The Role of Technology in the Bedside Encounter

Andre Kumar, MD, Gigi Liu, MD, MSc, Jeff Chi, MD, John Kugler, MD,*

Technology impacts nearly every aspect of modern life. Much of the technology that is used in our modern health care system is remote from patients and the patient care experience. It is the technology used in making new pharmaceuticals, new medical devices, new laboratory tests, and improved medical imaging. This technology is mostly hidden from patients as they receive care but makes headlines as society grapples with the cost of developing and implementing this new technology, such as with the combination drug ledipasvir/sofosbuvir for hepatitis C treatment. This article looks to examine how technology is affecting the clinical encounter in both positive and negative ways for patients and physicians. The authors hope to show that technology, specifically point-of-care ultrasound, can be used to enhance the patient-physician relationship and the care provided at the patients’ bedside.

Initial technologic developments, such as the stethoscope, brought physicians and patients closer together. Diagnoses were made in real time during the patient encounter. This practice changed as medicine moved into the modern era and new technology, especially laboratory and imaging technology, was used remotely from the bedside. Patients today need to wait for laboratory and pathology results or imaging reads to receive a diagnosis and a plan of care. Results are relayed over the phone, via electronic patient portals, during future visits, or sometimes not at all. The development of

Disclosure Statement: No authors have any financial relationships to disclose.

a Department of Medicine, Division of Hospital Medicine, Stanford University, mail code 5209, 300 Pasteur Drive, Stanford, CA 94305, USA; b Department of Medicine, Johns Hopkins University, 600 North Wolfe Street, Meyer Building 8th Floor, Room 147, Baltimore, MD 21204, USA

* Corresponding author.

E-mail address: jkugler@stanford.edu

KEYWORDS

- Technology
- Point-of-care ultrasound
- Bedside medicine
- Physical examination

KEY POINTS

- Technology has the ability to both strengthen and weaken the patient-physician relationship.
- The electronic health record has become a source of distraction from the bedside encounter, but it does not need to be.
- Point-of-care ultrasound is the most exciting way to bring physicians back to the bedside.
- Future technology needs to be implemented in ways that strengthen the patient-physician relationship.
Point-of-care ultrasound is reversing this trend, allowing the treating physician to expand the physical examination and improve bedside decision-making in real time. In the article “Tenuous Tether” the investigators speak of the importance of the stethoscope in binding physicians to patients: “Devices that bring us closer to the bed breathe new life into our roles as healers.” Although the investigators spoke of the stethoscope, the authors see how this equally applies to point-of-care ultrasound. In contrast, devices that take us away from patients have the potential to distract physicians from our roles as healers. The electronic health record (EHR) is an example of a potential distraction and is discussed in more detail (See Helene F. Hedian’s article, “The Electronic Health Record and the Clinical Examination,” in this issue for further details).

With the introduction of the EHR and time-saving functions like templates and copy/paste, physicians are suddenly able to document large quantities of notes in a fraction of the time. The ability to access the medical record from any location, even from outside the hospital, has eliminated the need to search for physical charts. Laboratory test results and vitals for multiple patients can also be quickly reviewed within a short period of time. Despite these advances, time-in-motion studies have consistently shown that physicians and trainees spend a significant proportion of their time at the computer interacting with the EHR. Time-intensive EHR tasks include chart review and data review, reflecting the exponential growth of documentation and laboratory data that have become prevalent in today’s health care landscape. Accordingly, trainees are becoming accustomed to prioritizing EHR data ahead of information gathered directly from patients, in contrast to the more traditional workflow of meeting patients first. This behavior has caused senior physicians to lament the evolving practice of medicine in the modern era, noting that physicians today spend more time in front of the screen, as opposed to time with patients. Although the EHR has often been cited as a detractor of direct patient contact at the bedside, it is interesting to note that time-in-motion studies predating the advent of the EHR also showed that physicians spent a significant amount of time engaged in indirect care. Perhaps the increasing use of computers in the health care workspace has suddenly made physicians more aware of the amount of indirect care for which they are responsible.

When used with a patient focus, rather than allowing the EHR to separate physicians and patients, it can be incorporated at the bedside in a way that facilitates communication. Mobile platforms and portable computers can be used to share imaging and patient data in ways that include patients in medical decision-making and promote awareness and engagement. In this way the EHR, which is often vilified for distracting from patients, could become a way to strengthen the relationship between the physician and patients.

Point-of-care ultrasound has the potential to reverse the trend of technology pulling physicians away from the bedside. Point-of-care ultrasound can be defined as limited ultrasound examinations performed by the treating clinician to make real-time decisions. It is different from traditional radiology- or cardiology-performed studies because the images are not obtained by a technician (ie, sonographer or echocardiographer) and interpreted later by a physician, but rather it is performed and interpreted by the treating clinician. The studies are generally termed limited because they tend to be less ambitious than traditional radiology and cardiology studies. Ideally, point-of-care ultrasound studies should be used to answer limited and specific diagnostic questions. This reflects the fact that most point-of-care ultrasound users have significantly less training and expertise than the specialists who read ultrasound images as well as the fact that point-of-care ultrasound machines tend to have lower resolution when compared with traditional ultrasound machines. For example, a point-of-care ultrasound study may be used to evaluate for the presence of a pericardial effusion but would be a poor choice to look for the vegetations of endocarditis.
FOCUSED ASSESSMENT WITH SONOGRAPHY IN TRAUMA

Emergency medicine has been a pioneer and driver of point-of-care ultrasound technology. In a field where decisions frequently need to be made quickly, point-of-care ultrasound is a natural fit. The focused assessment with sonography in trauma (FAST) examination was an early study that gained wide adoption within the emergency medicine community. The FAST examination is used to assess for intra-abdominal injury after blunt or penetrating abdominal trauma. FAST uses ultrasound primarily to find free fluid in the abdomen and has largely replaced diagnostic peritoneal lavage to assess for hemoperitoneum. The FAST examination is done as part of the trauma assessment, performed by both emergency medicine and trauma surgery physicians. Depending on the study, the test characteristics vary with generally high sensitivity but less specificity.11–14 A systematic review of articles about intra-abdominal injury and ultrasound noted that the FAST examination is a sensitive and specific test that can be performed to assess for intra-abdominal injury using computed tomography (CT) of the abdomen as the gold standard. In this review, a positive FAST examination had a likelihood ratio (LR) of 82 if studies included hemodynamically unstable patients and an LR of 36 if the studies excluded hemodynamically unstable patients. A negative FAST examination in studies that included hemodynamically unstable patients had a negative LR of 0.16. If hemodynamically unstable patients were excluded, the negative LR was 0.33.15 This review points out that a negative FAST examination in stable patients decreases the likelihood of intra-abdominal bleeding or injury, whereas a positive study essentially confirms the diagnosis. As with every examination the authors review, clinical judgment and incorporation of all the available clinical evidence is essential and best performed by the clinician at the bedside.

The FAST examination is rarely used by internal medicine because it is a trauma-specific study. Internal medicine first began to use point-of-care ultrasound for procedural guidance.

POINT-OF-CARE ULTRASOUND FOR PROCEDURAL GUIDANCE

Point-of-care ultrasound for procedural guidance is now considered the standard of care for central venous access16,17 thoracentesis,18 and paracentesis.19 The use of ultrasound to guide peripheral venous cannulation increases success rate and reduces the number of central venous catheters.20,21 A comprehensive review of the use of ultrasound for procedural guidance is beyond the scope of this article.

DIAGNOSTIC POINT-OF-CARE ULTRASOUND

Point-of-care ultrasound was first used by most internal medicine physicians for procedure guidance; however, in more recent years pocket ultrasounds are being used for diagnostic studies and are transforming the way many physicians conduct the physical examination.

CARDIAC

Point-of-care echocardiography is perhaps the most widely used point-of-care ultrasound assessment. It has been adopted by several major society guidelines, including critical care,22 emergency medicine,23 and cardiology.24 Point-of-care echo as opposed to a traditional echo study is more limited in scope, focuses on qualitative rather than quantitative evaluations, and should ideally address a binary question (eg, Is the LV function normal?). Bedside echocardiography focuses on 4 standardized views: parasternal long axis, parasternal short axis, apical 4 chamber, and subcostal.
With minimal training, physicians can reliably identify ventricular function, gross valvular abnormalities, and pericardial effusions and provide accurate assessments of intravascular volume status.22

Systolic Function

Point-of-care assessments of right ventricular (RV) and left ventricular (LV) systolic function vary from qualitative assessments using multiple views24 to formal methodologies that require the measurement of end-systolic and end-diastolic volume in 2 planes.22 Even among physicians with minimal training, qualitative assessments of reduced LV ejection fraction (LVEF) are reliable, with a reported sensitivity and specificity as high as 94% for identifying patients with a moderately reduced LVEF.22,25 However, a qualitative assessment of LVEF requires multiple views; several factors (eg, patient habitus, user experience, and so forth) can limit image acquisition. In instances whereby image acquisition is difficult, the parasternal long view can be used to estimate LVEF. For example, if the anterior mitral leaflet fails to come within 1 cm of the ventricular septum in this view, this suggests an EF less than 40% with a sensitivity 69% and specificity of 91%.26

As with LV function, assessments of RV systolic function rely on qualitative assessments based on multiple views as well as the demonstration of RV enlargement (which is defined as an RV to LV size ratio >1).27 Assessments of RV systolic function have been traditionally used to rule in acute pulmonary embolism (PE) or acute coronary syndrome. However, several chronic disease states (eg, dilated cardiomyopathy or pulmonary hypertension) can lead to RV enlargement and can make acute point-of-care assessments challenging. The sensitivity and specificity of RV enlargement or reduced RV systolic function to diagnose PE are low (29% and 51%, respectively).27 Furthermore, there is only fair to moderate interobserver agreement for RV enlargement and reduced systolic function among certified cardiologists.28 For these reasons, the American College of Cardiology and the American Society of Echocardiography conclude that the absence of these findings should not be used to rule out PE.27

Pericardium

Point-of-care ultrasound can be used to rapidly rule out pericardial effusions in patients with hypotension, which can be particularly helpful because the traditional physician examination findings of pericardial tamponade (eg, Beck triad, pulsus paradoxus) are not present in all patients or have low interobserver agreement.29 Users can readily detect the presence of pericardial effusions as small as 15 mL with high sensitivity.30 However, although the absence of a pericardial effusion can help triage critically ill patients, it is more challenging to determine if an effusion is hemodynamically significant with bedside echocardiography. Traditional findings, such as ventricular or atrial collapse, may be present with a sensitivity as low as 50%, whereas inferior vena cava (IVC) dilation is sensitive (97%) but not specific (40%).30 More formalized assessments for tamponade, such as tricuspid or mitral valve inflow variation, as well as assessments of constrictive pericardial disease are best reserved for a formal echocardiogram.

ASSESSMENT OF VOLUME STATUS

Physical examination maneuvers that assess volume status (eg, jugular venous distension, skin turgor, venous collapse, and so forth) lack sensitivity and interobserver reliability.31 For example, jugular venous distension has a sensitivity of 39% for acute decompensated heart failure.31 A key use of bedside echocardiography is the noninvasive assessment of central venous pressure (CVP). Several protocols...
have been designed to incorporate CVP assessments, including the extended-FAST (E-FAST) scan, rapid ultrasound in shock and hypotension (RUSH), and the cardiopulmonary limited ultrasound examination (CLUE). These protocols are discussed in further detail later. In addition, individualized examinations of the IVC or internal jugular vein (IJV) can be used to guide clinical judgment regarding CVP and the likelihood of fluid responsiveness.

**Comprehensive Volume Assessment**

Bedside ultrasound has an established role in patients presenting with shock or hypotension, when rapid assessments of CVP are needed. There are now more than 6 protocols that can be performed in patients with cardiac arrest or shock.32 Perhaps the best known are the E-FAST and RUSH examinations, which are used by emergency and critical care physicians to evaluate hypotension. The RUSH examination components can be remembered with the mnemonic HI-MAP: heart (including the 4 standard transthoracic views), IVC, Morrison pouch, abdominal aorta, and pneumothorax. It has a 97% negative predictive value at ruling out obstructive, hypovolemic, and cardiogenic shock with modest (k = 0.71) interobserver agreement.33

The CLUE is a standardized protocol that can elucidate LV function, left atrial enlargement, IVC enlargement, and evidence of pulmonary edema on ultrasonography in the form of comet tails (also known as B-lines) in patients with suspected elevated CVP. The examination and its components have demonstrated moderate to excellent sensitivity, sensitivity, and interobserver reliability for volume overload; a positive test has been shown to be predictive of worsened odds of in-hospital mortality.34,35

**Inferior Vena Cava**

The IVC can be used to estimate CVP based on the vessel’s diameter and collapsibility with respiration.36 It is best measured in the subcostal view approximately 1 to 2 cm from the right atrial junction.27 Studies investigating the accuracy and interobserver reliability of IVC measurements have varied. For example, resident physicians have moderate interobserver reliability at estimating IVC diameter (k = 0.60).37 IVC imaging should not replace the clinical assessment of volume status and should be incorporated into a more comprehensive clinical assessment.

**Internal Jugular Vein**

If the IVC cannot be visualized, the IJV provides an alternative method to measure CVP. Several methods exist to estimate CVP based on the IJV, including qualitative assessments based on sonographic wave patterns or measurements of the tissue pressure required to occlude the IJV.38,39 The Lipton method estimates CVP based on sonographic wave patterns and has a sensitivity/specificity of 98% and 59%, respectively, for an elevated CVP.40 The use of IJV collapsibility to measure CVP is comparable with the physical examination, although junior trainees may have higher accuracy with handheld ultrasound compared with the physical examination.41

**ASCITES**

Physical examination maneuvers aimed at identifying ascites (eg, shifting dullness or fluid wave detection) may have a sensitivity of 50% to 60% and are limited by patient mobility and body habitus.42 Point-of-care ultrasound can readily detect ascites with a sensitivity/specificity of 96% and 82%, respectively, with a high concordance with a formal abdominal ultrasound study (k = 0.78).43 Ultrasound can detect as little as
150 mL of fluid. Even pocket ultrasound devices have 95.8% sensitivity and 81.8% specificity for detecting ascites, and these results are concordant with formal abdominal ultrasounds ($R^2 = 0.781$).

**RENAUL ULTRASOUND**

Point-of-care renal ultrasound can be used by physicians to evaluate patients with acute renal failure or suspected obstructive nephrolithiasis. Although formal ultrasound has a poor sensitivity at detecting renal stones, the presence of hydronephrosis on bedside ultrasound in patients with suspected renal colic can be suggestive of nephrolithiasis and has a pooled sensitivity of 72% to 97% and specificity of 73% to 83% when compared with helical CT in patients with confirmed hydronephrosis due to nephrolithiasis. The early use of point-of-care ultrasound in patients with renal colic can reduce emergency department length of stay without a significant increase in secondary visits. This result is likely accomplished through the reduced need for CT scanning if no clinically significant hydronephrosis is present. The ability to detect hydronephrosis via point-of-care ultrasound can be taught to even junior learners with minimal training.

**BEYOND POINT-OF-CARE ULTRASOUND: HOW TECHNOLOGY WILL CONTINUE TO SHAPE THE BEDSIDE ENCOUNTER**

This limited review of the scope and evidence for the utility of point-of-care ultrasound points to a more extensive adoption of this technology in the future. As machines become smaller, cheaper, and more feature filled, we can expect to see point-of-care ultrasound devices become as ubiquitous as stethoscopes are today. The same technological advances that are making these ultrasound devices smaller and cheaper will create new opportunities for technology to make its way into the bedside encounter. These new technologies will have the same ability to both strengthen and enhance the patient-physician relationship or degrade that relationship depending on how they are used.

A great example of how emerging technology can potentially enhance the patient-physician relationship is virtual medical scribes. Medical scribes have been around for years (often in emergency departments, primary care, and specialty clinics) to decrease the burden of documentation and increase physician efficiency. In the traditional model, a scribe accompanies the physician during a visit to take notes or directly chart into the medical record. Virtual scribes leverage technology to transmit an audio or audio/video feed of the visit to a remote site, where scribes enter the visit notes into the EHR. The promise of this technology is in physician productivity gains but also in allowing the physician to devote greater attention to patients without the distraction of attempting to chart simultaneously. When done well, the technology is barely visible and does not distract from the patient visit, thus, enhancing the experience for both the physician and patients.

Some traditional medical tools are being upgraded by technology. Electronic stethoscopes have existed for decades. They have generally offered sound amplification and occasionally storage as their main features. For physicians with hearing impairment, this sound amplification represented an important feature that allowed them to overcome a disability. Newer devices have additional features, such as friction dampening, ambient noise reduction, and the ability to send the sounds to a cell phone for capture. Electronic stethoscopes allow for recording audio files for teaching. They can also connect to a speaker for improved bedside teaching and to allow patients to listen to their own heart sounds. In the near future, computer algorithms will enhance the diagnostic value of cardiac auscultation by giving physicians an interpretation of the heart sounds much like modern electrocardiogram machines do today.
The challenge of technology for many physicians is adapting to a change in practice and workflow once their formal training is complete. Learning new skills, especially point-of-care ultrasound, is difficult because of the time it takes to learn but also because each physician must decide when they are ready to incorporate the new data into their decision-making process. Continuing medical education courses are available to learn point-of-care ultrasound; however, the training is generally done with healthy volunteers and lacks the clinical context of a patient encounter. Nevertheless, an introductory course is necessary to get started but should be followed by access to a device so that regular practice can occur before incorporation into clinical decision-making.

**SUMMARY**

Technology’s impact on the practice of medicine is sure to continue in the future. New and unforeseen advances are likely and welcome. Like point-of-care ultrasound, each new advance has the opportunity to improve care and potentially improve the patient and physician experience. It is the responsibility of all providers to work to integrate technology into the medical system in a way that enhances patient value and strengthens the patient-physician relationship.

**REFERENCES**


