

Reflections on the design of an ultrasound study program in medical undergraduate

Ernesto CALDERÓN-MARTÍNEZ, Rodrigo PEÑA-CARRANZA, Raúl SAMPIERI-CABRERA

Introduction. The use of didactic tools for teaching basic sciences in the medical career focuses on anatomical models, electrodiagnostic equipment, and simulation. Only some study programs incorporate images for teaching basic sciences; some of the reasons are the cost of the ultrasound equipment. However, many medical schools have the infrastructure to do so.

Materials and methods. We conducted a review of the scientific literature in the Scopus, Web of Science, and Google Academic databases, after which the researchers conducted discussion sessions to select the main ideas that would help build the educational proposal.

Results. Describe a proposal for curricular design for creating training programs and teacher training that allows maximizing the use of ultrasound as a teaching tool for the basic sciences of the medical career.

Conclusion. The best way to strengthen the teaching of medical sciences is through constant academic training, both in disciplinary content and in teaching. Only in this way can we face the great need to train doctors who are very aware of their social responsibility.

Key words. Anatomy and physiology education. Biomedical basis of medical education. Medical education. Point of Care Ultrasound (POCUS). Teacher training programs. Ultrasound.

Reflexiones sobre el diseño de un programa de estudio de ultrasonido en el grado de medicina

Introducción. El uso de herramientas didácticas para la enseñanza de las ciencias básicas en la carrera de medicina se centra en modelos anatómicos, equipos de electrodiagnóstico y simulación. Solo algunos programas de estudio incorporan imágenes para la enseñanza de las ciencias básicas; algunas de las razones son el costo del equipo de ultrasonido. Sin embargo, muchas escuelas de medicina tienen la infraestructura para hacerlo.

Materiales y métodos. Se realizó una revisión de la literatura científica en las bases de datos Scopus, Web of Science y Google Academic, tras lo cual los investigadores realizaron sesiones de discusión para seleccionar las ideas principales que ayudarían a construir la propuesta educativa.

Resultados. Describir una propuesta de diseño curricular para la creación de programas de formación y formación docente que permita maximizar el uso de la ecografía como herramienta didáctica de las ciencias básicas de la carrera de medicina.

Conclusión. La mejor manera de fortalecer la enseñanza de las ciencias médicas es a través de la formación académica constante, tanto en los contenidos disciplinares como en la docencia. Solo así podremos afrontar la gran necesidad de formar médicos muy conscientes de su responsabilidad social.

Palabras clave. Base biomédica de la educación médica. Educación médica. Enseñanza de la anatomía y la fisiología. Programas de formación docente. Ultrasonido. Ultrasonido en el punto de atención (POCUS).

Introduction

Ultrasound has become an increasingly common tool in medical schools' curricula worldwide [1]. However, to date, only some comprehensive undergraduate ultrasound programs have been described, and those that exist have faced significant pedagogical challenges in their incorporation into the undergraduate [2]. This is due, in part, to the fact that

medical students have been taught using existing or adapted courses, which were designed for practicing physicians or were inspired by programs established in other institutions, needing an educational context [3,4].

Few study programs incorporate ultrasound in undergraduates to teach basic sciences like physiology. Also, there are no need or feasibility assessments to support the content and structure. Ac-

Learning Science Laboratory. Physiology Department. School of Medicine. Universidad Nacional Autónoma de México (UNAM). Mexico City, Mexico.

Correspondence:

Dr. Raúl Sampieri Cabrera. Departamento de Fisiología. Facultad de Medicina. UNAM. Coyoacán, Cd. Universitaria, 04510, Ciudad de México, México.

E-mail:

sampieri@comunidad.unam.mx

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cording to Stone-McLean et al [5], medical students may only learn an irrelevant and inappropriate curriculum for their level of training or be impractical for their future medical activity [5]. Traditionally, ultrasound resumes have been designed for practicing physicians to improve clinical decision-making [6]. However, in the early stages of the undergraduate medical training cycle, ultrasound should focus on teaching the basic sciences, elementary ultrasound skills, and as a tool to improve physical examination. Ultrasound improves cardiovascular anatomy and physiology understanding and develops physical examination skills [7,8]. According to Aldekhyl et al [9], introducing basic ultrasound concepts in the early stages of medical education allows a diverse foundation of ultrasound-specific cognitive and motor skills, which are then transferable to more demanding clinical applications performed with a high cognitive load. Some of the benefits of its implementation are exemplified in the study conducted at Northwestern University Feinberg School of Medicine, where it was shown that training with ultrasound as a complement to the traditional methods of teaching abdominal examination improves the technique of the physical examination in addition to demonstrating that the students' confidence in performing the physical analysis enhanced concerning those who were not trained in ultrasonography [10]. Furthermore, a study by DeCara [11] demonstrated that fourth-year medical students who were trained for four weeks on the use of the portable ultrasound device resulted in significantly more accurate bedside diagnoses as they progressed further in their training, compared to traditional physical examination techniques alone.

The implementation of ultrasound for the teaching of anatomy and physiology in the medical career can have the following effects at the teaching level:

- *Greater understanding of concepts.* It can help students to better visualize and understand the structure and function of the human body, which in turn can improve their knowledge of anatomy and physiology concepts.
- *Improvement of the quality of teaching.* It can allow more interactive and participative teaching since the students can use the equipment to explore the human body. In addition, incorporating state-of-the-art technology can improve the quality of education and make the experience more attractive and exciting for students.
- *Training of practical skills.* It can allow students to develop practical skills, such as identifying structures and interpreting ultrasound images,

which are necessary for their future medical practice.

- *Updating of teaching.* The incorporation of ultrasound can help to update the teaching of anatomy and physiology in the medical career since technological advances have significantly improved visualization and diagnostic capabilities.
- *Improved employability.* Students trained in ultrasound may have a competitive advantage in the job market, as these skills are increasingly valued in today's medical practice.

The medical career's extensive curriculum requires personnel trained in teaching tools that can be scaled to medical activity [9]. In this sense, our objective is to reflect on the need to create a comprehensive training program and teacher training in the use of ultrasound to incorporate ultrasound as an educational tool in teaching basic sciences in the medical career.

Ultrasound

The portable ultrasound imaging performer and interpreted by a clinician at a patient's bedside is now known as a Point of Care Ultrasound (POCUS), their applications have been expanded rapidly over the past years, this for the advances in the technology and the best portability and image quality, with all these improvements in image the necessity to create a curricula to train medical professionals with skills to manage this new technology is every day most needy [12,13].

Ultrasound inside the curricula

There are so many studies that show up improvement in the undergraduate students in many areas of the clinical activity.

One study investigated the impact of ultrasound in the first-year medical student on anatomy topics, showing an improvement in the comprehension and test scores of the students who took the course with ultrasonography in comparison with those who did not take this course [14,15].

Another study analyzed the exploration of certain organs such as thyroid, liver and lung; with and without ultrasound, demonstrating greater self-confidence in third-year students who relied on ultrasound [16,17].

Another study analyzed fourth-year medical students and showed that students could develop an advanced understanding of medical ultrasonography within a structured curriculum [18,19].

Among sixth-year students, studies have been carried out where it was shown that with a 2-week course, better results were obtained in the interpretation and use of these diagnostic elements compared to those who did not take it, it was also analyzed and it was obtained that the number of scans performed is not significant for learning, in another study a similar intervention was carried out, just with 1 day of training, obtaining similar results of achievement and satisfaction [2,20].

Materials and methods

A bibliographic review on the use of ultrasound in medical education was carried out at a basic and clinical level. Subsequently, the authors held three discussion sessions to establish a methodological proposal to design an ultrasound teacher training program while maintaining the pedagogical objective of university teaching. The systematized form of the process is specified below:

- *Literature review.* Search for scientific articles, books, and publications on the use of ultrasound in medical education at a basic and clinical level. The study must include national and international literature and the most important databases (Scopus, Web of Science, and Google Academic).
- *Analysis of the bibliographic review.* A critical analysis of the studies found was carried out to identify the key elements for the training of ultrasound teachers in the educational field. A synthesis of the information found was made, and the strengths and weaknesses of the reviewed studies were determined.
- *Discussion of the results.* The authors held three discussion sessions to discuss the literature review findings and the critical analysis results. The authors worked as a team to reach a consensus on the elements that should be included in the ultrasound teacher training program.
- *Design of the training program.* Once the critical elements for the ultrasound teacher training program were identified, a program proposal was designed that responds to the pedagogical objectives of university teaching.

Results

All evidence is enough to support the creation of well-structured programs for using ultrasound as a teaching tool, introducing this tool early in the curricula. As has been done by numerous institutions,

Table I. Adaptation of the published 4-year integrated point-of-care ultrasonography curricula in undergraduate medical education [13].

Topics/session	Objective/skills	
1	Introduction to ultrasonography	Basic ultrasonography principles, indications for ultrasonography, point-of-care ultrasonography terminology, transducer selection, scanning techniques, and image orientation and acquisition
	Cardiovascular	Visualization of parasternal, apical, and subxiphoid 4-chamber views of the heart and inferior vena cava
	Abdominal	Visualization of liver, kidneys, hepatorenal recess, gallbladder, spleen, bowel, and pancreas
2	Technical skills	Limitations of ultrasonography and clinical indications
	Physical examination and clinical skills	Cardiovascular, pulmonary, and abdominal physical examination skills
	Thoracic	Pleural/lung sliding, parasternal, apical and subxiphoid 4-chamber views of the heart (B-mode and color flow mode), heart sounds, and valve closure
3	Family medicine	Abdominal aortic aneurysm screening and musculoskeletal ultrasonography
4	Radiology elective	Performing scans, reviewing ultrasonography images, and ultrasonography-guided procedure skill development

which have developed a longitudinal ultrasonography (US) curriculum that span the duration of the medical career, which is incorporated into subjects like anatomy, physiology, pathology, and clinical skill courses, in order to develop physical examination skills, procedural skills, emergency medicine diagnostic skills and point-of-care US in clinical decision making [13] (Table I).

USG and first point care services

As members of health care, we must attend the more prevalent pathologies of the community, keeping this in mind we make a bibliographic review of a curriculum proposed by the World Health Association [21], this curriculum requires a big modification focused on the prevalence of the pathologies in the first level of care and the prevalence of the pathologies by country, the quality of the equipment and the professional category, but give us a good starting point (Table II).

Discussion

The design of study plans and programs requires

Table II. Table of topics for level in the curricula proposed by the World Health Organization [21].

	Topics
I	Basic physical principles Exploration principles Basic and sectional anatomy Liver Vesicle and bile ducts Pancreas Spleen Kidneys and adrenal glands Ureters and bladder Peritoneal cavity and gastrointestinal tract Retroperitoneal space Main abdominal vessels Thorax (diaphragm, masses and thymus) Female pelvis Pregnancy Thyroid Scrotum Mammary gland
II and III	Superior physics of visualization processes Advanced ultrasonography techniques and procedures Detailed anatomy Instrument management and equipment quality Difficult and complicated case diagnosis
Specialties	Cardiology Gastroenterology Tocology and gynecology Urology Internal medicine Surgery

the collegial participation of the different actors in the teaching-learning process [22]. Therefore, we propose the following actions to explore the feasibility of incorporating ultrasound in the primary subjects of the medical study program (Figure):

- To evaluate teachers' perception of the usefulness of ultrasonography as a teaching tool.
- To agree on using ultrasound as a teaching tool in the different subjects of the medical degree program.
- Design of the teacher training course.
- The workshop focused on the practical use of ultrasound in the classroom.
- To design teaching guides.

For this stage, it is proposed to carry out a 'permanent educational ultrasound seminar', which allows exploring the perception that academics have about the use of ultrasound as a tool in the teaching-learning process of basic sciences in medical training [23]. Additionally, it is helpful to provide the participants with bibliography related to the topic of discussion before the session.

The seminar sessions will discuss what teachers know about the use of ultrasound as a teaching tool, their experience in using it (if applicable), and what they want to learn about it. Subsequently, the published evidences on:

- What is known so far of the use of ultrasound as an educational tool?
- What has been done in other universities?
- The importance of including it within the study plan of a medical career will be discussed.

At the end of the session, the attendees will be asked to share what they learned about the topic, and they will be invited to discuss their opinions on it. A written memory of the contributions of the seminar in understanding the topic will be prepared.

Agree on the use of ultrasound as an educational tool in the different subjects of the medical degree study program

Once the first phase of the seminar has concluded, a discussion table will be held with academics and students from the elemental cycles of the medical career. The following questions will be addressed:

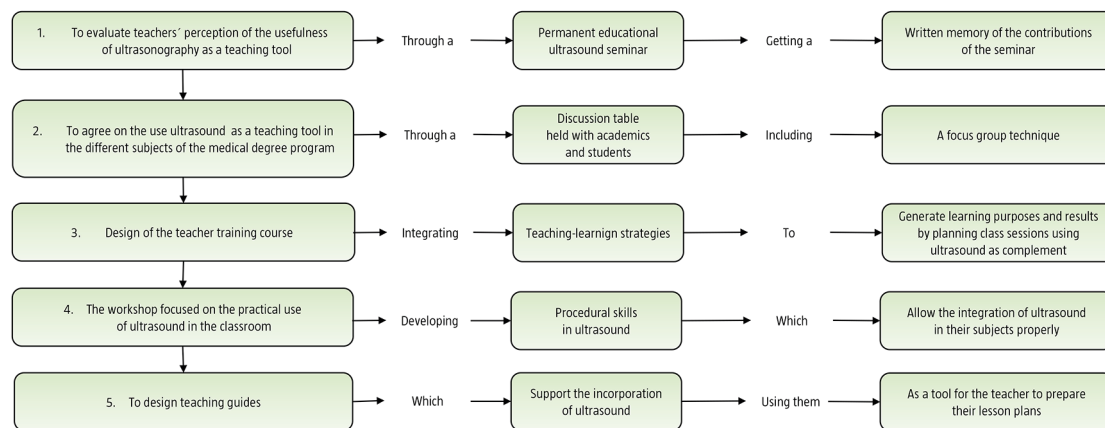
- What are the basic science subjects in which the use of ultrasound could be integrated as a teaching tool?
- If integrated, what are the topics that could be included?
- What are the activities and exercises proposed to develop significant and integrative knowledge of the basic and clinical sciences?

To collect and analyze the information derived from the discussion table, it is pertinent to carry out the focus group technique to explore in-depth the feelings of academics and students about the need to incorporate clinical tools for teaching the subjects of clinical cycles [24].

Design of the teacher training course

The course should be focused on the following learning outcomes [25]:

- At the end of the course, the teacher will be able to:
- Integrate teaching-learning strategies that allow you to promote medical skills that are part of the medical career curriculum.
 - Generate learning purposes and results by planning theoretical, practical, and theoretical-practical class sessions, using ultrasound as a com-

Figure. Methodological proposal for program design.

plementary instrument for teaching the subject to be understood.

The workshop focused on the practical use of ultrasound in the classroom

The workshop on the use of ultrasound allows developing procedural skills in ultrasound. Without being limited to a single subject, it allows its implementation in multiple academic areas. In which teachers are instructed in teaching-learning strategies that can be applied in the classroom, also, to the biophysical foundations of ultrasound and the necessary skills required for the proper use of ultrasound equipment and transducers. To evaluate the workshop, we will use a 'structured objective clinical evaluation' [26]. Where they will be able to apply what they have learned during the course, be evaluated, and reflect on the areas of opportunity they will have to improve to integrate ultrasound in their subjects properly.

Design teaching guides

After the work sessions and nourished with the information gathered by the different academics in the area, it is necessary to develop teaching guides, which support the incorporation of ultrasound with a high degree of evidence in the teaching of the basic sciences of the medicine. The guides will serve as a tool for the teacher to prepare their lesson plans and select assessment instruments that favor the achievement of learning purposes without this restricting their freedom of teaching [27].

Design proposal for an Objective Structured Clinical Examination (OSCE) for students

The Objective Structured Clinical Examination (OSCE) is a useful assessment tool for measuring student performance in specific clinical skills. The following proposal describes an OSCE designed to evaluate the use of ultrasound in anatomy and physiology:

- *Preparation station.* A list of the procedures that will be evaluated is explained to the students. In addition, students must be given access to the ultrasound equipment and a short practice period to become familiar with the equipment.
- *Anatomy station.* Students must identify specific anatomical structures using ultrasound, such as muscles, bones, blood vessels, and internal organs. Evaluators will provide a list of structures to be identified and the student will be assessed for accuracy and effectiveness in identifying them.
- *Physiology station.* Students will have to assess the function of different organs using ultrasound. For example, they may need to measure blood flow or assess heart activity. The student's accuracy and effectiveness in measuring physiological function using ultrasound will be assessed.
- *Report station.* Students will have to present a report on the findings of the previous stations to the evaluator, describing their conclusions and explaining their findings. The evaluator will assess the quality of the report submitted and the student's ability to communicate their findings clearly and concisely.

The OSCE would make it possible to evaluate the use of ultrasound in anatomy and physiology, measuring the accuracy and efficiency of the student in identifying anatomical structures and measuring functional. In addition, the student's ability to present and communicate their findings clearly and concisely would also be assessed.

Conclusions

Teachers who wish to teach anatomy and physiology using ultrasound may face several challenges. Some of them are:

- *Equipment access.* Access to ultrasound equipment can be expensive and limited, hindering its availability in all classes and the ability of students to practice and develop their skills adequately.
- *Training in the use of ultrasound.* Teachers may require additional training in the use of ultrasound and how to incorporate it into their teaching. In addition, students may also need the training to learn how to use the equipment effectively.
- *Difficulty interpreting images.* Ultrasound images can be complex for students and teachers, especially if they have no prior experience interpreting them.
- *Visualization limitations.* Ultrasound cannot visualize all anatomical structures clearly, so there may be limitations in visualizing some areas of the body. This can make teaching some areas of anatomy and physiology complex.
- *Integrating ultrasound into the curriculum.* Teachers may be challenged to effectively and consistently incorporate the use of ultrasound into the curriculum to ensure students are adequately exposed to technology and effectively develop their skills.
- *Equipment maintenance.* Ultrasound equipment requires regular maintenance to ensure proper operation and prevent failure. This can be expensive and requires additional resources for teachers and educational institutions.

Teacher training programs must be carried out in a collegial manner so that academics can share experiences and propose substantial changes in academic competencies development. In this sense, our proposal seeks that school decision-makers (educational administrators) consider their academic body's opinion to establish robust programs that do not violate academic freedom.

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