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Echocardiography: the transition from master of the craft to admiral of the fleet

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Echocardiography has become essential for the diagnosis and management of cardiovascular disease. Over my medical career, cardiac ultrasound has evolved from the blurry wavy lines of M-mode tracings understandable only to a few dedicated practitioners, to real-time intuitive anatomic images accessible to all healthcare providers. In addition, the development and validation of quantitative imaging and Doppler techniques has transformed clinical cardiology with the ability to measure left ventricular ejection fraction and cardiac output, estimate pulmonary pressures, evaluate diastolic function, and quantitate valve and congenital heart disease severity. More advanced imaging modalities including transoesophageal imaging, real-time three-dimensional (3D) and biplane imaging, contrast echocardiography, tissue Doppler, and other modalities have further extended our diagnostic capabilities. There is no question that echocardiography is an accurate and powerful diagnostic tool when performed and interpreted by highly skilled professionals at centres with a high volume of complex cardiac disease. However, the real challenge is ensuring that echocardiographic diagnosis is accurate and reliable, regardless of where or when the study is performed, resulting in improved patient outcomes. Unfortunately, many experts are concerned that the current quality of echocardiography across the clinical community fails to meet this goal.[1]

TRADITIONAL APPROACH "NOT WORKING"

The traditional approach to improving quality has been to require additional education, training and certification. My view is that this approach is not working. Standards for the content, length and volume of studies performed and interpreted have been established by several professional organisations for the education and training of cardiologists, cardiac anaesthetists and cardiac sonographers.[1–3] Both general cardiology and specialised echocardiography board examinations provide certification of competence for individual practitioners.[4 5] Accreditation of echocardiography laboratories provides an additional layer of quality assurance.[6 7] Still, despite rigorous training standards, credentialing and accreditation, the quality of echocardiography remains quite variable.[1] Although formal studies have not been performed or published, expert opinion suggests there has been little improvement in quality despite ever increasing requirements for the length and intensity of education and training. Maybe it is time to try a different approach.

This issue is of critical importance now that the use of cardiac ultrasound is expanding to more practitioners in more clinical settings. The term 'echocardiography' no longer connotes a single type of diagnostic test, instead it encompasses several types of studies of various lengths and complexity with different clinical goals. In my view, these different types of cardiac ultrasound are best defined by three elements: why, where, and by whom (table 1). 'Why?' is the most important question because it defines what data are acquired and measured, as well as the type of ultrasound equipment and the required healthcare provider expertise. The most comprehensive echocardiogram is a complete diagnostic examination which requires acquisition by a highly skilled sonographer with recording of a defined set of images and Doppler data using topline equipment, as well as quantitative measurements and an integrated interpretation of the data by a cardiologist with advanced training and experience in cardiac imaging. In contrast, data acquisition and measurement are different if the reason for echocardiography is monitoring, rather than diagnosis. For example, a subsequent study in a patient at risk of left ventricular dysfunction might only record and measure data specific to that diagnosis. In a more complex example, transoesophageal echocardiography performed to guide a surgical or transcatheter valve procedure requires considerable expertise, complete ultrasound systems, acquisition of numerous images and Doppler data with quantitative measurements. Although a comprehensive exam may be recorded in some cases, in others procedural guidance focuses only on specific elements of the exam and may be performed by a qualified cardiac anaesthetist, rather than by a cardiologist. Procedural guidance also might utilise other ultrasound modalities such as intracardiac echocardiography with images acquired and interpreted by the interventional cardiologist or electrophysiologist. At the other end of the spectrum, point-of-care ultrasound seeks to inform decision making at the bedside, and may require only a few basic cardiac images acquired with a small inexpensive ultrasound device by a healthcare provider with limited imaging training.

POTENTIAL TO IMPROVE PATIENT CARE

The dissemination of cardiac ultrasound throughout medicine has great potential to improve patient care. It is a safe, relatively inexpensive, portable and powerful diagnostic tool. Why my hesitation? The real danger of ultrasound imaging is what is not seen. Specifically, if the exam fails to record images showing the abnormality or if the healthcare provider fails to recognise the abnormality, there is the danger of a missed or incorrect diagnosis. This error is all too easy to make; even expert echocardiographers can only interpret the images that were recorded. When the correct image is obtained, the abnormality might not be recognised by the healthcare provider. For example, significant experience is needed to identify abnormalities in regional left ventricular wall motion; thus the diagnosis of acute myocardial infarction might be missed. Even among cardiologists, there is considerable variability in echocardiography interpretation. How can we hope to ensure high quality imaging and a correct diagnosis for every patient by all healthcare providers, including cardiologists?

The first step seems obvious, although not easy to implement. We need to move away from the concept of restricting cardiac imaging to a small group of highly skilled individuals towards a systems-based approach with cardiac imaging integral to standard medical care. This will require that we: (1) integrate imaging into educational curriculums right from the start of medical training; (2) set standards for the appropriate scope of practice, stratified by healthcare setting and provider training; (3) develop validated approaches for documenting competency of providers within each scope of practice; (4) use systems based approaches to prevent and identify

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Table 1 Cardiac ultrasound examination types defined by purpose of study, clinical setting and healthcare provider

		Procedural guidance			
	Diagnostic echocardiogram	**Cardiac surgery**	**Interventional procedures**	**Electrophysiology (EP) procedures**	**Point-of-care echocardiography**
Purpose of imaging	Diagnose and measure disease severity, evaluate progression or response to therapy, integrate with clinical information and other imaging approaches	Comprehensive perioperative exam and/or procedure guidance (baseline data, measure results, detect complications)	Direct catheter and device positioning, evaluate procedural results, detect complications	Direct catheter and device positioning, detect complications	Immediate patient triage and management or monitoring cardiac parameters
Clinical setting	Any inpatient or outpatient location under the auspices of a structured echocardiography laboratory*	Operating room	Interventional suite or hybrid operating room	Electrophysiology lab	Inpatient bedside, emergency department or outpatient clinic
Healthcare provider	Images recorded by cardiac sonographer and interpreted by cardiologist with expertise in echocardiography	Interventional echocardiographer or cardiac anaesthetist with expertise in echocardiography	Interventional echocardiographer, interventional cardiologist or anaesthetist†	Clinical cardiac electrophysiologist or anaesthetist†	Physician providing direct care to the patient with limited training in echocardiography
Ultrasound modalities	All echocardiographic modalities as appropriate	TOE Epicardial	TOE ICE TTE	TOE ICE TTE	TTE—primarily two-dimensional imaging and colour Doppler
Documentation	Formal written report in medical record	Results integrated into anaesthesiology procedure note	Results integrated into interventional procedure report	Results integrated into EP procedure report	Results reported in clinical progress note
Quality improvement	Long term PACS storage of digital images documenting entire study	Long term PACS storage of representative digital images	Optional long term PACS storage of representative images	Optional long term PACS storage of representative images	Images typically not recorded although key images may be saved for CQI

*Ideally the echocardiography laboratory is accredited by the Intersocietal Commission for the Accreditation of Echocardiography Laboratories (ICAEL) or equivalent process.
†Imaging may be performed by an anaesthetist with expertise in echocardiography, a cardiologist or the interventional cardiologist.
CQI, continuous quality improvement; ICE, intracardiac echocardiography; PACS, picture archiving and communications system; TOE, transoesophageal echocardiography; TTE, transthoracic echocardiography.

errors; and (5) provide mechanisms for continuous quality improvement. As technology evolves this may become easier. Perhaps smart ultrasound systems could acquire images automatically once the transducer is positioned on the patient. Perhaps the ultrasound system could measure and interpret the image itself; for example, the readout could be a numerical ejection fraction rather than a cross sectional or 3D image of a beating left ventricle. Perhaps images could be acquired at the bedside with simultaneous interpretation by experts at a central site. Perhaps patients could have pocket ultrasound systems that transmit complex cardiac data to their health record daily. An ultrasound machine should not be considered an 'instrument' that requires a 'musician' to play, it simply should be a computer with transducer inputs that provide quantitative and reliable data. Ultrasound companies have been remiss in focusing too much on new 'advanced' imaging approaches that are useful only in small subsets of patients, while failing to provide fail-safe imaging that would improve overall population health.

CARDIAC ULTRASOUND FOR EVERY PATIENT, EVERY TIME, EVERYWHERE

There will be many steps along the path to consistent and reliable echocardiographic diagnosis. We could start with improved tools for data acquisition and measurement that reduce the chance of error. We could use tools to ensure patients with abnormal findings on echocardiography also receive formal complete studies and are referred for appropriate sub-specialty care. We could implement standardised approaches to training and competence assessment, using both traditional approaches and high-level simulation technology to ensure each practitioner has mastered skills.[8 9] Similar approaches could be used for periodic updating of skills for acquisition and interpretation of ultrasound data. At the institutional level, we could set standards for scope of practice and for minimising error through oversight and active participation in quality improvement programmes for all cardiac imaging studies, with the hope that automated image interpretation will be possible in the future. No doubt there are many other potential approaches that will be effective within an institution or clinical practice. The point is that we need to start actively implementing these approaches now instead of passively waiting for adverse events that will prompt remedial rules and regulations. This action needs to be led by expert echocardiographers with the collaboration of colleagues who seek to improve patient care using cardiac ultrasound in the intensive care unit, emergency department, operating room, interventional cardiology suite, outpatient primary care clinic, and many other settings.

The integration of echocardiography into every aspect of medical care will not be easy with the specific challenges varying from country to country, between institutions and at the individual practitioner level. However, those most skilled in echocardiography now need to take a leadership role in ensuring this transition results in the best health care for our patients. We need to move beyond being master of our own small ship and instead take on the role of admiral of the entire fleet of cardiac ultrasound for every patient, every time, everywhere.

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