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Six Steps to Implement Bedside Ultrasonography in Critical Care

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A Roadmap to Rapid Improvements in Patient Safety

This article will provide an overview of how to accelerate adoption of bedside ultrasonography, based on experience in a large hospital system. Developing an evidence-based ultrasound training programme and the economic benefits of proven safety practices, such as ultrasound-guided central venous catheterisation (CVC), will be addressed.

Every day, more than 1,000 patients die in the United States from preventable hospital errors (Hospital Safety Score 2015). Ultrasound at the bedside is an extremely valuable tool for improving the safety and quality of care for critically ill patients, while also helping reduce—or even eliminate—certain errors and associated costs. Applications in critical care range from ultrasound guidance of needle-based procedures to rapid assessment of the heart (“pump”) and volume (“tank”) in patients with congestive heart failure (CHF) or shock.

Steps to Fast-Track System-Wide Adoption of Bedside Ultrasound

Many medical centres, including Banner Health where I practise, now mandate ultrasound guidance for all CVCs. Headquartered in Phoenix, Arizona, Banner Health operates 28 hospitals and acute-care facilities, along with many ambulatory health centres and clinics, across seven states. In 2013, 256,000 patients were admitted to our hospitals, 675,438 patients were treated in our emergency departments, and our clinics managed 2,636,000 visits. With more than 45,000 employees, including about 7,000 medical staff members, Banner ranks among the United States' largest healthcare systems.

Banner Health has launched a system-wide initiative called Care Transformation that unites best practices in clinical care with leading-edge technology to provide better, safer care to our patients. This initiative is designed to reduce the time between identification of evidence based clinical practices and their widespread adoption and implementation as a predictable part of daily care, including system-wide ultrasound-guided central-line placement and a bedside echocardiography programme with the ability to capture and interpret real-time ultrasound imaging on a 24/7 basis to monitor and guide treatment of ICU patients. Here is how this process worked at our system and lessons learned.

Step 1: Define clinical challenges to be solved by implementing bedside ultrasound

In the early 2000s, one of our chief nursing officers needed to place a PICC line (peripherally inserted central catheter) in a patient with difficult vascular access. She borrowed a bedside ultrasound machine from the radiology department and successfully inserted the line. This success motivated other clinicians to adopt this approach, initially with informal person-to-person training, followed by small pilot programmes supported by local department budgets.

Establishing vascular access is one of the most commonly performed hospital procedures, with several million central lines placed annually in U.S. hospitals. Up to 78% of critical patients have a CVC inserted at some point during their hospital stay (Gibbs and Murphy 2006), with a documented mechanical complication rate of up to 19% (McGee and Gould 2003), when landmark-based techniques are used.

Step 2. Examine the scientific evidence and safety benefits of bedside ultrasound

Procedural complications are among the most common—and costly—medical errors, according to a recent analysis (Van Den Bos et al. 2011). Of the errors analysed, iatrogenic pneumothorax (the accidental puncture and collapse of the patient's lung during medical treatment, such as CVC), was one of the most expensive, costing the U.S. healthcare system $580 million in 2008. This complication can lengthen hospital stay by 4 to 7 days, at an additional cost of up to $45,000 (Zhan et al. 2004).

If eliminating such serious safety risks as pneumothorax sounds impossibly ambitious, consider these findings: in a randomised trial that included 401 critical care patients (Fragou et al. 2011), ultrasound-guided CVC reduced rates of pneumothorax and haemothorax to zero, versus rates of 4.9% and 4.4% respectively when landmark methods were used. All other complications were also reduced or eliminated with ultrasound.

Based on robust safety data from multiple studies, evidence-based guidelines from numerous medical societies and government agencies, including the U.S. Agency for Health Research & Quality (AHRQ) (Shojania et al. 2001), the U.S. Centers for Disease Control and Prevention (CDC) (2011), and the UK National Institute for Health and Care Excellence (NICE) (2002), recommend ultrasound guided placement of central lines as a preferred safety practice.

Step 3. Identify an ultrasound champion and launch a bedside ultrasound training programme

A lesson learned from our experiences is the importance of physician leadership to accelerate adoption of bedside ultrasound. One of our physicians, Dr. Gregory Chu, not only was an early champion of this technology, but also played an important role in developing a training programme to teach respiratory therapists how to insert CVC under ultrasound guidance.

Respiratory therapists were selected as ultrasound trainees for two reasons. First, they are available 24/7 at our hospitals and therefore could perform middle-of-the-night CVCs as needed. Previously, only physicians could place central lines, creating workflow issues and strain on the emergency department when this procedure was needed at unusual hours. Second, our respiratory therapists had already been trained in ultrasound-guided PICC line insertions, so were experienced with this imaging technology.

Our training programme leveraged both internal and external resources. Our simulation centre was employed to provide training with virtual patients, followed by hands-on training with actual patients. We also partnered with our ultrasound provider, which offered such resources as access to CVC protocols used at other institutions and help with organizing training events.

To accelerate diffusion of ultrasound-trained clinicians, Dr. Chu and other physicians trained the initial cohort of respiratory therapists, who then became ultrasound trainers themselves after demonstrating proficiency in central-line placement. All Banner's residents also received the training, facilitating swift adoption of ultrasound guidance across our hospital system.

Step 4. Use clinical teams—and CVC safety bundles that include ultrasound guidance

Banner established dedicated vascular-access teams comprising respiratory therapists and nurses, available around the clock to perform ultrasound-guided line insertions. To reduce central-line associated bloodstream infections (CLASBIs), our health system uses a six-point safety bundle:

1. Hand hygiene;
2. Maximal barrier precautions;
3. Chlorhexidine skin antisepsis;
4. Optimal catheter site selection;
5. Daily review of CVC line necessity, with prompt removal of unneeded lines;
6. Ultrasound-guided line placement.

About 30% of ICU patients suffer one or more healthcare-associated infections (HAIs), according to the World Health Organization (WHO) (2016). About 75,000 hospitalised patients die from HAIs annually, with CLASBIs causing death rates ranging from 12 to 25 percent.

Hospitals that use central-line safety bundles that include ultrasound guidance have seen striking reductions in CLASBIs—or in some cases, have even eliminated them. For example, White Memorial Hospital in Los Angeles, California achieved a rate of zero between January 2010 and August 2011 at the 353-bed hospital, while also avoiding pneumothorax complications.

Step 5. Expand use of bedside ultrasound to new applications, such as bedside echocardiography

Our bedside echocardiography programme was also inspired by a clinical challenge, which occurred at 3 AM when a consulting ICU physician, Hargobind Khurana, was called to diagnose a patient in shock. He ordered an echocardiogram, but discovered that no cardiologist would be available to interpret the echo until later that morning. Since the results were needed immediately, to guide treatment of the critically ill patient, he asked a tele-intensivist in our iCare remote access centre to review the scan in real time.

In minutes, with the help of the tele-intensivist, Dr. Khurana was able to accurately evaluate cardiac output and intravascular volume, diagnose the patient and initiate lifesaving treatment. This case demonstrated the need to capture and interpret cardiovascular ultrasound images at any hour of the day or night to guide treatment in real time. Banner decided to partner with the iCare team's 24/7 capabilities, through remote consultation, as a recommended clinical practice for adult critical care.

As part of the bedside echo programme, respiratory therapists were trained to acquire high-quality bedside ultrasound images to transmit to the tele-intensivists remotely. All iCare intensivists were trained in interpreting echo images in real time and using the findings to assess the fluid and cardiovascular status of patients suffering from CHF, shock or other conditions.

In May 2015 the Surviving Sepsis campaign issued an updated, evidence-based bundle of care practices for patients with severe sepsis or septic shock (Surviving Sepsis Campaign 2015). Bedside cardiovascular ultrasound was one of the recommended methods for evaluating

volume status and tissue perfusion, with the scan to be performed with six hours of clinical presentation.

The rationale for implementing bedside echo also drew on studies citing the following benefits:

- Improved diagnostic accuracy;
- Reduced time delays for procedures;
- Superior accuracy in evaluating fluid status in heart failure patients, compared to physical examination techniques;
- Reduced cost for procedures;
- Support for use of ultrasound as the 'third eye' to help the intensivist manage patients;
- Assessment of shock to determine haemodynamic status, fluid resuscitation and interventions.

Step 6: Track ultrasound outcomes—and learn from success

Over the past three years, our health system has avoided any complications associated with central line placement. A key component of this success has been broad engagement of physicians through educating them about safety benefits of ultrasound guidance, including confidence that the needle is inserted correctly with a high degree of first-pass success. In this case, seeing truly is believing—in the power of ultrasound to truly transform the standard of care, particularly for those who need it the most: the critically ill.

Similarly, our bedside echo programme represents an exciting innovation in visual medicine: enhanced ability of intensivists— both at the bedside and via remote access tele- ICUs—to literally see how well the patient's heart is working and response to treatment in real time, allowing rapid adjustments in therapy if needed. As R. Adams Cowley, MD, the pioneering founder of the first U.S. shock trauma centre, famously observed, for critically ill or injured patients, "there is a golden hour between life and death" (University of Maryland Medical Center n.d.). With ultrasound at the bedside, and the clinical information it provides, physicians are ideally equipped torapidly help the sickest patients achieve optimal outcomes.

Abbreviations
CHF congestive heart failure
CLASBI central line-associated bloodstream infections
CVC central venous catheterisation
HAI hospital-associated infections
PICC peripherally inserted central catheter

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