Lesson 265: PreAnesthetic Assessment of the Obese Patient Who Insists on a Regional Block

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NEEDS STATEMENT
Anesthesiologists are treating an increasingly large overweight population. The perioperative risks associated with obesity are well documented. Regional block techniques offer benefits to the patient for early ambulation and good pain control and are often part of office-based anesthesia. Locating nerves, however, may be technically difficult in the obese patient. New techniques have been described that assist in the precise location of specific tissues; the use of such techniques is rapidly becoming a standard of care. The descriptions of these methods have been identified as required knowledge for anesthesiologists.

An increasing number of obese patients (BMI >30) are being admitted for surgery. Caring for these patients in the setting of ambulatory anesthesia can be challenging. Compared with normal-weight patients, obese patients have more comorbidities—such as hypertension, coronary artery disease, stroke, osteoarthritis, and diabetes mellitus—which have been well described. An examination of outcomes suggests that even patients with obstructive sleep apnea and other comorbid conditions can be adequately cared for with no increased risk. Obese patients who undergo shoulder surgery and are discharged in less than 24 hours frequently receive general anesthesia because of its ease of administration, comfort level of the practitioner, and time constraints of the facilities. Studies show that regional anesthesia, however, may increase patient satisfaction, in addition to decreasing postoperative pain, nausea, and vomiting. A primary concern for the obese patient is the development of respiratory complications, especially with block anesthesia of an upper extremity, in which the phrenic nerve is frequently paralyzed. Also, the number of failed blocks is slightly higher in these patients. The ultrasound-guided administration of regional anesthesia—especially in the upper extremities, where nerves are close to the surface—is a technique that may help avoid many of the problems associated with this type of surgery in obese patients.

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Physiologic Concerns of Obesity

Many of the difficulties encountered in the obese patient can be directly attributed to changes in the respiratory system (Table 1). Compliance of the chest wall is decreased, secondary to an increased amount of adipose tissue in the chest wall and abdomen.6 Already decreased motion in the chest and ribs is further compromised by changes in the skeleton (thoracic kyphosis and lumbar lordosis are both increased).6 These physical changes decrease the volume of the lungs and increase the work of breathing.7 Decreased lung volume causes alveolar closure, ventilation-perfusion mismatch, and subsequently hypoxia. In some cases, physiologic adaptations to these conditions include hypercarbia and an acceptance of the hypventilatory state.7

Chronic hypoxemia resulting from these changes can lead to pulmonary vasconstriction, a natural mechanism to decrease ventilation-perfusion mismatch, and eventually chronic pulmonary hypertension. As the deterioration progresses, right heart failure (cor pulmonale) develops in many obese patients, which can be particularly harmful because obesity also increases cardiac risk due to coronary disease and hypertension.2

The incidence of obstructive sleep apnea is increased in obese patients.2 The physical collapse of the upper airway caused by decreased muscle tone of the upper pharynx, in addition to an increased amount and distribution of fatty tissue, results in turbulent airflow and obstruction during inhalation.2 A diagnosis of obstructive sleep apnea is associated with an 8-year mortality rate of 40%. The incidence of sleep apnea increases directly with the weight of the patient.2 Frequently, a formal diagnosis has not been made before surgery but can be based on the patient’s history alone. Obstructive sleep apnea is an important consideration because it is associated with a poorer outcome.2

The numerous biochemical changes associated with obesity also bring higher risks for stroke, coronary disease, diabetes, cholelithiasis, and perhaps even psychological effects.8 These increased risks must be considered during the preanesthetic assessment of patients.

Regional Anesthesia

Controversy has surrounded the choice of anesthesia technique for many years. As previously noted, general anesthesia is frequently used because of expediency. Also, many patients have a fear of needles and prefer to be “asleep.” Shortcomings associated with general anesthesia include cognitive impairment in the elderly population9 and poor postoperative pain control.10 On the other hand, regional anesthesia in general is often discouraged because of a relatively higher failure rate and difficulty in mastering the techniques.

Benefits

In certain situations, regional anesthesia provides several advantages over general anesthesia, including minimal airway intervention, less cardiac depression, less postoperative pain, and decreased opioid use with less postoperative nausea (Table 2). Decreased length of hospital stay and improved patient satisfaction have also been noted.21 In one of the few prospective studies comparing interscalene block with general anesthesia in patients undergoing shoulder surgery, Hadzic et al11 found that in a series of 50 patients undergoing outpatient rotator cuff surgery, same-day recovery was better with nerve block than with general anesthesia.4 The average time to discharge after nerve block was 12.83 minutes, compared with 286 minutes after general anesthesia. Of the 25 patients receiving general anesthesia, 4 had unplanned admissions, compared with none of the nerve block group. The patients receiving regional anesthesia also had significantly higher satisfaction scores.

The finding of greater benefits of regional anesthesia in this study than in previous studies comparing regional and general anesthesia may have resulted from the higher rate of successful blocks.11 The result is especially encouraging in light of the introduction of new techniques of ultrasound-guided nerve blocks (not used by Hadzic et al11), which have been linked to a higher rate of success.12

Complications

Acute complications associated with upper extremity blocks are seizures resulting from local anesthetic toxicity, accidental subarachnoid block, and pneumothorax (Table 3). Borgeat et al13 studied the complications of interscalene block in a series of 521 patients. The incidence of seizures was 0.2%, which represented only 1 patient and is similar to the number reported elsewhere.14 A similar figure was obtained when investigators looked at intravascular puncture,15 which, along with a rapid absorption of local anesthetic, is presumed to be the cause of seizures.

The spread of local anesthetic to the cervical spinal cord resulting in spinal anesthesia has been described,16 but the incidence seems to be low. In a recent study by Candido et al17 of 660 patients administered an interscalene block, subarachnoid block was not reported. Although unintended spinal anesthesia is an infrequent occurrence, anesthesiologists must always be prepared to recognize and treat it quickly.

One case report has been published of permanent injury to the cervical cord18 associated with upper extremity nerve block. Sardesai et al19 suggested that an alternative to the Winnie approach in interscalene block would theoretically reduce the incidence of entry into the spinal canal by changing the angle of approach. The effect of ultrasound guidance to reduce this complication has yet to be proved but may be substantial.20 In the study by Borgeat et al,13 pneumothorax was diagnosed in 1 of 521 patients, a rate similar to that found in an earlier study by Ward.21 In both studies, nerve blocks were performed without the aid of ultrasound guidance.

Nonacute complications include hematomas, infection, respiratory compromise, and neurologic injury (Table 3). A recent article by Neuberger et al22 reports on a large series of patients in whom perineural catheters (n=2,265) were placed for postoperative analgesia at many anatomic sites. The incidence of infection was 3.2%, and no late complications developed. The incidence of hematoma formation is also low, and hematoma formation may not be a problem even if anticoagulants are administered.22

The neurologic sequelae of interscalene blocks are probably the most troublesome ones for both practitioners and patients because of possible long-term effects and the lack of specific therapies. The results of a large French study23 suggested an incidence of severe neurologic deficits of 2.9 per 10,000 interscalene blocks. Transient neurologic sequelae are much more frequent, with an estimated incidence ranging from 4%24 to 14%.25 Most of these problems eventually resolve.25 In a study of interscalene catheters by Borgeat et al,26 the incidence rates of neurologic complications at 1 month (2.4%) and 3 months (0.3%) were similar to the rates reported with noncatheter techniques.26 Some of the differences in study results were due to a differentiation between injuries attributed to interscalene blocks and those attributed to factors other than anesthesia.26 In the study by Candido et al27 of 660 patients receiving interscalene block, 31 patients had symptoms at 4 weeks that were likely associated with the block. The symptoms resolved spontaneously within 1 month in all but 2 patients. Borgeat and colleagues28 suggested an eventual long-term complication rate of 0.4%.

Table 1. Physiologic Changes in The Obese Patient

<table>
<thead>
<tr>
<th>Condition</th>
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<tbody>
<tr>
<td>Decreased compliance of the chest wall</td>
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<tr>
<td>Increased adipose tissue in chest wall and abdomen</td>
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<tr>
<td>Increased thoracic kyphosis and lumbar lordosis</td>
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<tr>
<td>Decreased lung volume</td>
</tr>
<tr>
<td>Increased alveolar closure</td>
</tr>
<tr>
<td>Increased work of breathing</td>
</tr>
<tr>
<td>Hypoxia, ventilation-perfusion mismatch</td>
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<tr>
<td>Hypoventilation syndrome and increased Pco2</td>
</tr>
<tr>
<td>Pulmonary vasoconstriction and cor pulmonale</td>
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Table 2. Benefits of Regional Anesthesia

<table>
<thead>
<tr>
<th>Benefit</th>
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<tbody>
<tr>
<td>Improved postoperative pain control</td>
</tr>
<tr>
<td>Rapid recovery and timely discharge</td>
</tr>
<tr>
<td>Decreased hospital stay and fewer unplanned admissions</td>
</tr>
<tr>
<td>Decreased postoperative nausea and vomiting</td>
</tr>
<tr>
<td>Increased patient satisfaction</td>
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<tr>
<td>Modest cost savings</td>
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</table>

Table 3. Complications of Upper Extremity Regional Block

<table>
<thead>
<tr>
<th>Type</th>
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<tbody>
<tr>
<td>Acute complications</td>
</tr>
<tr>
<td>Seizure</td>
</tr>
<tr>
<td>Pneumothorax</td>
</tr>
<tr>
<td>Subarachnoid migration</td>
</tr>
<tr>
<td>Nonacute complications</td>
</tr>
<tr>
<td>Nerve injury (at injection site or distribution of block)</td>
</tr>
<tr>
<td>Hypoesthesia</td>
</tr>
<tr>
<td>Paresthesia</td>
</tr>
<tr>
<td>Pain/dysesthesia</td>
</tr>
<tr>
<td>Infection</td>
</tr>
<tr>
<td>Hematoma</td>
</tr>
<tr>
<td>Hypoventilation, hypoxia, hypercapnia secondary to hemidiaphragmatic paralysis</td>
</tr>
</tbody>
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which is very close to the 0.3% rate suggested by the study of Candido et al.17

**Regional Anesthesia in Obese Patients**

Regional anesthesia can be extremely satisfying for both patient and practitioner when it goes well, but very frustrating and disappointing when it fails. Problems associated with unsuccessful regional anesthesia are exaggerated in the obese patient. Surface landmarks can be hard to find in obese persons, and positioning is often restricted, which makes the use of standard techniques difficult. The physiologic changes associated with obesity means that any side effects (e.g., respiratory compromise due to phrenic nerve block or spinal migration of local anesthetic) are more significant. The frequency of comorbidities such as diabetes and associated neuropathy can also make nerve stimulation techniques less successful.26

In studies examining regional anesthesia in obese patients, results suggest that although these patients present some barriers, regional techniques should not be precluded solely on the basis of obesity. Nielsen et al28 published a study of 9,038 blocks in patients who were stratified by BMI: more than 31% were obese. The study included different types of regional blocks, of which one third involved the upper extremities. The block failure rate was 12.7% in obese patients (BMI >30), compared with 9.5% in patients with normal weight (BMI <25), for all peripheral blocks in the study. In the 2 patient populations, those with successful blocks had similar good outcomes—low pain scores, decreased nausea and vomiting—and the same length of hospital stay and rate of unanticipated hospital admission.

Franco and colleagues3 reviewed 2,020 supraclavicular blocks, of which 22.5% involved obese patients (BMI >30). The overall success rate was 96.6% for all blocks—97.6% in the nonobese group and 94.3% in the obese group. Blocks were performed using nerve stimulators. Any occurrence of paresthesia was considered accidental. Elicitation of an appropriate neurologic response with the stimulator was lower in the obese group (68%) than in the normal-weight group (87%). In the obese group, blocks resulted in more accidental paresthesias (3.3% vs 2.2%), with an even higher rate (9.6%) in the morbidly obese subgroup (BMI >40).

Schwemmer et al30 evaluated the success rates of ultrasound-guided interscalene blocks in normal-weight and overweight patients and found no significant difference between the 2 groups; time needed to perform the block was only slightly greater in the overweight group. The results suggest a significant improvement in performing interscalene blocks in obese patients; however, the study was relatively small (50 patients in each arm). Visibility of the target structures was good in both the normal-weight and overweight groups (3 of 25 were considered difficult in the overweight group and 0 of 25 in the normal-weight group). Only 1 patient had a neurologic complication—not considered to be caused by the interscalene block. None of the normal-weight patients registered subjective complaints of phrenic nerve block, whereas 4 patients in the overweight group had such complaints. No intervention was reported.

**Ultrasound Techniques in Regional Anesthesia**

Ultrasound has been used to guide regional block procedures for more than 10 years. One of the earliest studies of ultrasound in interscalene block was reported by Chan.24 Several apparent benefits derive from the use of ultrasound in performing regional nerve blocks (Table 4). As the equipment becomes more widely available and is adapted to the operating room setting, the use of ultrasound guidance will most likely become commonplace during all regional nerve blocks.

Ultrasound guidance for nerve blocks has been well reviewed in several articles.12,20,31 The most obvious benefit of ultrasound-guided regional anesthesia is the ability of the practitioner to visualize the placement of the needle and the location and spread of local anesthetic relative to the target neuronal structures.31 Inherent in the ability to visualize is increased safety. Good visualization of adjacent structures like blood vessels and pleura should help the practitioner avoid damage to those structures. A few studies have suggested that ultrasound-guided upper extremity blocks can be performed faster and with higher success rates than upper extremity blocks with traditional approaches.31 A study by Sandu and colleagues,32 who used infraclavicular catheters, suggested that ultrasound techniques may provide some economic benefit in comparison with traditional block methods because of the decreased amount of time needed to perform blocks.

**Ultrasound Basics**

Medical ultrasound uses sound waves in the range of 2-12 million cycles per second (megahertz [MHz]); the sound waves are produced and detected by transducers contained in a handheld probe. The transducers are piezoelectric crystals that convert electric voltage into sound waves and reflected sound waves into electric voltage.31 The image on the screen of an ultrasound machine comprises many individual scan lines. Each scan line is produced from a transmitted and received ultrasound pulse from a set of crystals. Most modern transducer probes use a line of multiple send-and-receive crystal sets, called an array.

Tissue penetration, or the depth to which the sound waves produced by the transducer travel away from and then back to the transducer, depends largely on the frequency range of the transducer. Scanning for superficial structures (0.3 cm) requires high frequencies (6-12 MHz); deeper structures (4-7 cm) are better seen with lower frequencies (4.6 MHz).

The ultrasound probe generates pulses of ultrasound energy and then pauses, waiting for energy (echoes) to return from areas that reflect ultrasound waves. Reflections are created when the ultrasound waves encounter layers or boundaries of differing densities or rigidities. Some portion of the energy is reflected toward the listening probe. Other portions of the emitted energy are refracted in other directions, some are absorbed by tissues (and turned into heat), and some continue on to encounter other reflecting boundaries.

The speed (velocity) of sound waves in different tissues varies; they travel fastest in fluids and most slowly in air. For purposes of processing and calculating, the average velocity through tissues is 1,540 m/s, or 1.54 mm/mcs. This is important because the distance to a target (reflecting layer) is determined based on the time required for an emitted sound wave to return to the probe. Dividing the time required for an emitted sound wave to return to the probe in microseconds by 2 (time to the layer), then dividing the time to the layer in microseconds by 1.54 mm/mcs, yields the distance to the layer in millimeters. This calculation is repeated many times per second in the ultrasound machine and is the basis for placing the dots representing the depth vertically (along the y-axis) on the image map painted on the ultrasound screen. A scan line, made up of a stack of dots, represents echoes received by the transducer and placed vertically according to the calculated distance to the targets. The complete 2-dimensional real-time image is composed of many scan lines obtained from the array of transducers placed side by side and rewritten many times per second.
More on Ultrasound Machines

The 2 basic models of ultrasound machines are the console and the portable. The console model is a medium to large machine on casters that usually has input connectors for 2 or more transducer probes and receives power through an alternating current (AC) power cord to a wall supply. In the past, consoles had more features than portables, but with modern technology, this distinction has largely disappeared.

The portable model—which usually looks like a notebook computer—generally has input only for a single transducer probe and an indwelling battery power supply with a limited working lifetime. For most practical purposes, the portable machine is mounted on a cart and connected to a thermal printer, and it must be frequently plugged into an AC power supply to maintain its charge.

Within the portable format are 2 basic types of machines. The first is a small, dedicated, hardware-based portable that contains processing instructions chips within. This type of portable is designed and built only as an ultrasound machine. The second type of portable machine is personal computer (PC)-based. This type originates as a notebook or laptop computer and, with the application of extra circuitry and hardware, is turned into an ultrasound machine. Both designs have advantages and disadvantages.

As far as the authors are aware, every machine on the market is capable of all the modes needed in regional nerve blocks, but the purchaser of a machine should always confirm installation of the desired options. Any 2 machines are unlikely to differ much in actual processing speeds; however, differences in other features must be evaluated based on individual needs.

For interscalene or supraclavicular nerve blocks, the ideal transducer probe is a linear array probe in the range of 8 to 12 MHz, given that the trunks of the brachial plexus usually lie 1 to 3 cm below the skin surface.

The Scan Line

To illustrate how an ultrasound image is built from reflections, a single scan line from a single transducer crystal of the array appears in Figure 1. Under the control of a logic circuit, the power path to an element of the array switches on, sending voltage to the transmitting transducer crystal. The crystal, based on its piezoelectric properties, vibrates, producing ultrasound wave energy for a preset time at a set intensity and frequency; it then immediately switches off and enters receiving mode to “listen” for an echo. The ultrasound energy leaves the face of the transducer and travels across the coupling gel to pass through the body surface; the ultrasound wave is propagated along the tissue medium that will conduct the vibrations. Ultrasound waves tend to move in a straight line, unlike sound waves in the range of human hearing. (If sound in the lower ranges behaved the same way as ultrasound waves, we would be unable to hear people talking outdoors if they were facing away from us.)

When an ultrasound wave encounters a layer of differing density (eg, the most superficial layer of muscle fascia), some portion of the full amount of ultrasound energy is reflected toward the transducer, some is absorbed, and the rest continues traveling through the tissue. When ultrasound energy is reflected toward the transducer, the intensity of the reflected wave determines the brightness of the dot representing the layer in the scan line—and thus its brightness in the full image.

If the ultrasound wave strikes a boundary that is perpendicular to the sending and receiving transducer, much of the reflection will return directly to the transducer and the layer will show up very clearly. However, when a wave strikes an irregularly shaped layer, or a layer that is angled away from the perpendicular, much of the energy of the reflection produced will be scattered away from the receiving transducer. As a result, the layer will not appear as clearly. When a wave of less intensity is received at the transducer, a smaller dot of less brightness is placed in the scan line.

The directions of a reflected wave depend on the angle of incidence of the wave and the angles or roughness of the reflecting surface, in addition to the frequency of the wave. The amount (or percentage) of the reflection is based on the amount of reflecting surface of the layer, the properties of the layer encountered (density and rigidity), and the intensity of the wave (original intensity, or volume, minus energy already reflected, absorbed, or dissipated).

The greater the density or rigidity of the layer encountered, the greater the amount of wave reflected (bone reflects completely). Conversely, with an encountered layer of less density or rigidity, or a smaller difference between densities (at the new layer), less energy will be reflected and more of the original energy will continue along its path. A difference in propagation speeds across a layer also produces a reflection that appears as a dot in the scan line.

It should be clear from the variables discussed that even small changes in the angle at which the transducing probe is held to the body surface can produce very different images. In practical terms, to obtain a better view of target structures, the angle of the probe should be changed slightly before other adjustments are made.

The previous discussion describes how a single vertical scan line is generated. A full ultrasound image is made by stacking many scan lines side by side, next to each other. They are produced by a row of transducer elements that repeatedly create vertical scans one after another. With the use of 2-dimensional real-time ultrasound, a moving image can be produced that shows approximately 30 frames per second, or more.
Ultrasound Machines

Manufacturers are now designing ultrasound machines with consideration for the administration of anesthesia. Modern machines come in many different styles and designs and often include features that are not routinely used. Some are meant to be taken to the bedside where a block is to be performed, whereas other, less portable machines are better suited for use in “block rooms” in which the patient is brought to the machine.

Several “modes” of ultrasound are available. The mode most commonly used for nerve blocks is the 2-dimensional real-time mode; this can be combined with other modes, such as color and pulse width Doppler mode. Motion mode (M-mode) can be useful when a deeper probe is used to assess the function of the diaphragm after an interscalene block. The only absolute requirement for the combination of machine and probe is that it produce a readable image of the target area.

Ultrasound probes come in different sizes and produce differently shaped images, depending on the arrangement of the transducer arrays. The probe for a brachial plexus block should produce shallow images and thus should be in the range of 8 to 12 MHz. The choice of ultrasound machine and probes should be based on the needs of the practice.

Needle Approach Under Ultrasound Guidance

The ability to guide the needle quickly and safely to the nerve target begins with visualization of the position of the needle tip in the image. To consistently coordinate the positioning of the ultrasound probe and the needle to track the progress of the needle through the tissue, the operator must practice moving the needle within the scanning plane of the probe. Much has been written on the advantages and disadvantages of the different approaches of the needle, the scanning plane, and the target nerve.24,35 The differences in techniques involve the relationship of the probe to the nerve and the approach of the needle to the nerve. All the techniques are easy to practice, and the practitioner can adopt the most appropriate one.

The orientation of the probe and the needle to the target nerve can be organized by the relative alignment of the long axes of the elements. In other words, the long edge of the scanning probe can be aligned across or along the course of the target nerve, and the needle can be introduced across or in alignment with the long edge of the scanning probe.

There is some debate in the literature concerning the safety and effectiveness of the various approaches. Proponents of the individual variations all cite equally valid reasons. In the future, compelling arguments may be put forth in favor of one approach over another, but for now—as with many other techniques—the one preferred by the practitioner will be the safest. Different approaches for different nerve blocks or situations may be appropriate. The only needle approach that should be categorically discouraged is an oblique approach because one may lose track of the needle entirely.

The orientation of the face of the ultrasound probe can be either transverse (Figure 2) or longitudinal to the long axis of the nerve (Figure 3). These 2 planes have been referred to as transverse and longitudinal or, respectively, short axis and long axis.26 The orientation of the needle can be either transverse (Figure 4) or longitudinal to the long axis of the probe (Figure 5). To avoid confusion, these 2 orientations have been called out of plane (OOP) and in plane (IP).

When the IP needle approach is used (needle aligned with the face of the probe), a larger-gauge needle (eg, 18- or 20-gauge Tuohy needle) may be preferred because the needle artifact is more easily seen on the screen, which facilitates positioning. Table 5 lists key points in ultrasound technique.

Looking for the Needle: Deformation and Contrast

Locating the position of the needle in an ultrasound image depends on the orientation of the needle to the ultrasound probe. When the IP needle approach is used, most of the needle should be seen within the image; if it is not, the position of either the needle or the ultrasound probe should be adjusted. If the position of the needle is transverse to the plane or long axis of the ultrasound probe (OOP), some portion of the needle—preferably near the tip—should be crossing the plane of the probe. However, only a cross-section of the needle crosses the plane of the probe, which is a very small reflecting surface for the ultrasound energy, and thus the reflection of the needle in the image is very small. Depending on the angle at which the needle crosses the plane of the probe, there may not be a lot of reflection, even of the small surface available, which further hinders direct visualization of the needle. Rather than looking for the needle itself, the practitioner should identify the effect of the needle. As the needle is pushed through tissue toward the target under ultrasound guidance, tissue deformation is visible and evident over a much larger area than is occupied by the needle itself. The more substantial a tissue layer is, the greater the resistance to the needle that will be felt and seen on the image. For example, when a practitioner passes a short-bevel needle through muscle fascia while watching an ultrasound image, the bright echogenic band of the muscle fascia deforms and resists passage of the needle significantly before the needle finally “pops” through. This same cycle of “resistance and release” occurs repeatedly as the needle passes through tissue layers on its way to the target, with an intensity that depends on the thickness or density of the layers through which it is passing.

On a finer scale, location of the needle tip may be confirmed by injecting a small amount of contrast material, usually solution (local anesthetic) or air or both. Injection of 0.25 mL of local anesthetic solution is followed by the appearance on the screen of a dark, echolucent area. If a nerve stimulator is to be used, local anesthetic should not be injected because even a small amount near the nerve may cause it to become unresponsive to stimulation. Instead, a small amount of air may be injected.

Sometimes, forcefully aspirating with the syringe plunger while holding up the tip of the syringe will pull enough gas out of solution to create a bubble for use as contrast injection. Otherwise, a small amount of air can be injected down the needle while the screen image is watched. The air on ultrasound will create a “hard target”, the interface between the bubble of air and the fluid in the tissues will create a reflective surface that does not allow the passage of ultrasound energy, and shadowing out of structures beneath the bubble will be evident. If the ultrasound probe is aimed near the tip of the needle, an unmistakable localized defect in the image is created, which in turn indicates the location of the tip of the needle. Air injected in this way will dissipate quickly as long as the volume is smaller than 1 mL. Very small amounts of air are needed for this technique.

A more refined but time-consuming technique is to agitate saline solution with a small amount of air, essentially forcing more gas into cold solution. When the saturated solution is injected, gas is released from the solution and micro-sized bubbles create a foam—again easily spotted on ultrasound.

Table 5. Key Points Regarding Ultrasound Technique

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Develop a routine technique for the survey of</td>
<td>When the screen image is optimal, hold the ultrasound probe still. Movement of the probe changes the screen image.</td>
</tr>
<tr>
<td>every block.</td>
<td>Keep the target in view.</td>
</tr>
<tr>
<td></td>
<td>After introducing the needle beneath the skin, move it into the plane of the ultrasound probe as soon as possible.</td>
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<tr>
<td></td>
<td>When the needle is moving below the skin, attention should be fixed on the image.</td>
</tr>
<tr>
<td></td>
<td>When the needle is moving, the probe should be fixed.</td>
</tr>
<tr>
<td></td>
<td>When the probe is moving, the needle should be fixed.</td>
</tr>
<tr>
<td>If at any time track of the target or the needle is lost, the procedure should be stopped until the needle and probe are again lined up.</td>
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Another technique for locating the tip of the needle before or during injection, with or without contrast and/or tissue deformation techniques, involves use of the color Doppler feature on the ultrasound machine.

**Echogenicity: Recognizing the Nerves of the Brachial Plexus**

The roots or trunks of the brachial plexus are identified when an interscalene or supraclavicular brachial plexus block is performed for upper extremity surgery. The phrenic nerve is usually found along the anterior border of the anterior scalene muscle (Figure 6), but the location varies in a significant portion of the population. Scans of obese patients sometimes produce low-quality images that lack crisp resolution of structures and exhibit a “muddiness” of details, making both the brachial plexus and needle difficult to visualize. In such cases, it may be helpful to use a larger-gauge (eg, 20- or 18-gauge instead of a 22-gauge) needle.

Scans of the brachial plexus include interscalene and supraclavicular views. The interscalene view is determined anatomically. Soon after leaving their vertebral origins and forming the commonly seen trunks, the nerves of the brachial plexus are enveloped in a tissue sheath that extends to the axillary artery. As the trunks pass between the scalene muscles, the muscles press on them from both sides, causing a stacked arrangement of the trunks. The trunks of the brachial plexus pass at differing angles from the vertebral interspaces to the supraclavicular space; thus, an ultrasound probe oriented transversely to the long axis of one of the trunks will seldom be perpendicular to the others. Usually only 1 of the trunks (but sometimes 2) will appear as hypoechoic (dark) circles on the ultrasound image. Sometimes, only the most lateral trunk appears clearly at the most superficial edge of the interscalene border. Slight adjustments in the angle of the probe will usually reveal the other trunks.

**Scans of the Brachial Plexus in Obese and Normal-Weight Patients**

The supraclavicular view is seen after further division of the plexus. After passing between the scalene muscles, the trunks of the brachial plexus (still within the sheath and free of the lateral pressures of the muscles) form a roughly circular bundle lying along the superior and posterior aspect of the subclavian artery. The subclavian artery passes at a right angle to the lateral portion of the first rib, bordered in front by the insertion of the anterior scalene muscle and in the rear by the insertion of the middle and posterior scalene muscles.

The supraclavicular space is a landscape, with well-bordered areas for identifying the brachial plexus. The plexus bundle, in its sheath, lies like an extravagant wig or headdress on the posterior and superior aspect of the subclavian artery when it is viewed transversely in the supraclavicular space. The first rib below forms an extremely echo-dense floor on which the subclavian artery rests. With most ultrasound equipment, the glistening pleural layer is visible just below the rib. The cupola or dome of the lungs lies medial and posterior to this view. Ultrasound scans of obese and normal-weight patients and supraclavicular views of the brachial plexus appear in Figures 6 through 9.

**Perioperative Care of the Obese Patient**

When an obese patient is admitted for surgery, many factors must be considered, some of which relate to all patients but are exaggerated in obese patients. Because of reports of a high incidence of phrenic block and potential compromise of the respiratory system in morbidly obese patients, caution should be exercised before regional anesthesia is attempted. Patients whose history places them at risk for paralysis or compromise of the contralateral hemidiaphragm must be evaluated and, if warranted, excluded from an interscalene block technique. All of these patients must be considered at high risk for obstructive sleep apnea. For patients with relatively severe symptoms and histories, preoperative cardiology and pulmonary consultations should be considered. 12-lead electrocardiography should be specifically considered for those cases with a higher cardiac risk.

Obese patients are at higher risk for hypertension, cardiac disease, gastric reflux, and asthma, and they should be evaluated accordingly in a review of systems. Most routine medications should be continued into the perioperative period.

After a patient has been prepared for surgery and interscalene block, it is important to have a designated area where blocks can be routinely and quickly performed. An ultrasound-guided block can be accomplished with ease, and rapid onset of anesthesia will make the patient readily available for entrance into the operating room.

Postoperatively, patients should be made comfortable; they should spend only a short time in the postanesthesia care unit (PACU) or bypass it entirely. The opioid-sparing effects of the block serve to decrease problems with PONV. Although phrenic nerve block can result from an interscalene block, it rarely requires treatment in the PACU. Patients with obstructive sleep apnea may initially require a continuous positive airway pressure apparatus in the PACU.

If the patient’s condition is stable, without respiratory compromise and relatively pain-free, the patient can be discharged from the surgical unit. If significant pain is to be expected after the block has dissipated, admission of the patient for 24 hours should be considered because of problems associated with the excessive administration of opioids and airway compromise.

Because of the possibility of a late onset of phrenic nerve paralysis and nerve block (which has been described in case reports), patients should be counseled to inform the physician of any neurologic or respiratory changes that occur in the first 48 hours postoperatively and given a contact number to call.

**Future Directions**

Ultrasound guidance has introduced a reliability and precision to regional nerve blocks that heretofore was not possible. The ability to “see” beneath the skin and subcutaneous tissue and locate the essential nerves, vascular, and muscular structures has relieved the practitioner of the need to identify superficial landmarks to perform blocks.

Studies have already found advantages from the use of ultrasound in obese patients. It may be possible to further benefit this patient population with the administration of local anesthetic at volumes smaller than 20 mL and more precise placement of the anesthetic, thereby lowering the incidence of side effects, including phrenic nerve block. Techniques such as intraclavicular and supraclavicular blocks, which were at one time considered risky, may eventually be performed routinely and safely with ultrasound guidance. It is hoped that the newer ultrasound equipment will make these techniques even easier. The visual nature of ultrasound makes it an excellent tool for teaching via the Internet and gives practitioners the opportunity to aid one another in improving techniques.
Management of the Case Presented

On examination, the patient had an unremarkable airway, and despite the large size of her neck (45 cm), she had a normal range of motion. The remainder of the examination was noncontributory. Results of a preoperative chest X-ray were normal. Ultrasound examination of the patient’s neck and brachial plexus was carried out, and appropriate landmarks and nerve structures were easily identified in both the supraclavicular and interscalene regions. Both hemidiaphragms were surveyed with M-mode ultrasound and found to be intact and functioning. The procedure and its risks were discussed with the patient, and a regional technique for the shoulder surgery was planned.

On the morning of surgery, the patient’s blood glucose level was 166 mg/dL, and she received 4 units of insulin intravenously. An I.V. catheter was placed in the preoperative unit. The usual noninvasive American Society of Anesthesiologists monitors were applied. The patient received 2 mg of midazolam and 50 mcg of fentanyl during placement of the block. A brief ultrasound examination was performed to confirm the preoperative findings. The brachial plexus at the level of the interscalene muscles was easily identified, and an interscalene block was planned.

For the procedure, a 22-gauge, 2-in blunt needle and ultrasound guidance with a portable unit were chosen. The neck area was cleaned, and 12 mL of ropivacaine 1% was injected between the 2 most easily identified nerve roots at this level of the interscalene muscles. Little resistance was felt to the injection; the patient experienced a dull ache at the beginning of the injection.

The presence of local anesthetic in the region surrounding the nerve roots was confirmed with ultrasound, with no evidence of intraneural solution. Within a few minutes, the patient began to notice changes in her shoulder and arm movements. An ultrasound examination showed normal motion of the diaphragm. The patient was then taken to the operating room. After the placement of monitors and positioning of the patient (lawn chair position), a low-dose infusion of propofol (50 mg/kg per hour) was started. The area was tested for anesthesia, and the procedure began.

The procedure proceeded uneventfully, and the patient was brought to the recovery room after 90 minutes. She was comfortable and diaphragmatic movement was intact, as confirmed by ultrasound. She received no additional
analgesics in the recovery room. The patient was hospitalized overnight and discharged the next morning. The block had mostly resolved by the time of discharge (12 hours) and had completely resolved later that day. A single dose of oral acetaminophen and hydrocodone was administered at 10 hours following the block. She experienced some PONV overnight and received a single 12.5-mg dose of dolasetron with partial relief.

References
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