

A critical evaluation in the delivery of the ultrasound practice: the point of view of the Internal Medicine hospitalist

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The ultrasonography must be considered a milestone in medical diagnosis: it has changed the clinical approach and therapeutic decisions in many fields of medicine. At the beginning of the 80s, ultrasound has been utilized by traditional imaging specialists (radiologists, cardiologists, and obstetric-gynecologists). The rapidly growing field with numerous clinical applications developed the practice of ultrasound over the past 30 years also among doctors of several medical specialties, not only in the field of diagnostics but also in the interventional therapy. The expansion and the growing utilization of this technology in the recent past is also due to the development of low-cost (but high-tech) portable and handheld ultrasound machines. The availability of small ultrasound machines allowed the hospital specialist to perform the diagnosis to the patient's bed. But the fundamental reason for the extension of ultrasonography among medical specialist is that differently from *general sonologist* which performs an *organ oriented* examination, this specialist (particularly the internist) performs a *symptom oriented* sonography.

In this scenario, is the model designed in the 80s concerning a centralized sonography service with diagnostic survey carried out by a *pure sonographer* (generally radiologist) still valid?¹

In spite of the attempts to restrict the use of new

imaging technologies to *the imaging specialist*, the broadening use of ultrasound by doctors other than radiologist, made it possible to acquire knowledge useful in daily clinical practice in many fields. Not only cardiologist and gynecologist but also surgeon, urologist emergency physicians, intensivists and anesthesiologists have also begun using point-of-care ultrasound devices. In many branches of internal medicine such as nephrology, endocrinology, angiology, gastroenterology ultrasound is an essential diagnostic tool.^{2,3} This *focused (bedside) sonography* is very useful in those settings such as the departments of internal medicine where the ultrasound investigation completes the clinical examination to fulfill the so-called *integrated clinical examination*.

Focused (bedside) sonography is fundamentally different from the *general sonography* in many ways: in the past, the clinician taking care of a patient collected history, performed clinical examination and then decided to order a sonography. The patient is then transported to a different location (imaging department) where the exam is performed by a sonologist (usually radiologist), which interprets the study and reports this information back to the clinician in charge of the patient. Such a process delays the clinical decision because the sonography requested during a first visit, needs time to be performed, the report needs to be written and only after a second visit, during which clinical procedures are planned, it can take place. In focused bedside sonography the difference is that the clinician directly caring for the patient is also performing, interpreting and guiding patient care based on their own ultrasound examination. For these reasons sonography *clinician performed* is also called *point-of-care* ultrasound: although this definition well describes the type of examination performed, the term *focused (bedside) ultrasound* or *goal directed* seems to be the easiest to use and most widely recognized.⁴

This model *focused* on the performance of ultrasound examinations has many advantages: the most important is that the examination is performed quickly at the end of clinical examination and is capable to answer to specific questions and provides with rapidly *ruling out or ruling in* certain key diagnoses (Table 1).

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Received for publication: 16 June 2014.
Revision received: 29 July 2014.
Accepted for publication: 29 July 2014.

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Italian Journal of Medicine 2015; 9:1-4
doi:10.4081/ijm.2015.522

Finding on lung ultrasound scan a pleural effusion, a large number of lung comets (*B* lines), an inferior vena cava distension can differentiate the dyspnea due to heart failure from those due to a pulmonary disease.^{5,6} In an aortic patient with normal kidney a bladder distension can quickly differentiate urine retention from acute renal failure; as well as ultrasound can differentiate anuria due to obstructive urinary tract disease (*i.e.* hydronephrosis) from that due to advanced stage chronic kidney disease (*i.e.* small shrunken kidney) and can correctly address the treatment or the next diagnostic procedures. Ultrasound can differentiate abdominal pain due to gallstones, aortic abdominal aneurysm or renal colic.^{7,8} Focused ultrasound avoids useless examination and addresses correctly specific investigations: in a neoplastic patient with dyspnea, chest pain, hypotension with edema of the inferior leg, a simple compression ultrasound can highlight a deep vein thrombosis, hence calling for antithrombotic treatment and requesting a pulmonary computed tomography scan to confirm a pulmonary embolism.

Focused ultrasound is the best cost-saving method

in the follow-up of several diseases: in patients with pneumothorax the ultrasound daily search of *lung point* spares the patient from multiple X-rays examination so reducing radiation exposure and need to transport the patient.

Focused ultrasound is also useful in safely guidance of procedures such as thoracentesis, rachicentesis and vessel cannulation and in fluid challenge monitoring in some disease: the sonographic measurement and the breathing variations of inferior vena cava diameter, are a valid parameter to guide fluid infusion (Table 2).

Ultrasound scan performed in addition to traditional means of history and physical examination, allows a rapid fine-tuning and triaging of the differential diagnosis, and enables the optimization of the next steps for confirmatory diagnostic testing and appropriate treatment plan.⁹

The performance of focused ultrasonography, as any instrumental investigation, must be evaluated on the basis of cost analysis and quality issues in order to assess patient-centered outcomes. Focused (bedside) sonography demonstrated efficiency (*i.e.* saves valuable

Table 1. Focused sonography in Internal Medicine: key findings providing rapidly ruling out or ruling in certain diagnoses.

Cardiac ultrasonography

Is the left ventricular function preserved (EF)?
 Is left ventricular dilated?
 There is a left ventricular hypertrophy?
 There is a left atrial dilatation?
 Is right ventricular dilated?
 There is valvular regurgitation?
 There is pericardial effusion (tamponade)?
 Is IVC diameter increased (>25 mm) without (or low) breathing variation?

Vascular ultrasound

There is carotid stenosis?
 There is abdominal aortic aneurysm?
 Is CUS absent in leg veins (*i.e.* deep vein thrombosis)?

Endocrine ultrasound

Is thyroid gland enlarged?
 There is thyroid nodule (solid vs cystic)?

Lung ultrasonography

There is pleural effusion?
 There is pneumothorax (absent sliding sign)?
 Are ultrasound lung comets (*B* lines) present in this dyspnoic patient?
 There is pulmonary consolidation with air bronchograms?

Abdominal ultrasonography

Is liver enlarged?
 Is spleen enlarged?
 There are gallstones?
 Is gallbladder wall thickened (colecistitis)?
 Are bile ducts dilated in this jaundiced patient?
 Is ascites present?
 Are kidney size reduced and shrunken?
 There are urinary stones?
 Is hydronephrosis present?
 There is urine retention?
 Is prostatic gland enlarged?

EF, ejection fraction; IVC, inferior vena cava; CUS, compression ultrasound.

time and resources); in addition the use of ultrasound allows to: i) enhance the clinician's ability to identify immediate life threatening conditions in critically ill patients and guide adequate treatment; ii) avoid the transport of potentially unstable patients away from the clinician; iii) the clinician to more directly include the patient in their diagnostic work up and plan by explaining what they are doing as they perform their ultrasound; iv) in several conditions address correctly appropriate therapies and/or diagnostic procedures; v) in some cases to obviate the need for more resource-intensive imaging performed by a consulting radiologist.

These data demonstrated that the specialist - particularly internist - managed model is not only time saving but also cost-effective.¹⁰

With appropriate use, focused ultrasonography can decrease medical errors, provide more efficient real-time diagnosis, and supplement or replace more advanced imaging in appropriate situations. In addition, ultrasonography may allow more widespread, less-expensive screening for defined indications (*i.e.* abdominal aortic aneurysm). However, indiscriminate use of ultrasonography could lead to further unnecessary testing, unnecessary interventions in the case of false positive findings, or inadequate investigation of false negative findings. More imaging could simply lead to increased expense without added benefit, or might even be harmful.

Sonography is an operator-dependent diagnostic examination and as a user-dependent technology, ultrasonography requires consideration of appropriate training and quality assurance. Therefore it is widely recognized that ultrasound cannot be performed by a physician without adequate expertise. The risk of misdiagnosis is high when diagnostic ultrasound is used by inexperienced practitioners. False positive findings may lead to additional and often unnecessary testing, and false negatives may provide unwarranted reassurance and result in underdiagnosis.

Since these bedside ultrasound machines are available, highly accurate when used properly, at reasonable costs, the question is: what is the average of internal medicine trainees or physicians who learned to use these instruments? A number of studies has addressed this question. The answer is difficult first for the two

following reasons: i) acquiring the image is more difficult than learning how to interpret it particularly in patients frequently observed in internal medicine wards; ii) there are different levels of difficulties to discover and understand the picture. Most of the internists can acquire, relatively rapidly, the limited skills required to use ultrasound device in order to perform narrowly defined tasks, such as aortic aneurysm, pleural effusion, ascites. On the other hand acquiring and interpreting a small hepatic lesion is more difficult.

Although focused ultrasonography is a clinically useful tool with relevant applications across most specialties, the levels of training needed to ensure accurate use of the ultrasound device in many areas of internal medicine have not been defined yet. For these reasons an introduction of ultrasound training within the medical (particularly post-graduate) education system is necessary in order to identify trained faculty, access adequate resources, and appropriate integration into existing medical curricula. However, despite supporting evidence for echography performed by physician, an educational strategy and widely accepted guidelines for competency for focused ultrasonography have still to be established.

The internal medicine specialist, apart from few exceptions, does not have, during post-graduate course, specific curricula, competency assessment, and standardization of the quality of focused ultrasound training. The Federation of Associations of Hospital Doctors on Internal Medicine (FADOI) tried to fill this gap by implementing and organizing the School of Ultrasonography in Internal Medicine directed to develop hospital internists' proficiency in focused ultrasonography. In its document of Clinical Competence of Hospital Internal Medicine¹¹ it identified three levels of competence - with relevant skills requested - in ultrasound diagnosis: basic, intermediate and advanced. The basic level consists of a theoretical course of 32 h followed by a practical part of 80 h that would allow hospital internist to identify appropriate uses of instrument, acquire real-time ultrasound images, interpret ultrasound findings, and utilize ultrasound findings in clinical decision-making. In the intermediate level skills are required on eco-color-Doppler investigation of cardiovascular system

Table 2. Focused bedside sonography in Internal Medicine: safely assisting procedures and correctly guiding therapies.

Procedural guidance (safety improved)

Vascular access as internal jugular and subclavian cannulation, thoracentesis, paracentesis

Monitoring therapies and disease evolution

Assessment of fluid status by measurement of inferior vena cava diameter and breathing variations (IVC<15 mm with >50% reduction during inspiration high probability of fluid response)

Monitoring pneumothorax by searching *lung points*

IVC, inferior vena cava.

and evaluation of parenchymal lesions. The advanced level consists in skills such as contrast-enhanced ultrasound, elastosonography, performed by centers of excellence.

In the next years the major challenge will be to define *sonographic competence levels* and appropriately integrate the ultrasound training within the medical postgraduate program.

In 1816 Renè Laennec,¹² inspired by two children sending signals to each other using a piece of solid wood and a pin, developed the stethoscope and used this new instrument to investigate the sounds made by the heart and lungs. The discovery was considered revolutionary because instead of auscultating the heart and the lung directly placing the ear on the patient's chest, auscultation was *mediated and amplified* by the stethoscope. This diagnostic tool, which has undergone few developments in style and technology throughout years, has been universally used as diagnostic device over the following centuries by physicians and nurses. Any new technology requiring training and expertise meets the resistance from practitioners tied to older practices. This was the case of the stethoscope, which was considered a useless tool if not even harmful by physicians of the time. In the following years the real value of the discovery was recognized and at present, nearly two centuries later, the stethoscope is the icon of medical profession and it is a device used by virtually every type of physician.

After many years, another new tool has revolutionized the clinical examination and is now available to the internist in the daily clinical bedside practice: portable ultrasound machine.

During the past 50 years, diagnostic ultrasonography has replaced auscultation as the primary method of evaluating the mechanics of the heart, the status of vessels and abdominal organs thanks to the anatomic and functional information it provides without exposure to ionizing radiation. In cardiovascular medicine, echocardiography is the most used and cost-effective imaging method, despite the development of many other powerful new technologies. Scott D. Solomon in a commentary published on the *New England Journal of Medicine*¹³ writes: *A generation of physicians will need to be trained to view this technology as an extension of their senses, just as many generations have viewed the stethoscope. That development will require the medical education community to embrace and incorporate the technology throughout the curriculum.*

Ultrasonography will be a widespread tool universally used and valued as Laennec's stethoscope if training in its use becomes standard for future physicians. As for the stethoscope the *handled portable ultrasound machine* can be used by medical personnel

as well as non-medical one. Not only many specialists use the tool and an increasing number of general practitioners but also the nurses are using it currently to carry out interventions of their relevance (ultrasound-assisted venous cannulation, bladder catheter placement, etc.).

Future challenges include gaining a better understanding of when and how ultrasonography can be used effectively, determining the training and assessment that will be required to ensure competent use of the technology, and encouraging appropriate and effective use to improve medical practice at the point of care.

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