Reviews

Hand-carried Echocardiography

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Echocardiography constitutes a widely used diagnostic imaging method that provides important information concerning the anatomy, physiology and performance of the heart and contributes to clinical decision-making and patient management.

Today's echocardiographic devices take advantage of digital technology, thus providing excellent imaging quality. Conventional devices are however cumbersome, difficult to manoeuvre and are usually located in the echocardiography laboratory. Moreover, the use of these devices by inadequately trained staff may lead to misinterpretations and omissions with adverse medical, ethical and social implications[1]. Therefore, it becomes imperative to develop easily transportable and less complex echocardiographic devices.

At the end of the 70s, the development of a hand-carried echocardiographic device as an auxiliary tool to the standard physical examination was attempted. However, technological limitations and the high cost prevented its further development[2,3]. In recent years, progress in electronics has enabled the development of high-resolution hand-carried echocardiographic devices[4].

Hand-carried echocardiography provides rapid and readily available anatomic and functional information at the patient's bedside, overcoming difficulties imposed by the cumbersome standard echocardiographic equipment (Figures 1, 2). Hand-carried echocardiographic devices are attractive because of their minimal size, ease of transportation and cost. They weigh approximately 2.5 kg and they are provided with a phasic broadband (2 to 4 MHz) transducer capable of 2-dimensional imaging. Certain first generation miniaturized platforms, such as Sonoheart (Sonosite), are exclusively equipped with colour power Doppler. Colour power Doppler is a technique that measures the mean amplitude of the Doppler signal, not the Doppler shift as in standard colour Doppler. Therefore velocity is not measured and colour power Doppler is not-aliasing (Figure 3). Colour power Doppler lacks variance, which makes the identification of high-velocity turbulent jets more difficult. Other limitations of the first generation hand-carried echocardiographic devices include the larger transducer dimensions, the limited capacity of storing and transferring images and the non-availability of M-mode and pulse, continuous and spectral colour Doppler.

Second generation hand-held devices are usually equipped with tissue harmonic imaging, M-mode, pulse and continuous Doppler, cine-loop, improved software for calculations and capability for connection with a personal computer (Table 1). However, hand-carried echocardiography, with the currently available devices does not fulfill the criteria for a complete echocardiographic examination. Consequently, handheld devices cannot replace the standard echocardiographic equipment.

Figure 1. Long-axis parasternal view of the left ventricle.

Figure 2. Short-axis view of the left ventricle at the level of the papillary muscles with measurement of the end-diastolic diameter of the left ventricle.

It is well known that a comprehensive physical examination remains the cornerstone for the initial assessment of patients with suspected cardiovascular disease. However, proper physical examination (particularly heart auscultation) requires skills, which appear to decline in most physicians, despite the application of modern educational methods[5]. Hand-carried echocardiography may fill in this gap. Nowadays, it is well established that hand-carried echocardiography provides more information than physical examination alone, including inspection, palpation and auscultation[6]. According to the recommendations of the American Society of Echocardiography, it should be applied as an extension to the standard physical examination (the so-called ultrasound stethoscope) aiming to improve its diagnostic accuracy[7].

The clinical applications of hand-carried echocardiography include initial patients' evaluation at bedside, in the outpatient clinic, in the emergency department and in the coronary care unit.

"Limited goal oriented" echocardiographic examination

Complete echocardiographic examination performed with the standard devices includes an extensive and detailed approach, which is costly and time-consuming. However, a specific diagnosis, as well as long-term follow-up of many cardiovascular disorders, requires a restricted study (i.e. assessment of the amount of pericardial fluid, investigation for wall motion abnormalities, estimation of the ejection fraction, etc.)[8,9]. Hand-carried echocardiography is the most suitable approach in such cases, known as "limited goal oriented" examination[4]. In addition, handheld echocardiography can be applied for telemedicine purposes.

Screening test

Hand-carried echocardiography can be applied as a screening test for the diagnosis of several cardiac disorders in a given population.

Figure 3. Apical four-chamber view of the left ventricle with colour power Doppler. A jet within the left atrium is observed, due to mitral regurgitation.

Table 1. Availability and capabilities of the hand-carried devices available in the market.

Devices	M-mode	Pulse Doppler	Continuous Doppler	Colour Doppler
Sonoheart	–	–	–	–
Sonoheart Elite	+	+	+	–
Optigo	–	–	–	+

It is well known that left ventricular hypertrophy constitutes an independent factor of adverse cardiovascular events in hypertensive patients[12,13]. The early detection and treatment of left ventricular hypertophy is the cornerstone of the appropriate treatment of arterial hypertension. Electrocardiography alone is not a sensitive tool for the detection of left ventricular hypertrophy. Recent studies have shown that hand-carried echocardiography is a useful screening tool for the detection of left ventricular hypertrophy in hypertensive patients, with a reported agreement of 93% (kappa: 0,77)[12].

Hand-carried echocardiography constitutes a useful method for the assessment of left ventricular dimensions and ejection fraction, allowing the early detection of heart failure[12]. The incidence of heart failure increases with age and reaches 8% at the age of 65 years, with half of these patients being asymptomatic[13,14]. The early diagnosis and treatment of heart failure prevents the deterioration of the patients' condition.

Another application of hand-carried echocardiography is the detection of abdominal aortic aneurysms in high-risk patients, such as elderly individuals and patients with coronary artery disease or arterial hypertension[15].

Hand-carried echocardiography may also be applied for the detection of mitral valve prolapse, bicuspid aortic valve, enlargement or aneurysm of the ascending aorta (including screening of patients with Marfan syndrome) and finally for the screening of athletes with hypertrophic cardiomyopathy[16,17].

Use in the coronary care unit

Previous studies have shown that the use of echocardiography in the coronary care unit improves the patients' outcome[18]. Unfortunately, standard echocardiographic devices are cumbersome and difficult to maneuver. On the contrary, hand-held devices are very useful, as is the stethoscope, and when applied for a 'limited goal oriented' examination they allow the rapid diagnosis of potentially life-threatening conditions.

Goodkin et al compared the first generation hand-carried devices with standard echocardiography in 80 coronary care unit patients. They found that with hand-carried echocardiography an important finding was missed in 45% of patients and thus concluded that hand-carried echocardiography is clearly inferior, compared with conventional echocardiography, for the assessment of critically ill patients[19]. These results were attributed to the non-availability of colour Doppler in the first generation hand-carried devices. Subsequently, Rugolotto et al used hand-held devices equipped with colour Doppler and found that the diagnostic accuracy of the hand-carried echocardiography was improved in the coronary care unit, leading to treatment modification and to better patient management[20].

The contribution of hand-carried echocardiography is equally important in the emergency department, where a rapid and correct diagnosis is imperative for the clinical decision-making.

Recommendations concerning the level of training required for the performance of echocardiographic studies have already been established (Table 2)[7]. The American Society of Echocardiography suggests that training level I is the minimum required in order to perform and interpret echocardiographic studies with hand-carried devices. However, at this level of training supervision by a more experienced sonographer is necessary.

In the near future, the use of hand-carried echocardiography by other operators (internists, general practitioners, intensive care unit medical staff, medical students, nurses and paramedics) is foreseen. It is noteworthy that in the United States of America, the hand-carried echocardiography is already incorporated in the medical students' training.

Table 2. Minimal training requirements in echocardiography.

Level	Number of examinations performed	Number of examinations interpreted	Goals
I	75	150	Initial training
II	150	300	Performance, interpretation
III	300	700	Director of echocardiography laboratory

Conclusions

Although hand-carried echocardiography cannot replace standard echocardiography, it is very helpful for the completion of the physical examination, providing important anatomical and functional information related to the cardiovascular system. It can be described as 'an ultrasound stethoscope' and constitutes a useful screening method when applied in a 'limited-goal oriented examination'. Hand-carried echocardiography is expected to reduce the number of standard requested echocardiographic studies, eventually reducing cost and hospitalization time.

Hand-carried echocardiographic examination must be performed by sonographers with at least level I of training. It is emphasized that the inappropriate use of these devices, particularly by practitioners inadequately trained in the interpretation of echo-studies, must be avoided.

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