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ULTRASOUND-GUIDED PROCEDURES

FINANCIAL AND SAFETY BENEFITS

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Ultrasound Guidance Improves the Safety and Success of Needle Procedures

The European Prevalence of Infection in Intensive Care study reported that 78% of critically ill patients had a central line inserted, while several million central venous catheters (CVCs) a year are placed in American hospitals (Gibbs, 2006). Since this common procedure can have serious risks, including accidental puncture and collapse of the patient's lung (iatrogenic pneumothorax), arterial injury, haemorrhage and even death (Bowdle, 2014), it is crucial that the catheter be placed correctly, with as few attempts as possible.

Traditionally clinicians have used anatomic 'landmarks' to estimate where the target blood vessel lies below the skin. However, this method can be unsuccessful in up to 35% of cases (Bernard 1971; Defalque 1974; Sznajder 1986), with complication rates of up to 19% reported in the literature (Merrer 2001). Moreover, 9% of patients have anatomic abnormalities of their central veins, making CVC placement difficult, dangerous or even impossible (Denys 1991).

Ultrasound guidance allows clinicians to see their anatomical target and surrounding structures, such as soft tissue, vessels and nerves in real time as the needle advances to the procedure's endpoint, instead of working blindly. In addition, ultrasound visualisation can also help clinicians assess the patency and diameter of the target vein.

Ultrasound Helps Reduce Procedural Errors and Costs

Central line-associated bloodstream infections (CLASBIs) and pneumothorax rank among the six most expensive medical errors (Van Den Bos 2011). According to the Centers for Disease Control (CDC), about 250,000 CLASBIs infections occur each year in the United States with attributable mortality estimated at 12 to 25% and attributable cost estimated to range as high as $56,000 per infection (O'Grady 2011; O'Grady 2002). Collapsed lung increases length of hospital stay by 4 to 7 days at an additional cost of up to US$45,000 per case (Zhan 2004).

Yet there are proven safety practices to reduce or even eliminate these serious, but preventable complications. In a randomised controlled trial (RCT) of 900 critical care patients, ultrasound-guided CVC placements in the internal jugular vein lowered rates of pneumothorax to zero percent, compared to a rate of 2.4% for landmark methods (Karakitsos 2006). The study also reported the following outcomes:

- A 100% success rate with ultrasound-guided CVC placement, compared to 94.4% in the landmark group;
- A 0.6% rate of haematoma with ultrasound, versus 8.4% without it;
- A 1.1% rate of accidental carotid artery puncture with ultrasound, versus 10.6% with landmark methods;
- The ultrasound arm also had significantly reduced blood vessel access time, higher first-pass success, and a 35% lower rate of central line-associated bloodstream infection (CLASBI).

Similarly, in a recent RCT of ultrasound versus 'blind' landmark technique for placement of subclavian lines, patients whose CVCs were inserted under real-time ultrasound guidance had zero percent rates of pneumothorax and haemothorax, compared to rates of 4.8 and 4.4 % in the landmark group (Fragou 2011). All other adverse events were also reduced or eliminated when ultrasound visualisation was used. In this cohort of critical care patients, successful cannulation was achieved in 100% of the ultrasound group, compared with 87.5% of the landmark arm.

Based on these outcomes, an accompanying editorial by Andrew Bodenham suggested that, "there is now enough evidence for the benefits of ultrasound for it now to be considered unethical to continue to submit patients to the risks of landmark techniques for research practice if ultrasound guidance is available at that hospital" (Bodenham 2011).

A Cochrane systematic review by German and British researchers found striking safety benefits for ultrasound-guided CVCs of the internal jugular vein (Brass 2015), compared to the landmark method. Key findings from an examination of pooled data from 35 studies involving 5,108 participants included the following reductions in adverse events and improvements in procedure success in the ultrasound group:

- 71% reduction in total complications (14 trials, 2,406 participants);
- 72% reduction in accidental arterial puncture (22 trials, 4,388 participants;
- 73% decrease in haematoma formation (13 trials, 3,233 participants);
- 57% higher first-attempt success rate (18 trials, 2,681 participants);
- Significantly faster time to perform the procedure.

Indeed, the safety data is so overwhelming that in 2002 the United Kingdom's National Institute for Health and Clinical Excellence (NICE) formulated guidelines advising ultrasound guidance as the preferred method to lower the risk of iatrogenic pneumothorax, arterial puncture, arteriovenous fistula, nerve injuries and other complications (NICE 2002). An economic model developed by NICE's assessment group also suggested that ultrasound guidance was

"both more effective and less costly than the landmark method."

Now the standard of care in the UK, ultrasound-guided CVC placement is also endorsed as the preferred practice by the Agency for Healthcare Research and Quality (AHRQ 2001), the CDC and in related guidelines from many medical societies, including the American Board of Internal Medicine, the American Society of Anesthesiologists, and the American College of Chest Physicians, among others.

Best Safety Practices to Prevent Hospital Infections

Healthcare-associated infections (HAI) are now the most common adverse event affecting hospitalised patients, with about 30% of those in the ICU suffering one or more HAIs, according to the World Health Organization (WHO) (n.d.). In the European Union, about 4.1 million patients fall victim to these infections annually, killing about 37,000 patients and contributing an additional 110,000 deaths each year, reported by the European Centre for Disease Prevention and Control (ECDC) (2015).

CLASBIs rank among the leading HAIs, and major initiatives to combat these dangerous infections have been launched in both Europe and the U.S. For example, the European Commission has funded the PROHIBIT (Prevention of Hospital Infections by Intervention & Training) study, in which the ICUs of 14 participating hospitals implemented a bundle of CVC safety practices, including improved hand hygiene (WHO 2015).

In the U.S. a sustained reduction (of up to 66%) in CLASBIs occurred over 18 months in 103 participating ICUs after a five-point bundle of evidence-based CVC safety practices was implemented (Pronovost 2006). Now there is a growing movement to add a sixth element to the bundle: the use of ultrasound guidance for central line placement.

Hospitals that have implemented this approach, including Cedars-Sinai Medical Center in Los Angeles, California, have seen striking reductions in CLASBIs, while White Memorial Medical Center in Los Angeles was able to achieve a rate of zero between January 2010 and August 2011 at the 353-bed hospital. The six-point bundle used consisted of these components:

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.

Ultrasound–Guided Peripheral IV Access as an Alternative to High–Risk CVCs

Establishing vascular access is one of the most commonly performed hospital procedures, with speed and success rate particularly critical to optimal care of critically ill and unstable patients. However, failure rates of emergent peripheral intravenous (PIV) access of 10 to 40% have been reported in the literature, with the average time needed for PIV reported at 2.5 to 13 minutes, and difficult PIV access taking up to 30 minutes (Leidel 2009).

"Ultrasound-guided needle procedures can significantly enhance the safety and quality of patient care, while helping reduce costs and complications"

Difficult PIV access may occur due to such factors as obesity, history of IV drug use, chronic illness, chemotherapy or vascular pathology (Leidel 2009; Crowley 2011), and can lead to significant delays in essential treatment for seriously ill patients who need it the most. In this situation, clinicians often use CVCs as an alternative.

Ultrasound-guided PIV may prevent many unnecessary central line placements in patients with problematic IV access. In a study involving 100 emergency department (ED) patients with difficult vascular access, ultrasound-guided PIV access eliminated the need for CVC placements in 85% of cases (Au 2012). These patients were tracked for seven days, with a zero percent rate of complications.

Given that CVCs can have a complication rate of up to 15% (Feller-Klopman 2007), with estimated costs ranging as high as US$50,000 per case (Fraenkel 2000), the study's outcomes suggest that wider use of ultrasound-guided PIVs could yield substantial improvements in patient safety with a significant reduction in ED costs. Another study of ultrasound-guided PIVs in difficult-access ED patients reported a 97% success rate, compared to only 33% when traditional landmark approaches were used (Constantino 2005). The study also reported the following results for the ultrasound group:

- Faster vascular access (13 minutes with ultrasound guidance versus 30 minutes without it);
- Fewer percutaneous punctures with ultrasound guidance (1.7 versus 3.7 with landmark methods);
- Greater patient satisfaction when ultrasound was used.

Safer, More Cost–Effective Thoracentesis and Paracentesis

Ultrasound guidance may significantly reduce serious adverse events and the cost of care in patients undergoing two commonly performed needle procedures: thoracentesis (draining fluid from the chest) and paracentesis (draining fluid from the abdomen), according to a recent study (Mercaldi 2013). The study examined data from the national Premier Prospective automated hospital database, with the following results, after adjustment for possible confounding factors:

- For the 61,261 patients who underwent a thoracentesis, ultrasound guidance reduced the rate of pneumothorax by 19%. When collapsed lung occurred, this complication raised the patient's hospital cost to US$13,784, compared to $11,032 for a patient who didn't suffer a collapsed lung. In addition, the mean length of hospital stay was 7.9 days for a patient with a pneumothorax, versus 6.5 days for a patient without it.
- For the 69,859 patients who underwent a paracentesis—often a challenging procedure to perform with blind landmark methods—ultrasound guidance lowered the rate of bleeding complications, such as haemorrhage, haematoma, and haemoperitoneum, by 68%. A bleeding complication raised hospital costs to nearly US$30,000, about triple the cost for a patient without this adverse event ($9,476), and nearly doubled length of hospital stay, from a mean of 5.2 days for a patient without a bleeding complication to a mean of 9.5 days for a patient who suffered one.

Ultrasound at the bedside can also help eliminate the risks and costs of unnecessary procedures. In one study, 100 patients with suspected ascites were randomised to receive paracentesis with landmark or bedside ultrasound-assisted techniques (Nazeer 2005). In the landmark arm, 61% of the procedures were successful. In the ultrasound group paracentesis was found to be unnecessary in 25% of the patients. In patients who actually needed fluid aspiration, ultrasound-guided paracentesis was successful in 95% of cases.

Conclusion

Robust evidence from multiple studies demonstrates that ultrasound-guided needle procedures can significantly enhance the safety and quality of patient care, while helping reduce costs and complications. The reason is simple: just as radar helps airline pilots navigate safely to the right destination at night, ultrasound visualisation allows clinicians to see their anatomical target, instead of working blindly.

As we strive to improve healthcare and rein in costs, physician leaders and hospital administrators should carefully weigh the many benefits of ultrasound at the bedside for reducing the risk of medical harm from invasive procedures performed to help patients heal. Ultimately, it is the sickest patients who will benefit the most from a best-practice approach that leads to optimal outcomes. ■

Key Messages

- Evidence-based guidelines from many medical societies recommend ultrasound-guided central venous catheter (CVC) placement as an important safety practice.
- Compared to landmark techniques, ultrasound guidance can significantly reduce medical errors and costs of needle-based procedures commonly performed in critical care, including central line insertions, paracentesis and thoracentesis.
- Use of ultrasound-guided peripheral intravenous catheters may prevent the need for high-risk CVCs.
- Ultrasound at the bedside has become an increasingly valuable tool across hospital departments for a variety of applications, while sparing patients health risks associated with ionising radiation.

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