Commentary

# Innovations in technology for critical care medicine

Martin Chapman[1], David Gattas[2] and Ganesh Suntharalingam[3]

[1]Assistant Professor, University of Toronto, Sunnybrook and Women's College Health Sciences Centre, Toronto, Ontario, Canada
[2]Specialist, Intensive Care Services, Royal Prince Alfred Hospital, Missenden Road, Camperdown, Australia
[3]Consultant in Intensive Care Medicine and Anaesthesia, Northwick Park & St Marks Hospitals, Harrow, UK

Correspondence: Martin Chapman, dr.martin.chapman@sw.ca

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## Abstract

This new section in *Critical Care* presents a selection of clinically important examples of advances in critical care health technology. This article is divided into two main areas: diagnostics and monitoring. Attention is given to how bedside echocardiography can alter the cardiovascular physical examination, and to novel imaging techniques such as virtual bronchoscopy. The monitoring section discusses recent claims of improved efficiency with telemedicine for intensive care units.

**Keywords** echocardiography, health technology, telemedicine, telemetry, virtual imaging

## Introduction

This new triannual section will examine emerging health technologies. It is not meant to be a comprehensive scan of the horizon, but rather a selection of clinically important examples of advances in critical care technology.

## Diagnostics

### Ultrasound

The blurring of specialty domains is becoming more obvious. A good example of this is the use of ultrasound by intensivists [1]. Portable ultrasound as an extension of the physical examination is a fast growing area of expertise. A recent Canadian report [2] summarized several new hand-carried ultrasound units for point of care (POC) cardiac examination, including OptiGo™ (Philips Medical Systems, Andover, MA, USA), which has a laptop design, colour Doppler and smartcard storage (Fig. 1). In a prototype study conducted by Rugolotto and coworkers [3], the handheld device was compared with standard echocardiography in 121 patients. The studies were performed by echocardiographers with level II and III training. Parameters of ventricular and valvular function with two-dimensional and colour Doppler were graded on a point system using both devices. There were statistically significant differences between the two methods, although these were clinically minor in degree. The investigators concluded that the handheld device did represent an acceptable tool for conducting a focused assessment of a limited number of parameters of structure and function.

However, conflicting results were reported from another study with the same prototype unit [4]. Spencer and coworkers compared the diagnostic power of physical examination, POC echocardiography and standard echocardiography when performed by cardiologists. POC echocardiography was an improvement on physical examination but still missed 21% of major cardiovascular findings as compared with standard echocardiography. This emphasizes some of the difficulties in implementing new devices, among which are defining the limitations of use and ensuring standards in training.

### Diagnosing ventilator-associated pneumonia

Intensive care unit (ICU) staff have been aware for a long time that infections can have their own characteristic smell. This property may be put to diagnostic use in a more scientific way. The technology has evolved to produce a device containing an array of conducting polymer sensors that mimics the human process of smelling. This e-nose produces a signal specific for the volatile metabolites in expired gases, and these can be compared against signature signals of various bacteria. One study demonstrated the

CT = computed tomography; POC = point of care; ICU = intensive card unit.

**Figure 1**

OptiGo™ (Philips Medical Systems, Andover, MA, USA) hand-carried ultrasound unit.

**Figure 2**


Bleeding from angiodysplasia in the small bowel.

ability of an e-nose to differentiate swabs of various upper respiratory tract bacteria from control swabs [5]. When tested for its differentiating power, it could identify 11 out of 15 pairs of bacterial swabs. Further work is ongoing for lower respiratory tract infections.

### Telemetry

It seems that a more hands-off approach to patients is being promoted for the future physician. Several new technologies have recently been reported, including wireless capsule endoscopy. This is perhaps not directly applicable to critical care at the moment, but it could lead to some interesting real-time monitoring. The disposable unit comprises a miniature video camera, lens, light source, battery and transmitter. Currently, the dimensions are 11 × 26 mm, but a 9 × 23 mm version is being developed. In the outpatient setting the capsule is ingested and passes naturally through the bowel, transmitting pictures at a rate of two per second. A blood identification algorithm has been developed and this may have a role in the diagnosis of obscure gastrointestinal bleeding (Fig. 2). One of several studies published this year compared the capsule with standard enteroscopy to determine their efficacy for patients in whom colonoscopy and gastroscopy had been negative [6]. The capsule identified significantly more lesions than did endoscopy ($n = 50$; 68% versus 32%; $P < 0.05$), and understandably it was better tolerated. It recently gained US Food and Drug Administration approval as a first-line test.

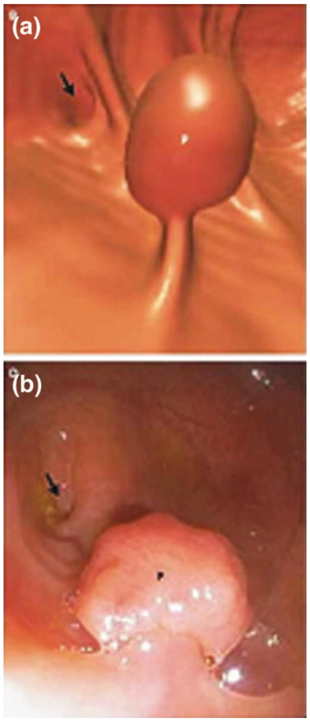
If ‘endoscopy’ still seems too close for comfort, virtual computed tomography (CT) colonoscopy may be the next step. This is an evolving technology that takes data from abdominal CT studies, creates two-dimensional and three-dimensional images of the colon, and generates endoluminal ‘fly-through’ sequences (Fig. 3). The procedure takes 15 min and interpretation 20 min. The bowel still requires insufflation and preparation as for colonoscopy, but fluid and stool can be removed from the images by a process of ‘electronic cleansing’. A recent editorial described the performance of virtual colonoscopy from one study as impressive, with adenoma detection similar to that with conventional colonoscopy. Again, this may not seem particularly relevant to the ICU patient, but perhaps the next time we send a patient for CT of the chest we should order their virtual bronchoscopy at the same time [7]. A recent case report described a young patient with a severe chest injury in whom an airway injury was suspected. Hypoxia precluded bronchoscopy but virtual bronchoscopic images reconstructed from thoracic CT revealed a large carinal laceration [8].

## Monitoring

### Telemedicine

An infrastructure for providing intensivist-led care from a distance is receiving much attention. Two years ago a report examined the poor uptake of information technology into medicine and presented a way of incorporating a technological change into the process of intensive care provision [9]. Two of the authors of that paper founded a company (http://www.visicu.com/) that is currently instituting these changes in various centres in the USA. The paradigm

**Figure 3**




Virtual competed tomography (CT) colonoscopy. **(a)** Three dimensional 'virtual image'. **(b)** Image acquired by colonoscopy.

involves remote monitoring of physiological parameters and audiovisual contact with patient and their bedside critical care nurse in a remote hospital. This requires a nerve centre with 24-hour intensivist and critical care nurse coverage but will serve several ICUs at one time. Early data published in *Critical Care Medicine* in January 2004 suggested that severity-adjusted mortality rates were reduced by 27% and length of stay was reduced by 17% [10]. The company achieved first place in the Healthcare Innovations in Technology Systems Partnerships Awards in 2001.

Intensivists remain a scarce resource in many centres [11,12]. Further data regarding the efficacy of remote monitoring as a substitute for high-intensity staffing still need to be collected. As a halfway step, remote access to specialist clinicians shows some promise. A recent pilot study in the neurointensive care setting showed the feasibility of a remote web-based specialist. Neurophysiological monitoring (electroencephalography, somatosensory evoked potential, brainstem auditory evoked potential) was available online and accessible by the specialist from a remote PC. Members of the nursing staff at the bedside were able to confirm abnormal trends and seek advice [13].

As a counter to these developments, technology may become folly if used as a substitute for good clinical care.



The pioneer surgeon William Mayo (1938) said 'we do not fully appreciate the value of our five senses in estimating the condition of the patient'. A study published in the *Lancet* last year demonstrated that the findings on physical examination by an attending physician were pivotal in the management of 26% of 100 medical patients [14]. This gives all the more reason why these technologies must be assessed adequately before widespread use complicates their evaluation.

## Competing interests

None declared.

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