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The Role of Pre-Procedural Ultrasound Examination for Anesthesia: Case Series

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Abstract. Ultrasonography is an ultrasound-based imaging technique which are utilized to visualize subcutaneous structures. In anesthesiology, ultrasonography is widely used for finding vascular access, nerve block and regional anesthesia, trans esophageal echocardiography (TEE), and epidural space measurement. Ultrasonography is a relatively safe, non-invasive, and easily accessible imaging modality which also provides ease of anatomical evaluation for anesthesiologists before a procedure. In the first case, a 55 years old man with chronic renal failure undergoing arteriovenous fistula procedure was examined with ultrasonography for brachial plexus block. In the second case, a 63 years old man with acute kidney injury (AKI) was examined with ultrasonography of the right jugular and right subclavian veins to identify vascular access for double lumen catheter insertion. In conclusion, the use of ultrasonography before peripheral nerve block procedures and central venous catheter placement can help anesthesiologist to determine the nerves to be blocked and determine the right vein for catheter insertion.

Keywords: *Catheter Double Lumen, Central Venous Catheter, Cimino, Peripheral Nerve Block, Ultrasonography.*

A. INTRODUCTION

Ultrasonography is an imaging modality that employs ultrasound technology to assess subcutaneous structures, such as blood vessels, joints, tendons, muscles, and internal organs in the context of pathological conditions, enabling detailed evaluation of soft tissue abnormalities. (Carovac et al., 2011) The use of ultrasonography in medicine began in the late 1950s and was initially applied in obstetrics, later expanding to other fields such as cardiology, ophthalmology, orthopedics, and anesthesiology (Carovac et al., 2011).

The use of ultrasonography as a guide in medical procedures has been widely adopted in the fields of anesthesiology and perioperative care (Salinas & Hanson, 2014). Ultrasonography is extensively used to assist vascular access, nerve blocks and regional anesthesia, transesophageal echocardiography (TEE), and assessment of epidural space depth in cases with difficult anatomy (Gupta et al., 2011).

Anesthesiologists require a diagnostic modality that is quick and accurate to provide effective management (Terkawi et al., 2013). Ultrasonography is a safe, non-invasive modality that is easily accessible and provides anesthesiologists with the ability to evaluate complex and varied anatomy before performing a procedure (Gupta et al., 2011; Terkawi et al., 2013). However, pre-procedural examinations with ultrasonography are still rarely conducted by anesthesiologists, as reported by Bailey et al. in their study (Lau & Chamberlain, 2016). This paper aims to highlight the role of ultrasound in pre-procedural assessments at various alternative sites to improve the success of procedures and prevent complications.

B. CASE SERIES

1. Case 1

A 55-year-old male patient with diagnosis of chronic renal failure was scheduled for an arteriovenous fistula procedure. Patient was mildly ill, conscious and alert, with height of 163 centimeters and weight of 56 kilograms. The patient's vital signs were as follows: blood pressure 130/80 mmHg, pulse rate 75 beats per minute, respiratory rate 20 breaths per minute, and body temperature 36.4°C. The patient has a history of routine hemodialysis twice a week since 2019.

Patient was classified as ASA III Chronic Kidney Disease (CKD) on hemodialysis, without complications in the airway, and regional anesthesia with brachial plexus block is planned for post-operative transfer to the recovery room. Ultrasonography was performed on the brachial plexus at the supraclavicular and infraclavicular sites. Based on the pre-scanning results from three brachial plexus sites, the anesthesiologist chose to perform infraclavicular block using 20 mL of 0.375% Ropivacaine.

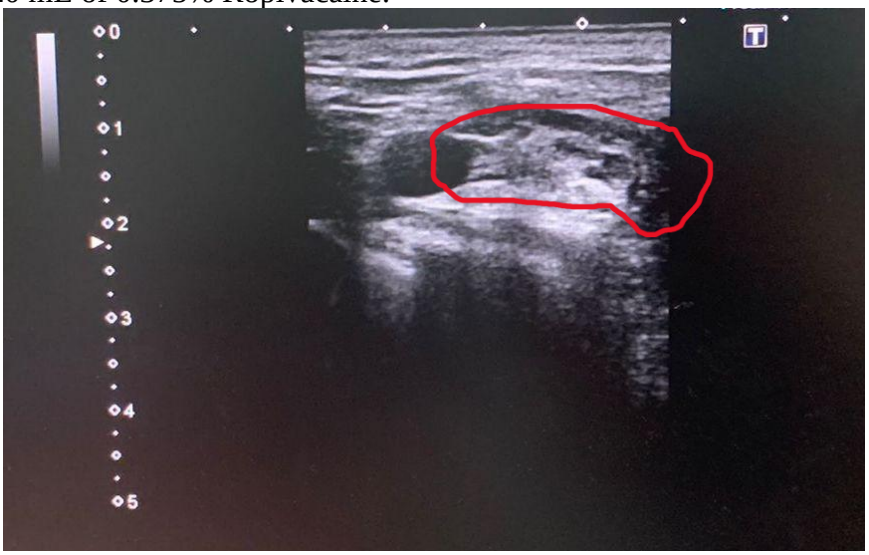

Figure 1. Brachial Plexus USG at Supraclavicular Level

Figure 2. Brachial Plexus USG at Infraclavicular Level

The surgery proceeded smoothly, with the patient fully awake, and a VAS (Visual Analog Scale) score of 0. The operation lasted for 60 minutes. Post-operative analgesia was administered with 1 gram of intravenous Paracetamol. During monitoring in the recovery room, the patient did not report any pain, nausea, or vomiting. However, the motor function of the

patient's right upper extremity was not yet restored. After an Aldrette score of 9 was achieved, the patient was transferred to the inpatient ward.

2. Case 2

A 63-year-old male patient with diagnosis of lower urinary tract syndrome (LUTS), bilateral hydronephrosis, acute kidney injury (AKI) possibly acute on chronic kidney disease (ACKD), and hypertension was scheduled for placement of double-lumen catheter (CDL) for haemodialysis. Patient appeared moderately ill, with consciousness intact. The patient's height was 167 centimeters and weight was 63 kilograms. The vital signs were as follows: blood pressure 137/91 mmHg, pulse rate 74 beats per minute, respiratory rate 16 breaths per minute, and body temperature 36.3°C.

Before the procedure, ultrasonography was performed on the right jugular vein and right subclavian vein. The results of the examination were as follows:

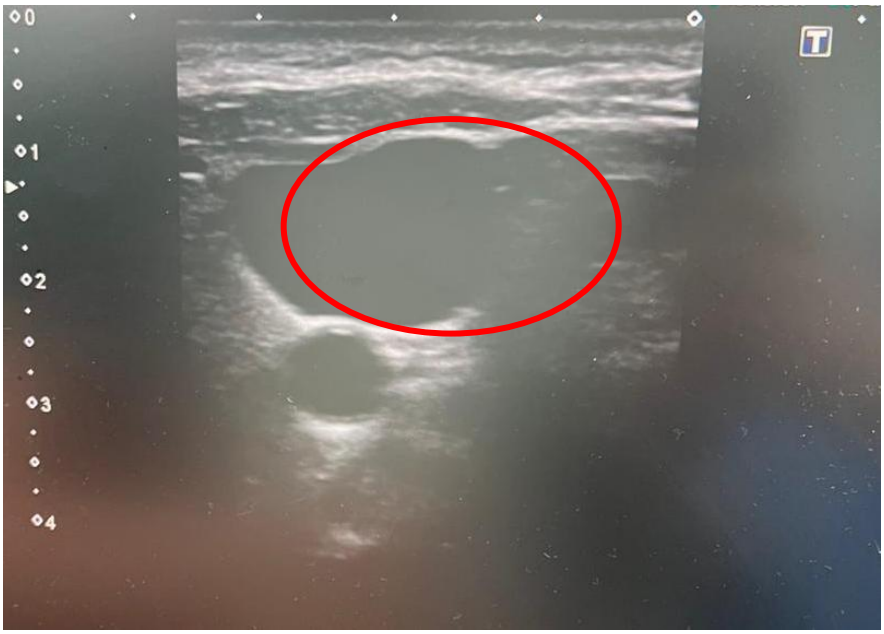

Figure 3. Right Jugular Vein USG

Figure 4. Right Axillary Vein USG

After performing ultrasonography, it was observed that the right jugular vein was larger and easier for the placement of the double-lumen catheter (CDL). Therefore, operator decided to place the CDL in the right jugular vein. The placement was successfully done using the Seldinger technique on the first attempt. Afterward, chest X-ray was performed, with the tip of the central venous catheter (CVC) located in the superior vena cava, with no evidence of pneumothorax.

C. RESULT AND DISCUSSION

In the field of anesthesiology and perioperative care, the use of ultrasonography has been widely applied (Salinas & Hanson, 2014). Several studies have shown that using ultrasonography to locate vascular access significantly increases safety, effectiveness, and efficiency compared to anatomical landmark techniques (Lamperti et al., 2012). In regional anesthesia, particularly peripheral nerve blocks, the use of ultrasonography has become the dominant technique to identify the location of the nerve to be blocked (Salinas & Hanson, 2014). Spinal and lumbar anesthesia are common procedures in anesthesiology and often present challenges when the anatomy of the spine is difficult to identify due to factors such as obesity, spinal deformities, or a history of previous spinal surgeries. With pre-procedural ultrasonography, spinal structures can be accurately identified, aiding in the success of spinal or epidural needle insertion (Perlas et al., 2016; Bhatty et al., 2025).

The effectiveness of regional anesthesia is determined by three key factors: precise identification of the target plexus or nerve, accurate needle placement in close proximity to the nerve without direct contact, and appropriate administration of local anesthetic surrounding the nerve structure (Warman & Nicholls, 2009). In clinical practice, anesthesiologists frequently rely on anatomical landmark techniques to elicit nerve stimulation or paresthesia in order to achieve accurate needle positioning. However, no single technique consistently fulfills all three criteria necessary for optimal regional anesthesia (Warman & Nicholls, 2009; Koscielniak-Nielsen, 2008; Kakaraddi et al., 2023). The integration of ultrasonography into peripheral nerve block procedures offers significant advantages, enabling real-time visualization of nerves and adjacent structures, such as blood vessels. This facilitates the avoidance of complications, such as intraneural or intravascular injections while also contributing to a more rapid onset of anesthesia, prolonged block duration, enhanced block efficacy, and reduced local anesthetic requirements (Terkawi et al., 2013;).

Based on a meta-analysis study by Abraham et al., which compared the use of ultrasonography with nerve stimulation in regional anesthesia procedures, it was found that ultrasonography improves block success, reduces procedure time, accelerates block onset, and prolongs block duration (Kakaraddi et al., 2023). Another meta-analysis study, comparing the use of ultrasonography with peripheral nerve stimulation in regional anesthesia procedures from 2004 to 2014 in Medline, EMBASE, and Cochrane databases, showed that ultrasonography significantly improves block success ($p < 0.00001$; odds ratio (OR) = 0.50; 95% confidence interval (CI) = 0.38-0.65), and reduces procedure time ($p < 0.00001$; OR=3.88; 95% CI=3.11-4.65) (Kakaraddi et al., 2023). From this study, it can be concluded that ultrasonography improves block success, shortens procedure time, and accelerates onset (Griffin & Nicholls, 2010).

The use of peripheral nerve stimulation in block procedures can lead to multiple needle insertions, which often causes discomfort to the patient. The use of ultrasonography in these procedures can reduce patient discomfort and prevent multiple needle insertions (Koscielniak-Nielsen & Dahl, 2012; Salam et al., 2021). Studies by Orebaugh ($P < 0.001$), Dufour et al. ($P < 0.001$), and Domingo-Triado et al. ($P < 0.001$) have reported that the use of ultrasonography

significantly reduces the occurrence of multiple needle insertions to achieve block success (Warman & Nicholls, 2009).

The use of ultrasonography in block procedures also affects patient satisfaction. Tran et al. conducted a study to observe pain scores during infraclavicular block procedures and found that the pain scores were significantly lower in the ultrasonography group compared to the peripheral nerve stimulation group (P = 0.01). This finding was also consistent with a study by Casati et al., which assessed pain scores in brachial plexus block procedures. In that study, the ultrasonography group had lower pain scores (P = 0.028) (Warman & Nicholls, 2009). From these studies, it can be concluded that the use of ultrasonography in block procedures can increase patient satisfaction.

In the case above, pre-procedural examination of the brachial plexus at the infraclavicular and supraclavicular levels was performed. Based on the examination results, the anesthesiologist chose to perform the block at the infraclavicular level, as the visualization of the brachial plexus was better at that level. The brachial plexus block with 20 mL of 0.375% Ropivacaine resulted in adequate block for performing the Cimino fistula procedure at the distal 1/3 of the right forearm.

Central venous catheterization is a procedure where a long, thin, soft, hollow catheter is inserted into a large vein. Central venous catheterization is usually required for long-term intravenous medication administration, such as in patients undergoing chemotherapy, hemodynamic monitoring, and for hemodialysis (Rathod et al., 2024). The most common sites for central venous access are the internal jugular vein, subclavian vein, and femoral vein. The choice of anatomical location for central venous catheterization must consider several factors such as indications, contraindications, previous access sites, and the expected duration of catheter use. The internal jugular vein is commonly chosen for central venous catheterization due to its ease of imaging with ultrasonography (Lockwood & Desai, 2019).

Central venous catheterization is a procedure frequently performed by anesthesiologists, and anatomical landmark techniques are still widely used. It is used for fluid and medication administration, hemodialysis, and hemodynamic monitoring (Sazdov et al., 2017). Landmark techniques heavily rely on the operator's knowledge of anatomical structures and palpation of the artery adjacent to the vein. However, landmark techniques cannot identify anatomical variations or venous thrombosis, potentially leading to acute complications such as arterial puncture, hematoma, hemothorax, or pneumothorax. In contrast, ultrasonography can easily visualize anatomical structures and confirm the vein's location, helping to avoid arterial puncture or cannulation failure (Saugel et al., 2017).

Ultrasonography in central venous catheterization can be used either statically or dynamically. Static ultrasonography is used to visualize the target vein, and the operator marks the skin for the puncture site, with catheter insertion done without the aid of ultrasonography. In contrast, dynamic ultrasonography involves visualizing the target vein and performing the entire procedure with real-time ultrasonographic guidance (Sazdov et al., 2017).

In a prospective study conducted by Darko et al. between 2015 and 2016, the success rates of central venous catheterization were compared between ultrasonography and landmark techniques. The study included 400 patients, split into two groups: one using ultrasonography and the other relying on landmark techniques. The success rate of central venous catheter placement was significantly higher in the ultrasonography group (98% or 196/200) compared to the landmark group (90.5% or 181/200), with a p-value of 0.0013. Additionally, the success rate for first-attempt catheter placement was 77% in the ultrasonography group, while it was 60.5% in the landmark group, with a p-value of 0.0032 (Sazdov et al., 2017).

Central venous catheterization carries potential risks, including cervical hematoma, cardiac tamponade, and in rare cases, death. Landmark techniques depend on the operator's

skill in palpating anatomical structures. While these techniques generally have a high success rate, they can be less effective in patients with abnormal central venous anatomy, affecting about 9% of individuals and increasing the likelihood of failure and complications. Common issues during jugular and femoral vein catheterization include arterial puncture, whereas subclavian vein catheterization is more frequently associated with pneumothorax (Sazdov et al., 2017; Saugel et al., 2017).

A meta-analysis by Wu et al. revealed an 82% reduction in the failure rate of central venous cannulation when two-dimensional ultrasonography (2D) was utilized (relative risk [RR] = 0.18; 95% confidence interval [CI] = 0.10-0.32; $p < 0.001$). The study also observed a significant decrease in complications, including arterial puncture, hematoma, pneumothorax, and hemothorax, within the ultrasonography-guided group ($p < 0.05$) (Lau & Chamberlain, 2016).

Ultrasonography offers significant benefits in central venous catheterization by enabling direct visualization of the target vein and adjacent anatomical structures both prior to and during the procedure. This capability enhances the success rate and minimizes the risk of complications (Sazdov et al., 2017). The National Institute for Clinical Excellence (NICE) currently advocates the use of ultrasonography for central venous access in both adult and pediatric patients. Despite these recommendations, the practical adoption of ultrasonography in central venous catheterization remains suboptimal. Bailey et al. highlighted this gap through an electronic survey conducted with members of the Society of Cardiovascular Anesthesiologists, revealing that 37% of respondents had never utilized ultrasonography for this procedure, while only 8% reported consistent use (Lau & Chamberlain, 2016).

Spinal and lumbar epidural anesthesia procedures are frequently performed by anesthesiologists, and before the development of ultrasonography, many used blind techniques. These techniques rely on anatomical landmark palpation, which can be inaccurate and heavily dependent on the anesthesiologist's experience. It is often difficult in patients with obesity, spinal deformities, or a history of prior surgery. These challenging conditions frequently lead to procedure failures, multiple needle insertions, and an increased risk of minor and major complications, such as dizziness and back pain after insertion, or even epidural hematoma and spinal cord injury (Sidiropoulou et al., 2021; Perlas et al., 2016).

Central neuraxial blocks are commonly performed for anesthesia and analgesia, and their success is judged by the needle's ability to reach the epidural or subarachnoid space. Blind techniques used by anesthesiologists are often difficult in elderly patients, those with spinal deformities, and those with obesity. In these patients, palpation of anatomical landmarks is challenging, increasing the risk of repeated needle insertions and extending procedure time. Several studies indicate that using ultrasonography before the procedure benefits patients with difficult palpation and provides a more accurate way to determine the needle insertion site compared to palpation alone. With ultrasonography, the operator can identify the position of the spinous process, lamina, and dura, allowing them to estimate needle depth and angle before the procedure (Brinkmann et al., 2013; Malarvizhi & Sreeranjani, 2014).

A randomized controlled trial by Sun-Kyung et al. compared the efficacy of ultrasonography and blind techniques in spinal anesthesia procedures for patients with spinal deformities. The study found that the ultrasonography group had a lower incidence of repeated punctures compared to the blind technique group ($p < 0.001$) and significantly increased the success of the procedure on the first attempt (50% vs. 9.1%; $p = 0.007$; relative risk (RR) = 5.5). The study also assessed periprocedural pain scores, with the ultrasonography group reporting significantly lower pain scores ($p = 0.012$) (Malarvizhi & Sreeranjani, 2014).

D. CONCLUSION

Pre-procedural use of ultrasonography in peripheral nerve blocks and central venous catheter insertions assists anesthesiologists in accurately identifying the target nerve and the appropriate vein for catheter placement. This imaging modality enhances procedural success, efficiency, and overall effectiveness, while concurrently minimizing the risk of complications. Nonetheless, the effective utilization of ultrasonography necessitates specific technical expertise and proficiency on the part of the operator.

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