.4 %): in 2.4 % by a national neurosonology society and in 19 % by another regulatory body such as the National Neurological Society or the Chamber of Physicians (▶ **Fig. 5**).

Question 7: What are the accreditation requirements?
Just a few countries (26.2 %) require certified personnel and appropriate equipment. Adequate teaching and research activities are only rarely (11.9 %) also necessary elements for laboratory accreditation (▶ **Fig. 5**).

▶ **Fig. 6** displays the answers to survey questions 1 to 7 for each participating country.

Question 8: How is your neurosonology laboratory organized?
Half of the neurosonology laboratories surveyed are run only by neurologists, some (29 %) have technologists, and few (21 %) also have trained nurses. With regards to fields of application, vascular ultrasound is performed in all laboratories, followed by critical care ultrasound (67 %), brain parenchyma imaging (39 %), and neuromuscular ultrasound (36 %). About 45 % of the experts surveyed also assess pediatric patients. Laboratories are mostly equipped with both duplex and transcranial Doppler (TCD) systems (92 %). Many (76 %) have more than one duplex and TCD machine with headframe for monitoring in stroke units/ICUs/operating rooms. Few laboratories (8 %) have only a duplex system. The majority of neurosonologists operate in stroke units, followed by general neurology, neurosurgery wards, and neuro-ICU.

Discussion

The results of this survey on neurosonology depict a very heterogeneous reality across 42 mainly European countries.

To our knowledge, this is the first international survey on neurosonology education. An earlier initiative by the European Federation of Neurological Societies reported in 2001 evaluated the teaching of neuroimaging in neurology [1].

According to our survey, formal education in neurosonology during the MD program is rare. Conversely, neurosonology is very often part of the neurology residency program although it is mandatory in less than half of the surveyed countries. The current situation might be due to a lack of qualified teachers in neurosonology, or a lack of interest in the subject. Instead, neurologists should be motivated to deal more intensively with neurosonology, for example in the acute phase of stroke, and obtain an image themselves, in order to monitor in real time what's happening with their patients so that they can immediately act accordingly [2].

It is internationally recognized that the use of ultrasound by neurologists should be encouraged in the fields of neurovascular, neuro-intensive, neuromuscular, and point-of care ultrasound [2–6].

Figure 1. NEUROSONOLOGY QUESTIONNAIRE

1. **Is Neurosonology part of the Medical program in your country?**
    a. NO
    b. YES, compulsory
    c. YES, optional

2. **Is Neurosonology part of the Neurology Residency program in your country?**
    a. NO
    b. YES, compulsory
    c. YES, optional

3. **Do you have a National Neurosonological Society?**
    a. NO
    b. YES, on its own (independent, autonomous)
    c. YES, but part of a larger society (eg. Neurological Society)

4. **Who certifies the Neurosonologists in your country?**
    a. No National Certification
    b. The National Neurosonology Society
    c. Larger Society/National Centers (eg. National Neurological Society)

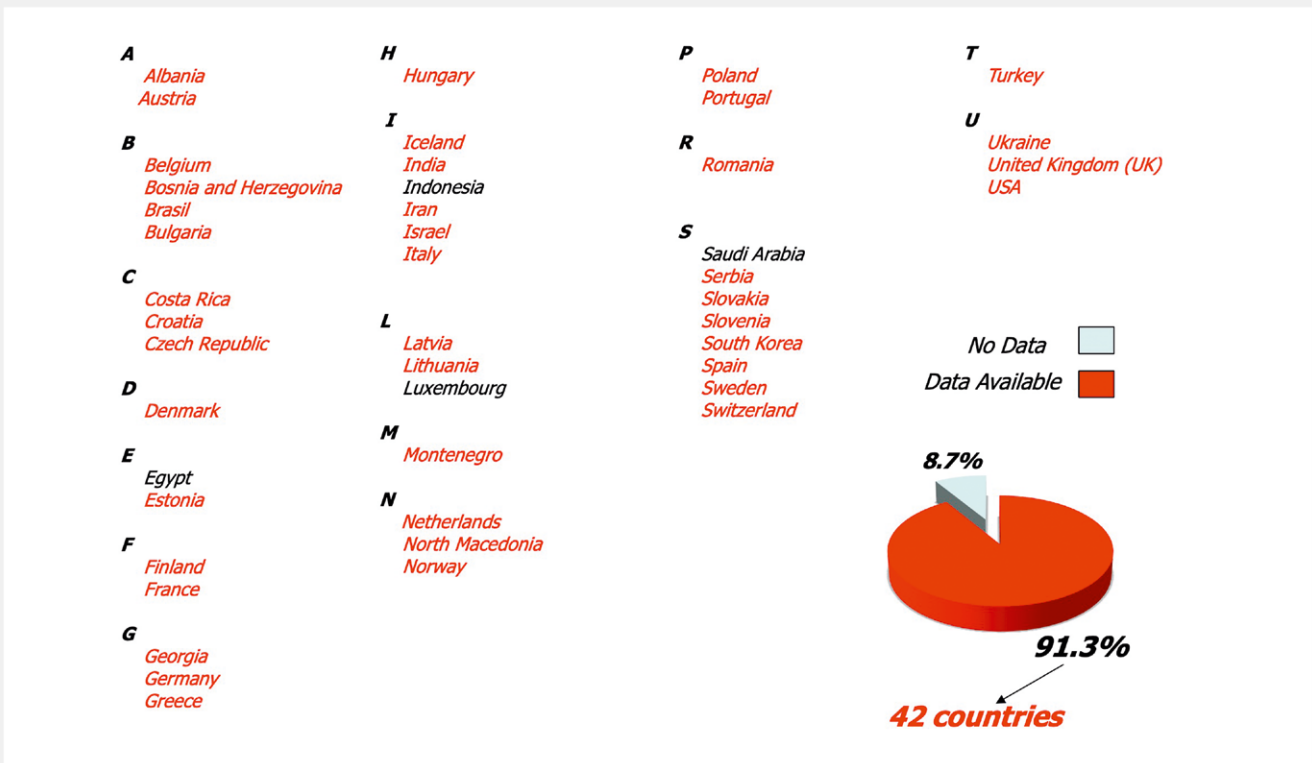
5. **What are the Certification Requirements?**
    a. No requirements
    b. Certified Practice but no formal exam
    c. Formal Exam + Certified Practice

6. **Who accredits the Neurosonology Centers in your country?**
    a. No formal accreditation
    b. The National Neurosonology Society
    c. Other Society (eg. National Neurological Society) or Groups (eg. Chamber of Physicians)

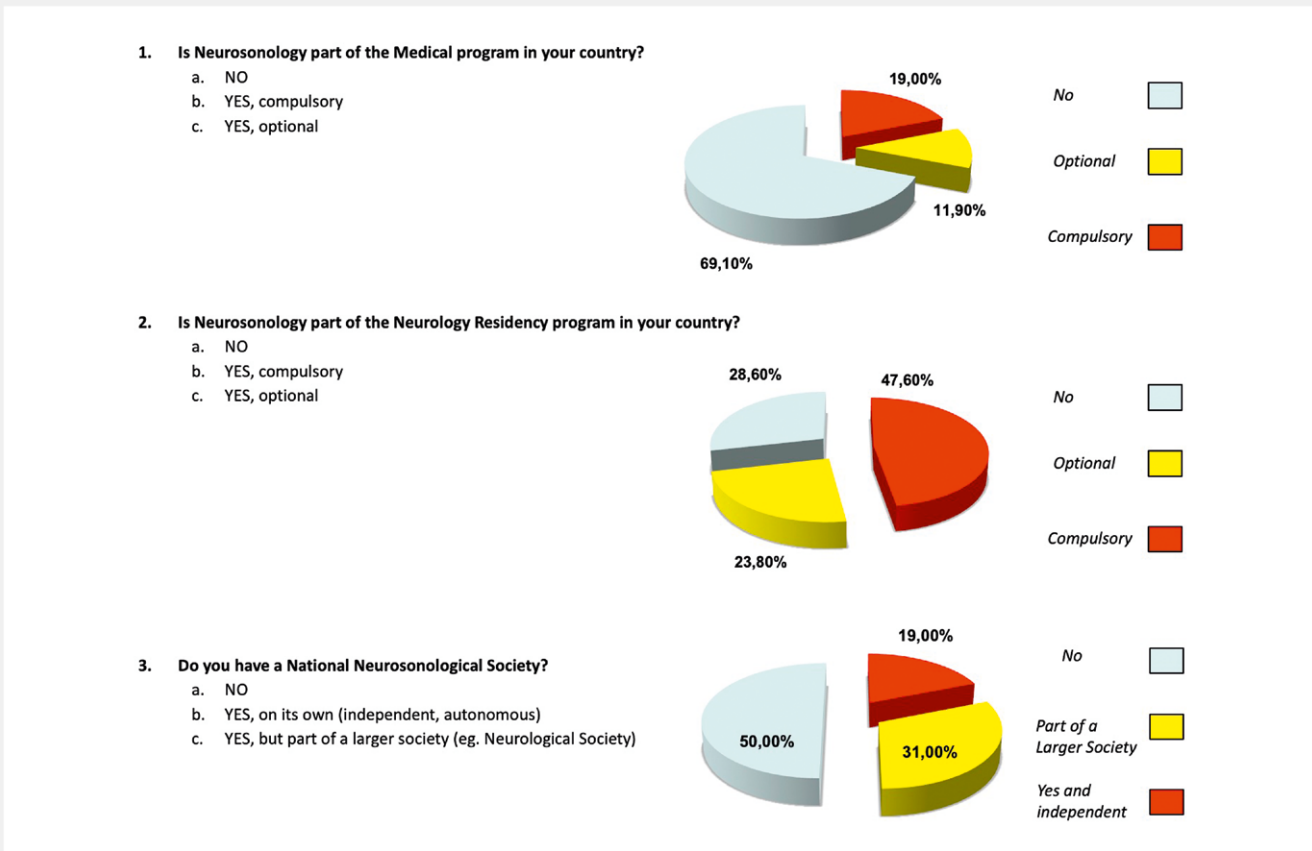
7. **What are the Accreditation requirements?**
    a. No requirements
    b. Certified Neurosonologist + Appropriate Equipment
    c. Certified Neurosonologists + Appropriate Equipment + Teaching Activities + Research Activities

8. **How is your Neurosonology Laboratory organized?**
    a. Personnel:
        i. Doctors only
        ii. Also trained Technicians
        iii. Also trained Nurses
    b. Equipment:
        i. Duplex Machines only
        ii. TCD only
        iii. Duplex + TCD
        iv. Duplex + TCD + Monitoring Headframe
    c. Patients:
        i. Adults only
        ii. Also Pediatric Patients
    d. Applications:
        i. Only Vascular Ultrasound
        ii. Also Critical Care Ultrasound
        iii. Also Neuromuscular Ultrasound
        iv. Also Brain Parenchyma Ultrasound

▶ **Fig. 1** Neurosonology questionnaire: set of questions asked of each survey participant.

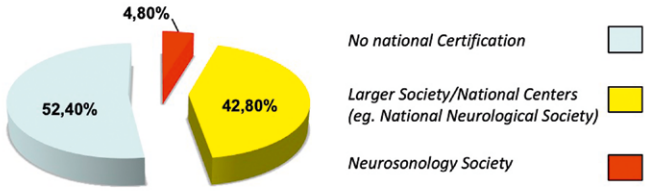


▶ **Fig. 2** Countries surveyed and percentage of respondents.

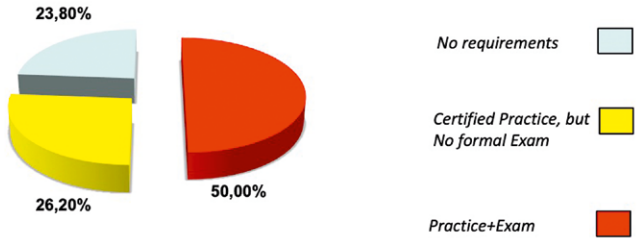


▶ **Fig. 3** Answers to questions 1-3 of the survey.

4. **Who certifies the Neurosonologists in your country?**
   a. No National Certification
   b. The National Neurosonology Society
   c. Larger Society/National Centers (eg. National Neurological Society)

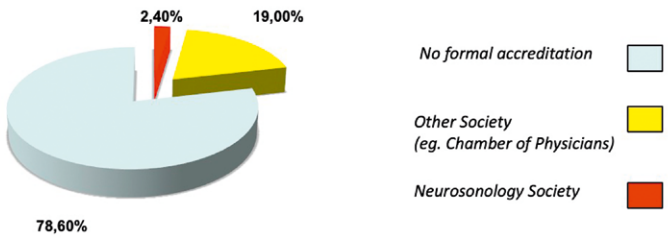


5. **What are the Certification Requirements?**
   a. No requirements
   b. Certified Practice but no formal exam
   c. Formal Exam + Certified Practice

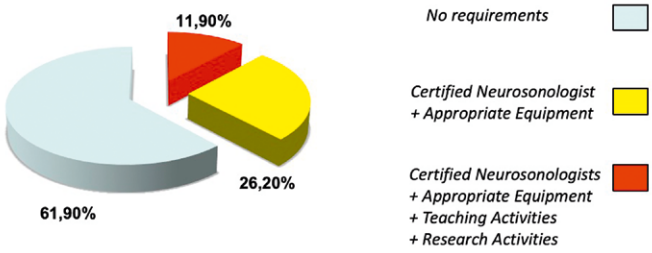


▶ **Fig. 4** Answers to questions 4-5 of the survey.

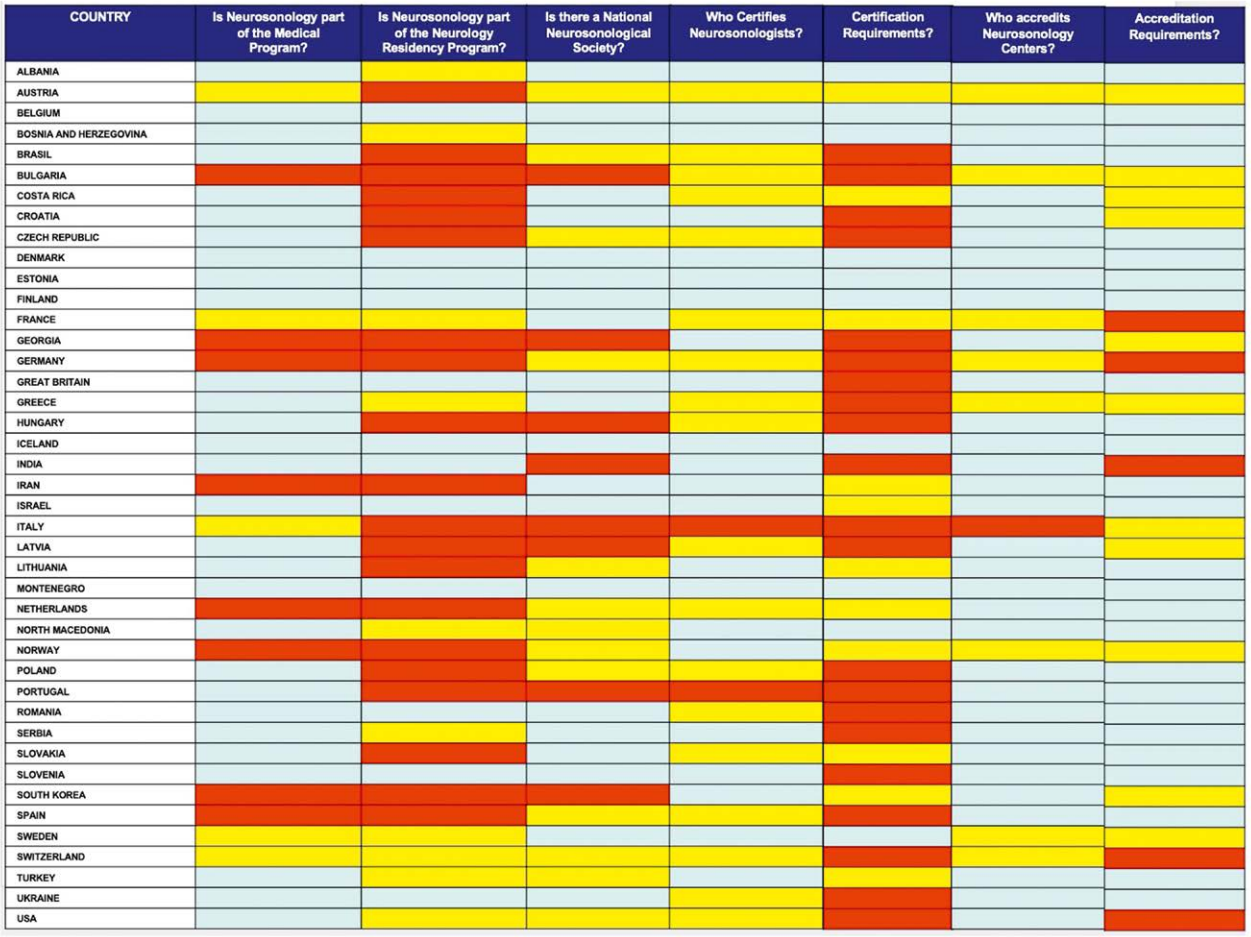
6. **Who accredits the Neurosonology Centers in your country?**
   a. No formal accreditation
   b. The National Neurosonology Society
   c. Other Society (eg. National Neurological Society) or Groups (eg. Chamber of Physicians)



7. **What are the Accreditation requirements?**
   a. No requirements
   b. Certified Neurosonologist + Appropriate Equipment
   c. Certified Neurosonologists + Appropriate Equipment + Teaching Activities + Research Activities



▶ **Fig. 5** Answers to questions 6-7 of the survey.



▶ **Fig. 6** Answers to survey questions 1 to 7 for each participating country. Light blue response: no/no/no/nobody/none/nobody/none. Yellow response: optional/optional/yes, but part of a larger society/larger society/certified practice only/other society/certified neurosonologist and appropriate equipment. Red response: compulsory/compulsory/yes and independent/neurosonology society/certified practice and formal exam/neurosonology society/certified neurosonologists, appropriate equipment, teaching activities and research activities.

Guidelines for competency and quality assurance in the different fields of neurosonology have already been reported and can readily be implemented [3, 4, 7, 8]. Meanwhile, to increase the motivation of postgraduates to proactively deal with ultrasound, several programs aim to include hands-on ultrasound courses in the rotations of medical students [9–11]. These efforts might enhance the education in neurosonology as long as the various structural deficits highlighted by the present survey are overcome.

The lack of a specific neurosonology society in most countries complicates post-university training and continued medical education (CME) which are crucial for growth within a specialty.

Even more important is the lack of national certification as only half of the countries surveyed have a formal assessment with a theoretical and practical examination. This means that an unacceptably low percentage of neurosonologists are certified. There should be a supra-national pan-European or international accreditation council for CME in neurosonology to ensure that neurosonologists have access to quality learning opportunities and solid means to obtain and meet licensing and credentialing requirements.

In most countries there is no accreditation of neurosonology laboratories. Indeed, only a few countries require certified personnel, appropriate equipment, and research activities as necessary elements for laboratory accreditation. There should be an international accreditation council to ensure that neurosonologists and neurosonology laboratories meet rigorous, high standards.

The last question of the survey, the only open-ended question, dealt with laboratory organization and was specifically addressed to the national representative. All laboratories are run by neurologists, but surprisingly a neurovascular technologist and/or a trained nurse is part of the lab personnel only in a minority of cases. This means that in most labs the exams are performed directly by the neurologist who is also responsible for the final report. This results in the issue of internal quality control in the case of a one-man show infrastructure.

With regards to ultrasound systems, most labs are fully equipped with adequate instrumentation, i. e., duplex and TCD systems with a headframe for monitoring patients in stroke units/ICU/operating rooms.

Concerning fields of application, all laboratories perform neurovascular ultrasound, which is expected since the majority of neurosonologists operate in stroke units. The second most frequent field of application is neurocritical care ultrasound, as a good percentage of neurosonologists work in neurosurgery wards and the neuro-ICU. Just over one third of laboratories also perform brain parenchyma imaging – mainly for movement disorders – and neuromuscular ultrasound. Surprisingly less than half of the survey respondents assess pediatric patients, even though there are several indications for performing ultrasound in children, especially in sickle cell disease (SCD). This is a major drawback considering the pivotal role of TCD in stroke prevention and the increasing number of SCD patients in Europe, due to a rise in global human population movement and reduced child mortality thanks to advances in diagnosis and treatment [12].

This survey has some limitations that need to be addressed: 1. The national representatives were asked to provide information regarding the current state of neurosonology in their country, considering the average laboratory. Of course, we are aware that some labs are excellent in terms of practice standards and qualified personnel in spite of national requirements, but the objective was to get a global picture. 2. Although this survey does not require the input of new data by the respondents, which makes it very attractive, it is based on the personal judgment of experts and a change of the respondents can yield different results. However, the respondents were selected because they are also aware of the current neurosonological situation in their country. 3. Although in some countries there is no neurosonology society, there is a strong ultrasound society which includes neurosonologists and offers excellent training. However, these are exceptions. 4. Single neurosonologists might have received education and training in excellent institutions abroad and might be known worldwide. Yet, an island on its own, even if it is beautiful, always remains an island. We are much more interested in connectivity and networking between laboratories. 5. Finally, considering that a national representative is proud to represent her/his country, the responses to the survey must be viewed as an optimistic representation of the current situation. Therefore, any negative response cannot be underestimated. Rather, action must be taken to improve the current situation by promoting in different countries courses, training, and international certification in the main fields of neurosonology for teachers and for experts.

Conclusion

The results of this survey indicate that there is a substantial need for transnational harmonization of neurosonology standards to guarantee uniformity and quality of performance. This survey will also provide guidance to promote an international accrediting council and create a quality-controlled laboratory network for implementing neurosonology in clinical trials.

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Conflict of Interest

The authors declare that they have no conflict of interest.

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