The future is in your hands – Handheld ultrasound in the emergency department

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The Canadian Association of Emergency Physicians (CAEP) Emergency Ultrasound Committee recently recommended that a handheld ultrasound is preferred for point-of-care ultrasound (PoCUS) examinations as part of an infection control strategy to minimize the risk of the transmission of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), the virus that causes coronavirus disease (COVID-19).[1] In recent years, handheld ultrasound devices have become smaller and cheaper, with models recently approved for use in Canada that are available for a fraction of the cost of a typical cart-based PoCUS machine. At this price point, they are within reach of not just hospitals purchasing, but also individual physicians. The COVID-19 pandemic has already forced frontline physicians to make many decisions in the absence of high-quality evidence. Before adopting handheld ultrasound systems, a discussion of the potential strengths and weaknesses is warranted.

Handheld ultrasound devices (also known as *ultraportable* or *pocket-sized* ultrasound) use an ultrasound transducer connected to a smartphone or tablet. These devices are battery powered, weigh only a few hundred grams, and, as the name implies, are small enough to fit in a pocket or a bag. Typically, a handheld ultrasound is operated with one hand operating the probe ("scanning") and the other hand holding and operating the screen on which the images and controls are displayed, using a cloud-based application. Compatibility with operating systems such as iOS or Android varies by device and manufacturer. Archiving images and clips for every performed PoCUS examination is recommended as best practice,[2] and many handheld ultrasound manufacturers facilitate this with products that can integrate with common archiving systems.

There is existing literature describing the use of handheld ultrasound for all core PoCUS applications, including extended focused assessment with sonography for trauma (eFAST), identification of abdominal aortic aneurysm and first trimester intrauterine pregnancy, focused cardiac and thoracic ultrasound, and procedural guidance of vascular access.[2] Handheld ultrasound has also been described for core PoCUS applications in pediatric emergency medicine, and may have an added benefit in this setting where the reduced size of the machine and prior familiarity with smartphones may be less intimidating and better tolerated by children. The portable and lightweight nature of these devices makes it an ideal modality for use in austere environments, disaster situations, and resource-limited settings without access to advanced imaging nor the financial resources for cart-based ultrasound. Lack of equipment and funding has already been identified as barriers to PoCUS use in Canadian rural emergency departments (EDs).[3] Portability between institutions also has practical appeal for individual physicians who work or locum at multiple sites (or office and ED settings), as they would have consistent experience with a single machine rather than multiple different systems.

Handheld ultrasound has shown promise as a tool in medical education. First year medical students have found the devices easy to use and a valuable aid to understanding anatomy.[4] It has proven a feasible and accurate extension of the physical exam when used by medical students during clerkship and residents.[5,6] In the future, undergraduate and postgraduate learners may desire to use handheld ultrasound in the ED, and an understanding of the indications and limitations of these devices will be necessary to adequately supervise such examinations.

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There are no specific clinical contraindications in the use of handheld ultrasound, but it is important to recognize the technical limitations therein. Previous studies comparing conventional PoCUS workstations to earlier generations of handheld ultrasound had shown that handheld ultrasound may have limited image quality compared to conventional cart-based systems.[7,8] However, more recent handheld ultrasound systems ("third generation handheld ultrasound") have improved frequency ranges and use screen resolution that is comparable, if not superior, to many cart-based systems. Resolution is only one parameter that contributes to subjective image quality; other relevant factors include frame rate, image processing/optimization, and screen size. Depending on the clinical indication, selection of one versus many probes may necessitate a tradeoff between convenience and image quality. For example, a handheld ultrasound that uses an all-in-one transducer may not generate cardiac images of the same quality as a dedicated phased array probe, nor may it be able to reproduce the same abdominal image as a dedicated curved array probe. Given this, purchasing multiple transducers may quickly become an expensive proposition. The small screen size of a handheld ultrasound device may hamper image interpretation or prevent demonstrating images to a larger resuscitation team or groups of learners. Additionally, many handheld ultrasound devices lack ultrasound modalities commonly employed by PoCUS users, such as a pulsed-wave or continuous-wave Doppler. This may preclude a clinical question being addressed with the same confidence as cart-based PoCUS systems. Although handheld ultrasound appears to have fair agreement with cart-based PoCUS systems for many clinical indications, there is an overall lack of evidence as to relevant patient-oriented clinical outcomes or other healthcare system benefits, such as cost or environmental impact.

The most practical impetus for using a handheld ultrasound device in the era of COVID-19 is to minimize viral transmission. Current recommendations from CAEP regarding PoCUS machine infection control are that cart-based systems should be stripped of all unnecessary items, such as gel bottles, and the entire surface of the machine should be disinfected thoroughly twice after patient use.[1] For use during aerosol-generating medical procedures, a cart-based device should be entirely draped with gowns or plastic while using separate probe covers for whichever transducer is in use. By contrast, due to its small size, a handheld ultrasound system (smartphone and transducer) can simply fit within a standard sterile plastic probe cover sealed at one end. Aside from being fast and simple to implement, it is also likely that keeping the handheld ultrasound system completely enclosed in an airtight sheath would have lower risk of contaminating the device. This does not obviate the need for cleaning with disinfectants after the exam is complete, although users may find it easier to clean the smaller surface of a smartphone than an entire cart-based system, including the monitor, keyboard, and other control surfaces. Although these strategies make general sense, handheld ultrasound has not been proven to reduce transmission of infection resulting in improved health outcomes. In a surge scenario overwhelming the ED, there would be obvious benefit to minimizing PoCUS machine downtime between patients. If standard sterile plastic probe covers are to be used, the smartphone or tablet needs to be small enough to fit inside. If needed, larger probe covers are available or can be made from commercially available rolls of clear plastic sheeting. When contained entirely within a plastic sheath for infection control purposes, handheld ultrasound devices may overheat due to inadequate ventilation, especially when using scanning modes that require increased processing.

Given the portable nature of pocket-sized handheld ultrasound devices, there is a potential risk for it being misplaced or even outright stolen. Providers using handheld ultrasound should be conscientious about their devices and develop a system to minimize theft that is amenable to local practice.[2] When purchasing mobile devices for this purpose, hospitals should consider the ability to remotely track, lock, and erase devices accordingly.

Security and privacy of patient data are an important consideration for adopting handheld ultrasound. Manufacturers of these devices are not just producing the transducer hardware, but also often an application (app) interface and image storage solutions. Such apps run on consumer grade smart devices that transmit the images and data to an existing local image archiving infrastructure, electronic medical record, or cloud-based storage platform. The amount of data retained locally on the smartphone is usually minimal and temporary, although this varies depending on the specific handheld ultrasound system. Regardless, any locally stored data represent the potential for a privacy breach. It is imperative that the smart devices, operating system, handheld ultrasound app, and cloud-based storage all must meet rigorous technical standards with respect to security and data encryption. Although regulatory approval for handheld ultrasound devices is usually covered nationally, before purchasing a system, physicians should confirm with departmental and hospital leadership, information services, and privacy office to ensure that such devices and apps comply with institutional security and privacy policies, as well as the associated privacy, regulatory, and professional obligations in their jurisdiction.

The Canadian Medical Protective Agency has published guidance on meeting standards for patient privacy on electronic devices, which strongly encourages utilization of encryption, firewalls, and physical security.[9] Privacy commissioners, ombudsmen, and review officers generally agree that when hardware is secured by strong encryption, there is no need to disclose to patients, even if the hardware contained sensitive patient information.[10]

There can be little doubt that handheld ultrasound will play an increasing role in the future of PoCUS in the ED. In 1942, when Austrian physician Dr. Karl Theodore Dussik worked on transmission ultrasound investigation of the brain, his instruments occupied an entire room. Indeed, Moore's Law – the exponential increase in computing power resulting in the development of smaller and cheaper mobile electronics – is manifest in the evolution of ultraportable PoCUS devices. Future directions include a more widespread incorporation of handheld ultrasound to *teleultrasound* and a*rtificial intelligence* to provide real-time coaching of image generation and interpretation. For now, though, the consideration of handheld ultrasound by many has been prompted by the COVID-19 pandemic. This situation demands novel strategies for navigating diagnostic and logistical challenges, but it remains important that enthusiasm for handheld ultrasound is tempered by a balanced understanding of potential drawbacks.

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