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Implementing an Echocardiography Service in the Intensive Care Unit

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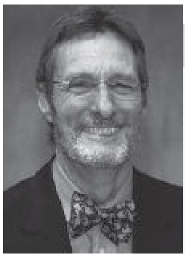

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Echocardiography is often an essential component in the management of a critically ill patient and setting up a service of acceptable quality requires attention to efficiency, sustainability and operator competency.

Introduction

The value of echocardiography at the bedside of a critically ill patient is well established (Cholley et al. 2006). Initially provided as an offshoot of regular radiology or cardiology ultrasound services, echocardiography in the care of the critically ill patient has increasingly been performed by critical care physicians themselves (Kaplan and Mayo, 2009). In addition to the obvious diagnostic advantages, real time echocardiography allows a greater focus on haemodynamic evaluation, thereby providing essential patient information in a more timely fashion. However, this enhancement to patient care comes with responsibilities, often unappreciated when contemplating setting up or expanding an already existent rudimentary service. Good planning will save frustration and costs compared with allowing development to occur in an ad hoc fashion.

Components to be considered include machine selection, recording and reporting studies, archiving, interdepartmental connectivity and training. Machine availability, a major challenge in the past, is less so now with less expensive, yet more sophisticated machines, within the budget of many Intensive Care Units (ICUs). It is acknowledged that machine acquisition may still be a problem in developing countries, especially where external influences dictate who may or may not have ready access to machines on site. Often overlooked when setting up an in-house service are machine care, maintenance costs, producing quality images in wellstructured examinations, recording images, archiving images and delivering reports that can be accessed in other sections of a major hospital.

Training remains a major challenge, not only in the availability of adequate educational resources, where the emphasis on practical hands-on training predominates at least for beginners, but also in assessing appropriate levels of competency. Useful guidelines and manuals dedicated to the critical care physician are becoming available (De Backer et al. 2011; McLean and Huang, 2012).

Consideration	Specifics
1. Transducer – type, number	cardiac, lung, vascular, abdomen
2. Size/mobility	handheld, laptop size, large
3. Scanning capability	range of Doppler applications – PW/CW/colour,TDI, velocity vector tracking, 3D strain-rate
4. TOE	included in purchase package or optional?
5. Compatibility	other ultrasound machines in ICU/ED/OR
6. Image management	magnification, cineloop, annotation, display, machine storage memory
7. Maintenance	cost, support staff, sterilisation TOE probe
8. Upgrade capacity	ease and cost of future upgrade
9. Cost	what is, what is not, included in quoted price?

Table 1. Considerations in Selecting Echocardiographic Machine

Intensive Care Medicine and Echocardiography

Echo has many advantages in the ICU with rapid application at the bedside, using either transthoracic (TTE) or transoesophageal (TOE) echocardiography for the purposes of cardiac diagnosis, haemodynamic evaluation, haemodynamic monitoring, and assistance in therapeutic procedures. Often the diagnostic information cannot be readily obtained by alternative invasive techniques, including fixed and dynamic valvular dysfunction, left ventricular diastolic dysfunction, the presence of segmental wall abnormalities in reduced left ventricular contractile dysfunction, and pericardial tamponade. Many of the underlying components contributing to circulatory status are readily assessed when haemodynamic evaluation/monitoring is the primary focus of a study (see Figure 1).

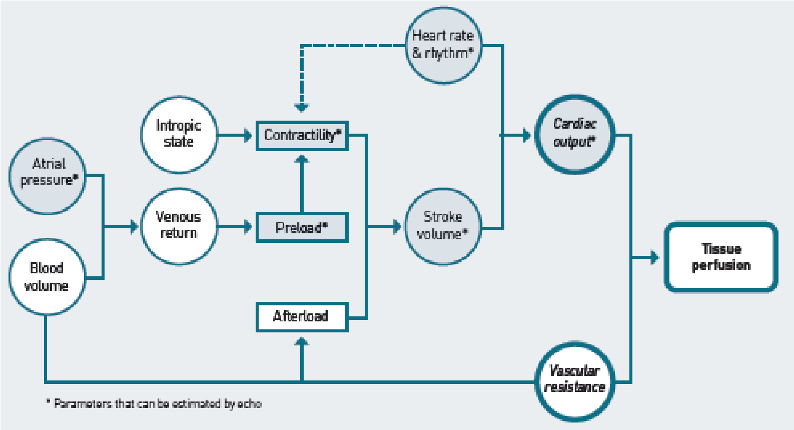

Figure 1. Haemodynamic Parameters Measured by Echocardiography

It is beyond the brief of this article to describe in detail the considerable information an experienced operator can obtain from a single or multiple studies; the benefits of critical care echo are well described elsewhere (Repesse et al. 2013; De Backer et al. 2011).

Machine Selection, Acquisition and Maintenance

A variety of ultrasound machines with cardiac capability are available, and selection should be approached in a deliberate and pragmatic manner. Often selection decisions are influenced by exposure to the same brand in another setting such as central line insertion in the operating theatre, persuasiveness of the sales representative, bias of other departments owning an echo machine, and automatically updating that particular brand. Technological advancements have created a wide range of available machines with varying capabilities over a cost range from 10,000 to 200,000 Euros. The medium range of ultrasound machines today, the size of a laptop computer, is markedly more sophisticated than a large high-end machine available 20 years ago, yet today costing one third of the larger one purchased at that time.

Selection criteria should be objective, with considerations of proposed additional noncardiac ultrasound uses of machine, software content, mobility, maintenance costs, upgrade ability, transoesophageal echocardiography (TOE) capability, and, underlying all these criteria, the cost or rather value for money. Only limited assistance is available in the literature, with comparison of machines in specific considerations or for targeted software applications (Royal College of Radiologists 2005; Wynd et al. 2009). One reason for this void is that machines are in continual evolution and an evaluation is outdated at the time of publication. Generic considerations to assist a rational approach are given in Table 1. For those engaged in newer advanced software applications like strain-rate and speckle tracking, an appreciation of intersystem agreements is important (Nelson et al. 2012; Fine et al. 2012).

Image Acquisition and Archiving

Acquiring a proper set of sequential images, with cardiac cycle timing provided by concurrent ECG monitoring should be standard practice. The practice of waving a transducer hurriedly across the chest belongs to the amateurish past. For both transthoracic echocardiography (TTE) and

TOE a predetermined standard set of views should be attempted, even though it is anticipated not all will provide suitable images. Images from each view should be recorded.

Evolution from utilising echocardiography as a quick diagnostic tool to a haemodynamic assessment/monitoring one necessitates image storage for later review, post-processing, or comparison with subsequent studies. Since any machine has limited internal storage, an external archiving system is an important component to consider when developing an in-house critical care echo service. Access to a system external to the ICU, such as a hospital clinical information system, radiology or cardiology system, is preferable to setting up a stand-alone system. It is less costly and also allows access to images elsewhere in the hospital. However, this is not always possible and a stand-alone system is necessary. There are two possible approaches – that of a proprietary system, using the same supplier as the machine provider, or a 'home grown' variety. The latter is less expensive and is not so difficult where local IT assistance is available, but may not have the same post-processing ability as a proprietary system. If multiple different machines are in use then a vendor neutral platform becomes an important consideration (Strowig 2013) (see Figure 2). Reporting of studies is essential. It improves the diagnostic and analytical skills of the operator, delivers necessary information to the medical team caring for the patient, and provides a succinct record. Archiving reports is also important, and some systems store both images and reports.

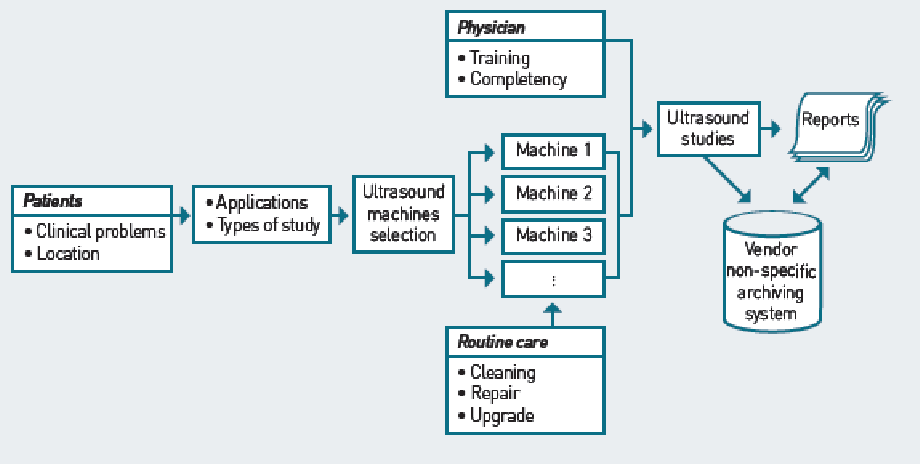

Figure 2. Image Capture, Storage and Reporting

Training

Dedicated enthusiasts have brought echocardiography from the periphery of critical care practice to what can appropriately be regarded as an essential tool in patient care. Introducing the practice into the ICU has by necessity developed in an ad hoc manner, dependent upon local resources, physician commitment, management support and, frequently, external political influences. Training has generally been via the apprenticeship model, resulting in a gradual increase of critical care physicians competent in the provision of around the clock bedside echo assisted patient management. Over the past two decades, training programmes to cope with the increasing demand have developed, the most notable example being established in France. To fill the training gap within the ICU setting, programmes initially came from a general ultrasound background or were cardiology based with a critical care flavour. The recognition that many aspects of echo application in the ICU setting differ substantially from those of radiology or cardiology, namely the need to rapidly assess multiple haemodynamic parameters, has led to a focus on developing specific CCE training programmes (Mayo et al. 2009). This need is further accentuated by Intensive Care training programmes around the world, making competency in basic echocardiography a mandatory component in the overall training programme.

Once the necessity of training critical care physicians in echocardiography was established, the question then arose as to what were acceptable levels of competency. Gaining experience is a continuum from the moment a doctor first places a transducer on the patient's chest, to measuring strain-rate in the right ventricular free wall. The next important step was international cooperation in determining the components required for competency in basic critical ultrasound, with a major emphasis on echocardiography. Representatives from Intensive Care bodies in Europe, Asia- Pacific, North America and South America met in Vienna in 2009, and a consensus paper was subsequently published in 2011 (Expert Round Table on Ultrasound in the ICU, 2011). This recommended that all trainee intensivists should be capable of performing a basic critical care echocardiographic study. A smaller proportion of physicians will seek to develop competency in advanced practice, with the emphasis moving from diagnosis alone, to diagnosis and haemodynamic assessment using both TTE and TOE. It is recognised that simulation techniques may enhance training, especially in TOE (Shakil et al. 2012). Recommendations on what constitutes advanced practice are now available in the literature (Narasimhan et al. 2014a; Narasimhan et al. 2014b). Some countries such as France and Australia already have training and credentialing programmes for critical care physician in advanced practice. Although individual institutions or countries can set standards, there is considerable benefit in developing international criteria. To achieve this single objective, a gathering of expert representatives from multiple national Intensive Care bodies met to debate and identify what constitutes advanced competency in Critical Care Echocardiography. This consensus document will be published in Intensive Care Medicine early in 2014 (Vieillard-Baron 2014). Such documents do not necessarily prescribe what a particular institution or national IC training body should do, but rather provide guidelines. This may have more value in those ICUs where the Director is not au fait with echocardiography.

Summary

Echocardiography is becoming commonplace in the ICU setting, and this evolution brings with it responsibilities to provide a competent, safe, and meaningful service to the patient. The simple approach of merely obtaining an ultrasound machine and performing studies is no longer valid. It is necessary to organise a service in a rational, sustainable, efficient way and ensure doctors involved in performing the studies have demonstrated competency, either at basic or advanced levels.

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