Sonopathology:

Case Studies and Clinical Pearls with an Anesthetic "Game Changer"

Brian D. Sites, MD
Associate Professor of Anesthesiology
Director of Regional and Orthopedic Anesthesia
Dartmouth-Hitchcock Medical Center
Lebanon, New Hampshire

John Antonakakis, MD
Portsmouth Anesthesia Associates
Portsmouth Regional Hospital
Portsmouth, NH

As anesthesiologists expand their exposure to and experience with ultrasound-guided regional anesthesia (UGRA), many clinicians are recognizing that there exists a wealth of sonographic information beyond imaging the standard neural targets. In addition to revealing pathological situations, many images depict intriguing anatomical variations or turn out to be errors in ultrasound presentation, otherwise known as acoustic artifacts (Table). To borrow a metaphor from the sports world, sonopathology has become an anesthetic "game changer."

Dr. Sites has consulted for Philips, Inc.

Table. Structures To Look for on Ultrasound

Nerves	
	Anatomical variation
	Inflammatory neuritis
	Nerve entrapment
	Nerve tumors
Blood Vessels	
	Anatomical variation
	Aneurysm
	Arterial thrombosis
	Atherosclerosis
	Elevated central venous pressure
	Venous thrombosis
Viscera	
	Diaphragmatic dysfunction
	Hernia (inguinal, incisional, midline)
	Thyroid nodules
	Thyroiditis
Subcutaneous	
	Abscess
	Edema
	Foreign bodies
	Lymphadenopathy
	Subcutaneous emphysema
Bone	
	Absent rib
	Cervical rib

The anesthesia specialty is now in the midst of a debate over the appropriate training and scope of practice for clinicians who conduct UGRA. In light of this debate, we thought it would be illuminating to share several cases of UGRA-related sonopathology. These educational clinical scenarios underscore the power of using ultrasound to its fullest capabilities. Awareness and recognition of such sonopathology represents an excellent opportunity for anesthesiologists to add to their role as perioperative physicians.

Case 1

A 42-year-old man presents for an open reduction, internal fixation (ORIF) of a right radial fracture. He is on clopidogrel (Plavix, Bristol-Myers Squibb) for a drug-eluting stent placed 3 months earlier. The planned approach is a single-injection supraclavicular nerve block.

Upon conducting a preprocedure ultrasound exam, the brachial plexus appeared to be transected by a large branch of the subclavian artery. The divisions of the brachial plexus clearly appeared both anterior and posterior to this large arterial branch (Figure 1). Transducer maneuvers, including alignment and rotation, were unable to develop an image free of arterial flow. Based on the ultrasound image, it was concluded that an inevitable arterial puncture would be needed to block the posterior aspect of the brachial plexus. Given that the patient was on clopidogrel, the anesthesiologist felt that this approach would expose the patient to excessive risk for major bleeding. The anesthesiologist therefore examined the patient's infraclavicular fossa and found a normal-appearing axillary artery and clear cord-level landmarks. An infraclavicular block was performed with 30 mL of 0.5% ropivacaine, which served as a successful surgical anesthetic.

Clinical Pearls

1. This branch of the subclavian artery is likely the transverse cervical artery. It is important to scan the anticipated trajectory of the needle with color Doppler, as the 2-dimensional image alone may not identify all blood vessels. This was true in this case, as the artery was identified only after color Doppler interrogation.
2. Compressive ischemic neuropathy as a result of a perineural hematoma is a well-described event and clearly is more likely in a patient prone to major bleeding.[1]
3. Preprocedure scanning allows adequate machine settings, identification of unexpected findings, and the efficient altering of the anesthetic approach.

Case 2

A 64-year-old woman presents for an elective right total knee arthroplasty. The initial plan consists of a general anesthetic for surgery and a continuous femoral nerve block for postoperative pain management. However, ultrasound scanning of the patient's right inguinal region reveals significant lymphadenopathy, with one of these lymph nodes directly anterior to the femoral nerve (Figure 2). Placing and leaving a catheter through this inflammatory process was considered to pose an increased risk for infection. A decision was made to perform a single-injection femoral nerve block. Ultrasound was used to avoid puncture of the inflamed lymph nodes.

Clinical Pearls

1. Lymphadenopathy can be identified easily with ultrasound. The classic appearance is a hypoechoic oval or circle. Peri-lymph node edema often will generate an anechoic rim around the node. Chronic inflammation can lead to fatty infiltration of the node and increase the echogenicity.
2. Such abnormalities should be communicated to the surgeons and visual inspection of the leg and knee for signs of infection is indicated.
3. The decision to place a femoral nerve catheter in the context of such pathology will need to be made weighing the potential benefits of continuous analgesia.

Case 3

A 69-year-old woman presents for a right shoulder arthroscopic acromioplasty in the beach chair position. Her medical history includes hypertension and tobacco use. The anesthetic plan calls for a general anesthesia combined with a single-injection interscalene block. During the preprocedure short-axis ultrasound scan of the mid neck, a hyperchoic lesion in the carotid artery was noted. Further long-axis imaging revealed lesions involving the carotid bifurcation (Figure 3). The diagnosis of atherosclerotic disease was made. Examination on the contralateral side revealed a similar lesion.

Given that the patient was asymptomatic, the anesthesiologist offered 2 potential new plans. The first: Cancel the procedure and order a formal vascular surgical consult. The second: Proceed with the regional block serving as a surgical anesthetic in order to allow effective intraoperative neuromonitoring. The patient chose the latter and underwent the surgery uneventfully and with minimal sedation. The anesthesiologist arranged for a follow-up evaluation with a vascular surgeon.

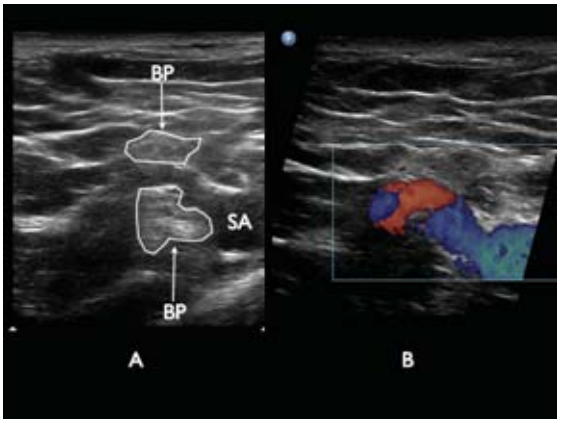

Figure 1. **Short-axis images of the brachial plexus in the supraclavicular fossa. (A) Arrows represent the brachial plexus, which appeared to be transected by a large branch of the subclavian artery. (B) The use of color Doppler clearly reveals the presence of what is likely a very large transverse cervical artery.**

BP, brachial plexus; **SA,** subclavical artery

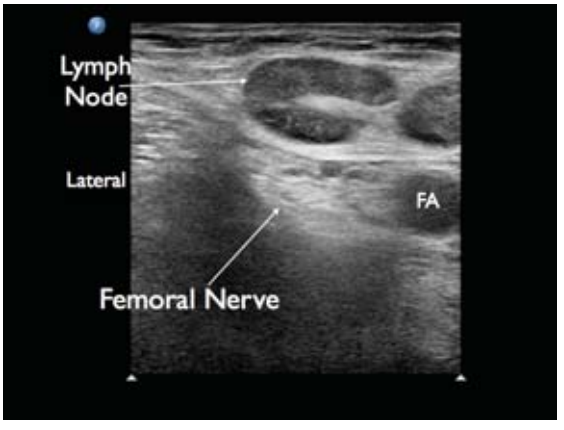

Figure 2. **Femoral lymphadenopathy noted during the performance of a planned continuous femoral nerve block.**

FA, femoral artery

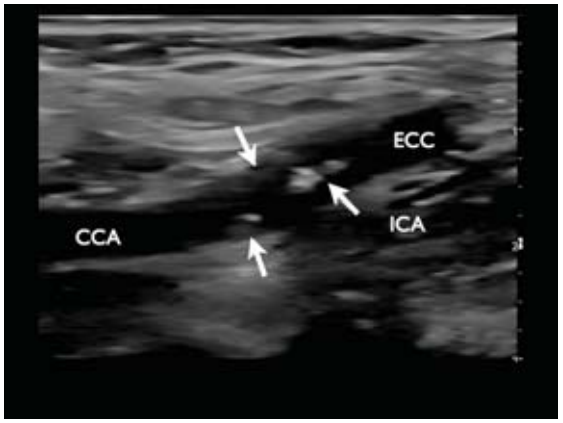

Figure 3. **Long-axis image of the common carotid artery during an interscalene block. The anesthesiologist incidentally noticed the hyperechoic lesion immediately proximal to the carotid bulb and extending into the external carotid artery.**

CCA, common carotid artery; **ECC,** external carotid artery; **ICC,** internal carotid artery.

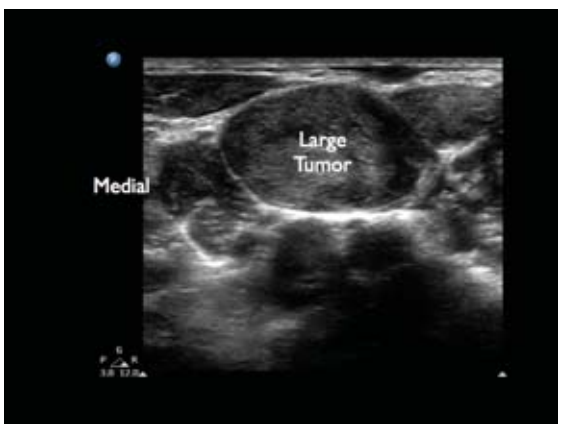

Figure 4. **A short-axis image of the brachial plexus in the neck demonstrating a large neurofibroma. In this ultrasound image the neurofibroma appears hypoechoic and is homogeneous in nature.**

Clinical Pearls

1. Major neurologic complications have been reported secondary to the beach chair surgical position, presumably the result of decreased cerebral perfusion.[2]
2. A patient with flow obstructions in the carotid arteries may be at higher risk for complications resulting from cerebral ischemia. Therefore, the identification of asymptomatic carotid lesions may be extremely beneficial.
3. With effective regional anesthesia, arthroscopic shoulder surgery can be performed easily and with minimal patient sedation. An awake patient likely is the best neurologic monitor of adequate cerebral perfusion.
4. If carotid lesions are identified, careful consideration should be made to gathering additional data and seeking expert consultation.

Case 4

A 26-year-old man with asthma and neurofibromatosis presents to the operating room for an ORIF of his mid-shaft humerus, which was fractured during a motor vehicle accident. The patient expressed a strong desire to avoid general anesthesia, having experienced a severe asthmatic flare-up after a prior anesthetic. The anesthesiologist discussed the concern of a nerve block-related neural injury in the setting of his preexisting peripheral neuropathy. The patient agreed to undergo an ultrasound examination of his brachial plexus to assess possible disease sparing in the supraclavicular fossa. A standard short-axis image of the mid-neck brachial plexus was generated using a high-frequency linear transducer. Large hypoechoic lesions immediately revealed that the patient's neurofibromatosis directly affected the brachial plexus (Figure 4). Figure 5 also illustrates the same process involving the brachial plexus at a more distal location where a supraclavicular block would be performed. Based on these findings, the anesthesiologist strongly encouraged the use of general anesthesia. The patient agreed and underwent an uneventful general anesthetic with careful medical management of his reactive airway disease.

Clinical Pearls

1. Ultrasound examinations can facilitate preoperative decision making. Patients are likely to appreciate objective evidence for or against an anesthetic plan.
2. A neurofibroma is a peripheral nerve-sheath tumor derived from Schwann cells. (Schwannomas are another type of nerve-sheath tumor.) The ultrasound appearance of such tumors is quite variable

but usually presents as hypoechoic and homogenous. Neurofibromas may have a heterogeneous "target" appearance with a hyperechoic center and a hypoechoic periphery.

Case 5

A 54-year-old woman with chronic renal insufficiency presents for a revision of an arteriovenous fistula in her left upper extremity. She underwent a previous right upper lobectomy for lung cancer. She prefers to have a regional anesthetic and avoid general anesthesia. The anesthesiologist's desired approach was a supraclavicular brachial plexus block. However, given the patient's history of a right upper lobectomy, the anesthesiologist believed the best technique would be axillary, thus avoiding a potential left-sided phrenic nerve paralysis. A preprocedure short-axis ultrasound image of the axillary brachial plexus revealed multiple partially arterialized and engorged veins (Figure 6). Based on the ultrasound image, inadvertent venous puncture appeared likely. These findings were discussed with the patient and she agreed to have general anesthesia, which proved uneventful.

Clinical Pearls

1. Phrenic nerve paralysis can occur with interscalene and brachial plexus nerve blocks.[3]
2. Venous puncture may further compromise the integrity of the arteriovenous fistula. In a partially arterialized venous system, venous puncture also may lead to a compressive neuropathy.
3. Inadvertent IV injection of local anesthetic leading to seizure and cardiac arrest has been well described with axillary brachial plexus nerve blocks. This complication would be more likely in the setting of an enlarged vascular network surrounding the target nerves.

Case 6

A 39-year-old man presents for an ORIF of a left olecranon fracture sustained after falling off a ladder. He underwent a full trauma evaluation, with a chest x-ray revealing left-sided rib fractures. The patient agreed to a supraclavicular brachial plexus nerve block with sedation for surgery. However, subcutaneous emphysema was observed during a preprocedure ultrasound examination of the supraclavicular fossa (Figure 7), which degraded the image of the subclavian artery and brachial plexus. The pleura of the lung was visible, although a "sliding sign" could not be reliably detected, indicating the possible presence of a pneumothorax. A new chest x-ray was ordered, which revealed a small pneumothorax on the patient's left side. Surgery was postponed, a general surgery consult was obtained,

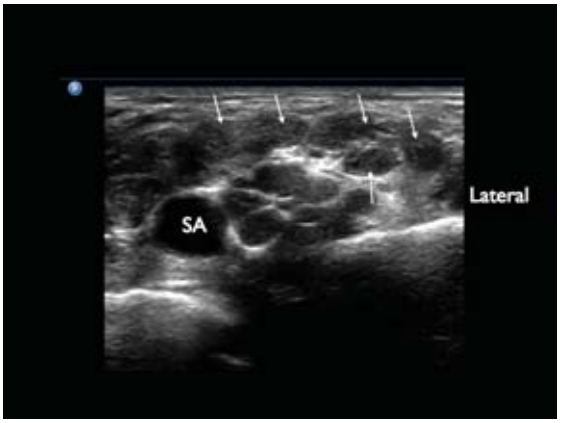

Figure 5. **A short-axis image of the brachial plexus in the supraclavicular fossa. Multiple neurofibromas are visible (white arrows).**

SA, subclavical artery

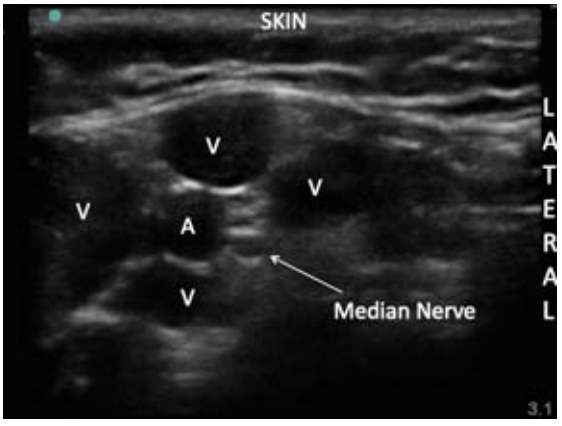

Figure 6. **A short-axis image of the axillary brachial plexus in a patient with end-stage renal disease. Multiple partially arterialized and engorged veins are noted surrounding the axillary artery and target nerves.**

A, artery; **V,** vein

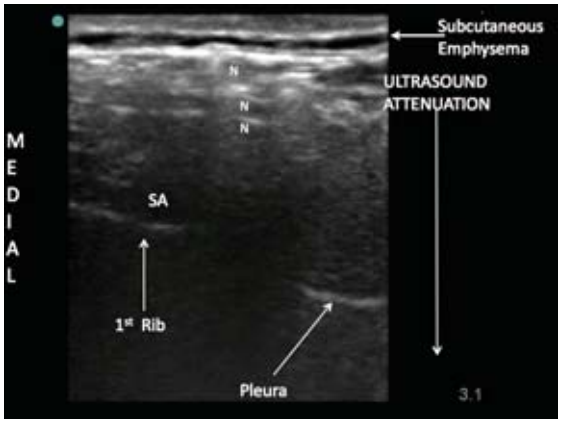

Figure 7. **A short-axis image of the brachial plexus immediately ceph-alad from the supraclavicular fossa in a patient with extensive subcutaneous air resulting from a pneumothorax. Note how the subcutaneous air degrades the ultrasound image.**

SA, subclavical artery

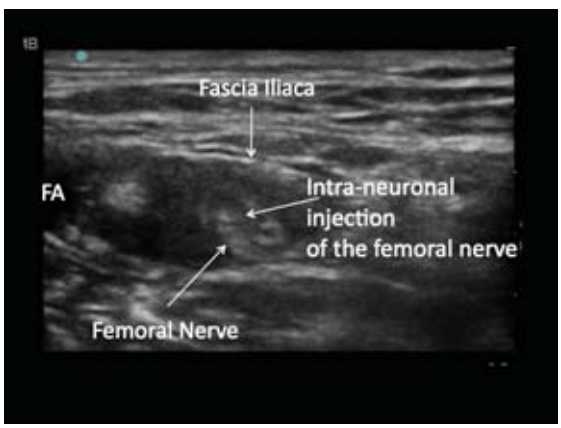

Figure 8. **Intraneural injection of local anesthetic during the performance of a femoral nerve block. Note the eccentric swelling of the nerve as a result of the hypoechoic local anesthetic.**

FA, femoral artery

and a chest tube was inserted. The subcutaneous air was still present several hours later, resulting in continued poor-quality image of both the infraclavicular and supraclavicular brachial plexus. Positioning the ultrasound transducer in a more proximal location on the neck, an adequate image of the brachial plexus image could be obtained. The anesthesiologist administered 30 mL of 0.5% bupivacaine to achieve a solid block of the brachial plexus with the exception of the medial brachial and medial antebrachial cutaneous nerves, suggesting inadequate C8-T1 nerve root/inferior trunk coverage. A subcutaneous wheal of local anesthetic was injected in the medial aspect of the mid-upper arm, effectively blocking these nerves. The patient subsequently underwent a successful regional anesthetic for surgery.

Clinical Pearls

1. An unidentified pneumothorax presents an anesthetic risk, especially if positive pressure ventilation is used. Intraoperative hypoxemia may result from an expanding pneumothorax. Direct hemodynamic compromise also may occur if a tension pneumothorax develops.
2. Ultrasound has been shown to be a sensitive modality for detecting a pneumothorax.[4] A sliding sign is evident when the visceral pleura moves along the parietal pleura. When a pneumothorax occurs, the visceral pleura no longer slides along the parietal pleura. M-mode ultrasound can be used to further characterize the presence or absence of pleural sliding.
3. Air, through ultrasound absorption, highly attenuates ultrasound energy. The presence of air anywhere results in a uniformly anechoic ultrasound image, compromising image quality. The ultrasound exam complements the physical exam, as in this case of the diagnosis of a pneumothorax.

Case 7

A 63-year-old woman with a history of diabetes presents for a right knee arthroplasty. The anesthetic plan calls for spinal anesthesia and a single-injection femoral nerve block for postoperative analgesia. At the inguinal crease, a short-axis image of the femoral nerve was obtained with a high-frequency linear transducer. Using the in-plane needle-insertion technique, 25 mL of 0.5% ropivacaine was injected to generate a circumferential spread of local anesthetic around the femoral nerve. However, toward the end of the injection the needle inadvertently penetrated the nerve and approximately 1 to 2 mL of local anesthetic was injected intraneurally (Figure 8). The nerve swelled eccentrically and the patient experienced a

simultaneous dysesthesia. The injection was aborted and the needle withdrawn, whereupon the dysesthesia quickly resolved. A close inspection of the nerve revealed an intraneural area of hypoechoic local anesthetic. These findings were evaluated and the patient was deemed at a higher risk for nerve injury given her diabetic state and the need for a surgical thigh tourniquet. The surgery was canceled. The patient reported that her motor block lasted approximately 24 hours, while full sensory function did not return for more than 48 hours. The patient presented 2 weeks later and underwent a successful and uneventful femoral nerve block and knee replacement.

Clinical Pearls

1. Intraneural injection may lead to a mechanical and/or ischemic nerve injury.
2. Ultrasound imaging can augment the anesthesiologist's clinical skill to help him or her detect when an intraneuronal or intrafasicular injection is occurring.
3. The decision to postpone an elective knee replacement stems from the hypothesis of the "double-crush phenomenon." According to this hypothesis, multiple neural insults (preexisting neuropathy, intraneural injection, and tourniquet ischemia) may increase the risk for permanent neurologic injury.

References

1. Jamjoom ZA, al-Bakry A, al-Momen A, Malabary T, Tahan AR, Yacub B. Bilateral femoral nerve compression by iliacus hematomas complicating anticoagulant therapy. *Surg Today*. 1993;23(6):535-540.
2. Less L, Caplan R. APSF Workshop: Cerebral perfusion experts share views on management of head-up cases. *APSF Newsletter*. Winter 2009-10. Accessed April 12, 2010.
3. Mak PH, Irwin MG, Ooi CG, Chow BF. Incidence of diaphragmatic paralysis following supraclavicular brachial plexus block and its effect on pulmonary function. *Anaesthesia*. 2001;56(4)352-356.
4. Garofalo G, Busso M, Perotto F, De Pascale A, Fava C. Ultrasound diagnosis of pneumothorax. *Radiol Med*. 2006;111(4)516-525.

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