Editorial

Ultrasound in Anaesthesia, Intensive Care and Pain Medicine: A New Era of Precision and Safety

AKM Akhtaruzzaman

Professor and Division Head, Division of Pain Medicine and Regional Anaesthesia, Bangladesh Medical University, Dhaka. Email> akm.akhtaruzzaman@bmu.ac.bd ORCID: 0000-0002-2427-1863

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Ultrasound (USG) has profoundly transformed regional anaesthesia and perioperative anaesthesia care and pain management. It also transforms intensive care services worldwide. Historical landmark-based teaching in anatomical skill labs establishes a foundational understanding of human topography, which directly translates to clinical competence in surface anatomy and safe landmark-guided regional anaesthesia practice since ancient era of medical education. Now a days, especially in the first world, replacing blind, landmark-based techniques with real-time, high-resolution imaging, USG has evolved into a vital diagnostic and procedural tool for both anaesthesiologists, intensivists and pain physicians [1]. Today, it bridges the gap between diagnosis and Intervention, heralding a true "new era" for anaesthesia.

The Paradigm Shift in Regional Anaesthesia

Ultrasound-guided regional anaesthesia (UGRA) is now widely considered the gold standard, with high-frequency probes providing detailed, real-time visualization of nerves, vasculature, muscles, and fascial planes [2]. This visual precision helps the clinicians to track the needle tip and witness the exact spread of local anaesthetic, ensuring targeted blockades with reducing dose [3]. The real-time visualization dramatically reduces the risk of inadvertent intravascular injections and direct neural trauma. The Brazilian *J Anesth Analg Crit Care (2025) and* The American College of Emergency Physicians (ACEP) 2023 guidelines note that the risk of peripheral nerve injury with ultrasound-guided blocks is as low as 0.03%, with local anaesthetic systemic toxicity occurring in only 1.3 per 10,000 patients [4, 5].

The emergence of fascial plane blocks including the erector spinae (ESP), serratus anterior (SAPB), and transversus abdominis plane (TAP) block — has broadened the application of regional anaesthesia to thoracic and abdominal pain management. Randomized trials have demonstrated significant reductions in pain scores and opioid consumption with these techniques for rib fractures, renal colic, and thoracostomy tube placement [2,4,6].

Vascular Access and Safety

Ultrasound allows for dynamic, real-time imaging of vessels, confirming patency and ruling out anatomical anomalies before needle insertion. USG guidance is now routinely applied to complex vascular access, dramatically increasing first-attempt success rates and minimizing patient discomfort. A 2022 national Delphi survey recommended that anaesthesiology residents perform a minimum of 20 ultrasound-guided central line and 20 arterial line placements during training to ensure competency [7, 8.]

The Rise of Perioperative POCUS

The role of ultrasound extends far beyond procedural guidance. The rise of Point-of-Care Ultrasound (POCUS) empowers the anaesthesiologist to act as a perioperative physician, with POCUS seamlessly integrated into several critical domains [8, 9]. The 2024 AHA/ACC Perioperative Cardiovascular Management Guidelines now formally recommend the emergency use of perioperative TEE or Focused Cardiac Ultrasound (FoCUS) as reasonable (Class 2a) in patients with unexplained hemodynamic instability during noncardiac surgery, when

expertise is available. A structured "head-to-toe" POCUS framework has been described for cardiac surgical patients, incorporating optic nerve sheath diameter, transcranial Doppler, cardiac ultrasound, and venous excess ultrasound (VExUS) for comprehensive assessment [10, 11].

Airway USG aids in evaluating difficult airways, verifying endotracheal tube placement, and guiding emergent cricothyrotomy. A large meta-analysis cited in the ACEP 2023 guidelines found that transtracheal ultrasound identified endotracheal versus oesophageal intubation with 99% sensitivity and 97% specificity [3]. On the other hand, lung USG is highly effective for diagnosing pneumothorax, consolidation, and pleural effusions. POCUS assessment for B-lines demonstrates 83–92% sensitivity and 84–92% specificity for pulmonary oedema, and 85–92% sensitivity and 93% specificity for pneumonia [3]. Bedside assessment of gastric content and volume lowers the risk of pulmonary aspiration in emergency or high-risk patients [12, 13].

Handheld Ultrasound: The 21st-Century Stethoscope

A transformative development is the proliferation of handheld, ultra-portable ultrasound devices. These pocket-sized probes can achieve multiple transducers and offer cloud-sharing and teleguidance capabilities, making bedside ultrasound accessible to all physicians[15]. The ACEP 2023 guidelines acknowledge that wireless transducers, handheld systems, and app-based imaging connected via smart devices even in cell phone are expanding the availability of ultrasound to new clinical settings[3]. However, concerns regarding operator qualifications, device security, cloud storage, data ownership, disinfection protocols, and patient confidentiality remain important considerations requiring adherence to institutional policies[3,16].

Artificial Intelligence and Machine Learning

The integration of AI and machine learning into USG technology represents the next frontier. AI-driven tools can now automatically measure left ventricular ejection fraction (LVEF), inferior vena cava collapsibility index, left ventricular outflow tract velocity time integral (LVOT VTI), and identify B-lines on lung ultrasound with reasonably high diagnostic accuracy [17]. The artificial intelligence (AI) and machine learning (ML) are revolutionizing ultrasound (USG) technology by automating image acquisition, enhancing diagnostic accuracy, and streamlining clinical workflows [23].

Training, Competency, and Standardization

While the benefits of USG are significant, the transition has not been without hurdles. Mastery of ultrasound requires a dedicated learning curve, as "sonoanatomy" differs fundamentally from the interpretation of standard cross-sectional imaging.

Incorporating ultrasound technology especially point of care USG (POCUS) and USG guided regional anaesthesia (UGRA) into the postgraduate anaesthesia curricula is essential. Its transitions from blind and landmark based techniques to real time image guided procedure, drastically reducing complications, lowering the local anaesthetics volume, improving diagnostic accuracy in pain medicine and intensive care patient at bedsides.

The World Federation of Societies of Anaesthesiologists (WFSA) and the European Society of Regional Anaesthesia and Pain Medicine (ESRAPM) strongly endorse a competency-based, simulation-integrated curriculum. The WFSA provides comprehensive educational materials through its Virtual Library, which includes direct-access tutorials on both basic ultrasound physics and ultrasound-guided neuraxial/caudal blocks. The ESRA has also established dedicated assessment frameworks like the European Diploma of Regional Anaesthesia (EDRA) to formalize qualifications across training centers in Europe and in Asia like Division of Pain Medicine and Regional Anaesthesia, Bangladesh Medical University in Bangladesh. They also offer its members exclusive access to structured digital learning programs and Point-of-Care Ultrasound (POCUS) guidelines.

The Path Forward

As technology continues to advance, the convergence of ultra-high-resolution imaging, AI-assisted interpretation, handheld device

miniaturization, and standardized competency-based training promises to further democratize ultrasound and enhance patient safety. The portable ultrasound probe is increasingly recognized as the 21st-century stethoscope, and its integration into perioperative and intensive care practice is no longer optional — it is essential [24].

Gradual addition of diagnostic tools like USG in undergraduate teaching needs to be incorporated. In the postgraduate anaesthesia curricula, we advocate for a structured, competency-based approach to ultrasound-guided (USG) training. Training generally incorporates classroom theory, simulation/phantom or cadaver models, and step by step clinical observation, culminating in supervised practice before independent competency is achieved.

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