Regional Anesthesia - How to Make It Work

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Regional anesthesia has enjoyed a tremendous increase in popularity over the past two decades. The expanding involvement of anesthesiologists in the treatment of pain syndromes, the financial motivation to decrease hospitalization times, and the satisfaction for both patient and anesthesiologist are a few of the reasons for this increasing interest in regional anesthesia. Associated with the growing enthusiasm for regional anesthesia has been an incredible volume of published information on new techniques, drugs and adjuvants. The challenge for contemporary anesthesiologists is to provide regional anesthesia effectively and efficiently. This lecture will review practical suggestions on technique, anatomy and equipment, which will help make a more effective and efficient practice of regional anesthesia possible.

ADVANTAGES OF REGIONAL ANESTHESIA

There are many well-publicized advantages of regional anesthesia. Some of these reported advantages include decreased post-operative intensity of care, decreased incidence of nausea and vomiting, decreased recovery times, increased mobility and increased post-operative alertness.1-3 Recently published outcome data has suggested that patients undergoing regional anesthesia or regional anesthesia combined with general anesthesia may actually have decreased morbidity and mortality when compared with patient undergoing general anesthesia alone.4 One additional advantage of regional anesthesia is the potential economic savings. Using both actual costs and developed models of the cost of general and regional, Gonano and Greenberg analyzed the cost of performing anesthesia for each of these techniques. (Table 1) Regional anesthesia care was significantly less expensive than general anesthesia.5-6

Table 1. Cost of Anesthesia Excluding Personnel (Gonano)

	GA group	**SA group**	**P-value**
Anesthesia			
Supplies	34.5	27.0	<0.01
Drugs/Gas	51.5	16.8	<0.01
Subtotal	**86.0**	**43.8**	**<0.01**
Recovery			
Drugs/Supplies	3.6	2.6	<0.05

BARRIERS TO THE PRACTICE OF REGIONAL ANESTHESIA

Despite the potential advantages of regional anesthesia, these techniques were used in only 30% of anesthetics performed in the United States in the last decade7. Some of the barriers to the practice of regional anesthesia include a reluctance to invest valuable pre-induction time on regional techniques, the fear that a block may not work intra-operatively, or a lack of experience performing regional blocks on the part of the anesthesiologist. The goal of this review will be to address these specific barriers to the performance of regional anesthesia. We will review four areas of regional anesthesia—thoracic epidural catheters, spinal anesthesia for outpatients, arm blocks and leg blocks with an emphasis on the practical use of each of these techniques.

SPECIFIC TECHNIQUES

Thoracic Epidural Anesthesia—Epidural anesthesia is the most versatile and extensively utilized of currently available regional anesthetic techniques. It is used not only for surgery but also for obstetrics and in the management of both chronic and acute pain states. The vast experience most anesthesiologists have in the placement of lumbar epidurals can be easily translated to the thoracic area. Thoracic epidural anesthesia offers the post-operative benefits of enhanced pain relief and decreased use of systemic analgesics, improved pulmonary function and early extubation, early ambulation, as well as early return of GI function and fulfillment of discharge criteria.8

When performing thoracic epidural anesthesia it is important to note that the maximum angulation of the spinous processes occurs in the T4-T9 area. In this region the paramedian approach is often much more successful than the midline. Also, the distance of the epidural space from the skin varies widely. It is most commonly 4 cm (50% of the population) with the lumbar midline approach9. There is even more variability in the thoracic area with the paramedian approach. The actual space between the ligamentum flavum and the dura varies inversely to the content of the spinal canal. In areas where there are high densities of neural tissue (providing innervation to the upper extremities) the epidural space is narrow. Once the spinal cord ends, at L2, the epidural space widens. From L2 downward distances of 5-7 mm exist between the ligamentum flavum and the dura itself. In the midthoracic region measurements of 3-5 mm of dorsal epidural space have been made, whereas in the lower cervical region the distance may be 2 mm or less.

Thoracic epidural anesthesia may be performed with the patient in the lateral or sitting position. The spinous processes are identified and marked. An “X” is placed on the skin 1.5-cm lateral to the spinous process below the intended interspace. The needle is inserted perpendicular to the skin until it rests on the lamina or transverse process of the vertebral body caudad to the intended space. The needle is advanced upward and medially at a 45 to 50 degree angle and walked off the lamina into the interspace. Alternatively, the needle can be walked toward the midline until the base of the spinous process is contacted. At this point the needle is directed cephalad and advanced until the interspace is located. Shortly after the interspace is located, ligamentum flavum will be contacted. Loss of resistance is established just as in the lumbar epidural space, and the catheter should thread easily into the thoracic epidural space.

When dosing a thoracic epidural catheter, it is important to keep in mind the smaller size of the thoracic epidural space compared to the lumbar epidural space. Much less volume of solution is needed to spread several dermatome levels in the thoracic versus the lumbar epidural space. A good rule of thumb is to begin dosing with one half of the local anesthetic volume you would use to spread an equal number of dermatomes in the lumbar epidural space.

Many anesthesiologists are concerned about the incidence of complications when performing thoracic epidural anesthesia. A 1994 study published on the complications of over 40,000 lumbar and thoracic epidurals reported that the most common complication was failure to locate the epidural space in the first attempt (4.1%).10 All other complications including intravenous catheter placement (0.6%), paresthesia (0.2%), and intravascular injection (0.1%) occurred more frequently with lumbar than thoracic epidurals.

Spinal Anesthesia—The emphasis here, particularly for outpatients, is drug selection. Ideally local anesthetics would have an appropriate duration of action with an acceptable side effect profile and adjuvants would add to anesthetic efficacy without prolonging recovery. 5% hyperbaric lidocaine has long been the gold standard for short acting spinal anesthesia. Lidocaine has an optimal onset and duration of anesthesia for outpatients but also has the potentially unacceptable side effect of transient neurologic symptoms.11, 12 The incidence of TNS has been shown to be highest in outpatients versus inpatients and in patients undergoing surgery in the lithotomy or arthroscopy position (30% and 20% respectively). Because of the concern about the potential for the development of TNS many anesthesiologists are considering alternatives to lidocaine for short duration spinal anesthesia.

Currently available alternatives for spinal anesthesia in the United States include procaine, mepivacaine, bupivacaine and very low dose lidocaine or bupivacaine combined with an intrathecal narcotic. Procaine has an optimal duration of action for outpatient anesthesia and has been shown to have a lower incidence of TNS than lidocaine, but a higher incidence of nausea and block failure. Mepivacaine also has a lower incidence of TNS than lidocaine but a longer duration of motor and sensory block. Studies with low dose lidocaine (20-25 milligrams) and bupivacaine (5 milligrams) combined with fentanyl (20 micrograms) have shown the most promise for optimal discharge profiles with a decreased incidence of transient neurologic symptoms. Recent volunteer studies utilizing 2-chloroprocaine for spinal anesthesia suggest that this may ultimately be an ideal drug for outpatient anesthesia. 13-16

Arm Blocks—Brachial plexus blocks are the most extensively utilized peripheral nerve block technique. The advantages of brachial plexus block include less nausea, vomiting and airway intervention, and earlier discharge for outpatients, smooth transition to oral pain medications and increased blood flow to the extremity. The brachial plexus supplies all of the motor and most of the sensory function of the upper extremity. The descending branches of the cervical plexus supply the skin over the shoulder, and the intercostobrachial branch of the second intercostal nerve supplies the posterior medial aspect of the upper arm.

The brachial plexus begins with the anterior primary ramus of C5-T1. Once these nerves leave the intervertebral foramina, they form three trunks, which lie between the anterior and middle scalene muscles. The trunks leave the interscalene space and converge toward the upper surface of the first rib. At the lateral edge of the rib, each trunk divides into an anterior and posterior division, which enters the axilla. In the axilla, the divisions reunite to form the lateral, medial and posterior cords, which are named because of their relationship with the axillary artery. At the lateral border of the pectoralis minor, the three cords break up to form the peripheral nerves of the upper extremity. It is possible to block the nerves to the upper extremity at the level of the nerve roots (interscalene block), at the level of the nerve trunks (supraclavicular block), or at the terminal nerves (axillary block). The success rate of brachial plexus blocks can be increased by appropriate block selection for each procedure and by awareness of the onset time, advantages and disadvantages of each of the various techniques.

Axillary Block—The axillary nerve block takes advantage of the close relationship between the axillary artery and the peripheral nerves. This approach to the brachial plexus is associated with a very low incidence of complications and its utility for surgery of the hand, forearm and upper arm makes it clinically very appealing. Controversy over the best technique for axillary block remains unresolved. There is no conclusive data to support that one technique (perivascular, paresthesias, transarterial, nerve stimulator) may consistently be more "successful" than others.17
The block is traditionally performed high in the axilla, in the area where the axillary artery is most easily palpable.
One specific anatomic consideration for the axillary block includes the location of the musculocutaneous nerve. This nerve is responsible for the sensory innervation of a large part of the superior aspect of upper arm and is located very superior and posterior to the axillary artery between the biceps and the coracobrachialis muscles. The musculocutaneous nerve must be blocked very intentionally because of its distant location from the axillary artery in the axilla. The musculocutaneous nerve may be blocked with a separate injection either in the axilla or more distally in the arm. Lack of anesthesia in the distribution of the musculocutaneous nerve can be a significant cause of axillary block failure.
It is important to recognize that the axillary technique requires a 15-minute onset time. If a block is performed immediately prior to surgery, additional anesthesia or sedation may be required until the block has time to become established. If sodium bicarbonate is added to your local anesthetic solution (1cc for each 10cc or lidocaine, 0.1 cc for each 10 cc of bupivacaine) the onset time will be reduced, but only by about 3 minutes, thus supplemental sedation may still be required.
One final consideration for axillary block involves the use of the transarterial technique. When injecting behind the axillary artery in an attempt to block the radial nerve, it is important to note that the radial artery lies immediately behind and inferior to the axillary artery. If the needle tip is placed too deeply behind the axillary artery the local anesthetic solution will be injected intramuscularly, and the radial nerve will not be anesthetized. Thus the local anesthetic should be injected as close to the artery posteriorly as possible without injecting intravascularly.

Infraclavicular Block—The infraclavicular coracoid approach has several advantages for anesthesia of the upper extremity. This block can be performed with the arm in any position, only a single injection is required and the technique is better suited to continuous catheter placement than an axillary approach. Once the coracoid process is located, a point 2 cm caudad and 2 cm medial is identified. A 22 gauge-stimulating needle is directed perpendicular to all planes. Stimulation of the intrinsic muscles of the hand at a very low current (0.3mA) is needed for a successful block. The average depth from the skin to the neurovascular bundle is 4.2 cm in men and 4.0 cm in women.18 Approximately 50 cc of local anesthetic is required to completely anesthetize the upper extremity. This block provides excellent anesthesia of the hand, elbow and upper extremity exclusive of the area innervated by the intercostobrachialis nerve. This block appears to be one where the use of ultrasound guidance may significantly improve block efficacy.

Intrascalene Block— The most important factor in successful performance of the interscalene block is accurately identifying the groove between the anterior and middle scalene muscles. A common error when performing this block is beginning at the posterior border of the sternocleidomastoid muscle, and thus anterior to the interscalene groove. The block is performed at the level of the cricoid cartilage, utilizing either a nerve stimulating or paresthesia technique. The needle should be inserted in a caudad and posterior direction, angling toward the transverse process of the sixth cervical vertebrae. The needle should be perpendicular to the skin in all planes. As the needle is advanced either a paresthesia is obtained or the bone is contacted. If the tubercle is reached before the nerve, the needle should be withdrawn and redirected in an anterior to posterior plane. As with the supraclavicular block approximately 25-30 ml of local anesthetic is required to achieve anesthesia.
The interscalene block will provide excellent analgesia for shoulder surgery. Important considerations include the fact that the ulnar nerve is frequently not blocked with this approach, that the posterior shoulder will not be anesthetized (necessary for shoulder arthroscopy), and that general anesthesia with pectoral muscle relaxation may be needed for a Bankhart repair. The phrenic nerve is paralyzed 100% of the time.19 If the phrenic nerve is directly

stimulated during the performance of the block, remember that the phrenic nerve is located anterior to the anterior scalene muscle, and the needle should be repositioned posterior to the anterior scalene muscle

Leg Blocks—The motor and sensory innervation of the lower extremities arises from the nerve roots of the second lumbar through the third sacral spinal segments. The upper branches (L2-4) form the lumbar plexus, which divides into the lateral femoral cutaneous, femoral, and obturator nerves. These supply the upper leg, with a branch of the femoral (the saphenous nerve) extending medially below the knee. The lower roots (L4-S3) form the two major trunks of the sciatic nerve, the tibial and the common peroneal nerves. These provide the bulk of the innervation below the knee. We will review two blocks that are important for anesthesia of the upper leg.

Femoral Block–This block is easy to learn and perform, has a very low complication rate and provides terrific post-operative analgesia not only for outpatients undergoing anterior cruciate ligament repair but also for patients undergoing total knee replacement surgery.20 Thus it is an ideal technique for the anesthesiologist who is just beginning to learn regional anesthesia. The block is most successfully performed at the level of the inquinal ligament where the femoral nerve lies immediately lateral to the femoral artery. With the patient in the supine position, an "X" is placed immediately lateral to the femoral artery pulsation. After skin prep and local infiltration the needle is introduced perpendicularly. The nerve is identified at a depth of 2.5 to 6 centimeters. If a nerve stimulator technique is used, it is essential that the knee cap and quadriceps muscles be stimulated rather than the adductor muscles.

KEYS TO SUCCESS—Clearly familiarity with anatomy and block technique are the most important determinants of regional anesthesia success. Nonetheless, there are several organizational concepts that can help promote the efficient and effective practice of regional anesthesia.

1.While you are learning try to perform your regional anesthetics on the **1st case of the day**. This will give you additional time to perform the block without the pressure of knowing that the surgeons and operating room nurses are waiting on you. If the case that you want to do a regional technique for begins later in the day, prepare all your equipment during the previous case.
2.**Centralize your equipment**—Induction room, rolling cart or plastic bins are all acceptable ways to keep drugs, adjuvants, needles, and other equipment easily accessible. All supplies, including bicarbonate, syringes and tape for securing catheters should be in one place.
3.**Pick the right block**—Knowledge about the extent and limitations of each block is essential for appropriate block selection. For example, interscalene block is not a good choice for surgery of the hand because of the high incidence of ulnar nerve sparing, and sciatic nerve block is not appropriate for outpatients since they will not be able to ambulate safely until their block has resolved.
4.**Know the anatomy**—Familiarity with the relevant anatomy is the single most important factor for determining the success of regional anesthesia. Review the relevant anatomy for any unfamiliar technique prior to performing the block.
5.**Know the potential complications**—The 100% incidence of phrenic nerve paralysis with interscalene nerve block is a good example. This block may not be the best choice for a patient with pulmonary compromise.
6.**Pick the right patient**—Appropriate patient selection is a critical consideration for the safe and successful performance of regional anesthesia. Most patients accept the idea of regional techniques when they are reassured that they have the option of preoperative and intraoperative sedation. It may be inappropriate to perform regional anesthesia on patients with great anxiety, needle phobia, poorly controlled psychiatric disease or language barriers. The performance of regional anesthesia may be more technically difficult in obese patients or patients with severe arthritis or degenerative joint disease.
7.**Pick the right surgeon**—Pick the surgeon who is amenable to learning about the potential outcome benefits for his/her patient with regional anesthesia. Select a surgeon who may be willing to wait a few minutes for the outcome benefits to be realized.
8.**PACU Culture**—If there is a mandatory amount of time that patients are required to stay in the recovery room, it will be difficult to realize some of the benefits of regional anesthesia.
9.**Be confident**—Even if your blocks do not always work perfectly you always have the option of inducing general anesthetic or providing supplement sedation. Don't be afraid to try.

Anesthesiologists continue to learn about new drugs, equipment and techniques throughout their careers (laryngeal mask airways, fiberoptic intubation, and transesophageal echocardiography). Clearly, learning about regional anesthesia and performing these techniques in the fast paced operating environment is less than an ideal situation. However the potential advantages provided to patients by regional anesthesia clearly makes learning these techniques worthwhile.

REFERENCES

1.Parnass SM, McCarthy RJ, Back B. et al. A prospective evaluation of epidural versus general anesthesia for outpatient arthroscopy. Anesthesiology 1980; 73: A23.
2.Neal JM, Deck JJ, Lewis MA et al. A double blind comparison of epidural 2-chlorprocaine versus lidocaine for outpatient knee arthroscopy. Anesthesiology 1993;79:A12
3.Kopacz DJ, Mulroy MF. Chlorprocaine and lidocaine decrease hospital stay and admission rate after outpatient epidural anesthesia. Reg Anesthesia 1990; 15:19-25.
4.Rodgers A, Walker N, Schug SA, et al. Regional anaesthesia reduces postoperative mortality and morbidity: results from an overview of randomized trials. British Medical Journal 2000; 321:1-12.
5.Greenberg CP, Wald A, Roth JM. Cost conscious anesthetic choices for ambulatory surgery. Anesthesiology 1994; 81: A1202
6Gonano C, Leitgeb U, Sitzwoho C et al. Spinal Versus General Anesthesia for Orthopedic Surgery: Anesthesia Drug and Supply Costs. Anesth Analg 2006;102:524-9
7.Hadzic A, Vloka JD, Kuroda MM, et al. The Practice of Peripheral Nerve Blocks in the United States: a national survey. Reg Anesth Pain Med 1998, 241-6.
8.Liu S, Carpenter RL, Neal JM. Epidural Anesthesia and analgesia. Their role in postoperative outcome. Anesthesiology 1995;82:1474-506.
9.Bromage P. Epidural Analgesia. Philadelphia. WB Saunders, 1978, p. 197.
10.Tanaka K, Watanabe R, Harada T et al. Extensive application of epidural anesthesia and analgesia in a University Hospital: Incidence of Complications Related to Technique. Reg Anes and Pain Med 1993: 18;34-8.
11.Pollock JE, Neal JM, Stephenson CA, et al. Prospective study of the incidence of transient radicular irritation in patients undergoing spinal anesthesia. Anesthesiology 1996, 84:1361-7.
12.Freedman JM, Li DK, Drasner K, et al. Transient neurologic symptoms after spinal anesthesia. Anesthesiology 1998; 89: 633-41
13.Kouri ME, Kopacz DJ. Spinal 2-Chloroprocaine: A Comparison with Lidocaine in Volunteers. Anesth Analg 2004;98:75-80
14.Smith KN, Kopacz DJ, McDonald SB. Spinal 2-Chloroprocaine: A Dose Ranging Study and the Effect of Epinephrine. Anesth Analg 2004; 98:81-8
15.Vath JS, Kopacz DJ. Spinal 2-Chloroprocaine: The Effect of Added Fentanyl. Anesth Analg 2004;98:89-94
16.Na KB, Kopacz DJ. Spinal Chloroprocaine Solutions: Density at 37 C and pH Titration. Anesth Analg 2004, 98;70-74.
17.Goldberg ME, Gregg C, Lorijani GE, et al. A comparison of three methods of axillary approach to brachial plexus for upper extremity surgery. Anesthesiology 1987; 66:814-6
18.Wilson JL, Brown DL, Wong Gy et al. Infraclavicular Brachial Plexus Block: Parasagittal Anatomy Important to the Coracoid Technique. Anesth Analg 1998; 87:870-3
19.Urmey WF, Talts KH, Sharrock NE. One hundred percent incidence of hemidiaphragmatic paresis associated with intrascalene brachial plexus anesthesia as diagnosed by ultrasonography. Anesth Analg 1991; 72:498-503
20.Allen HW, Liu SS, Ware PD, et al. Peripheral nerve block improves analgesia after total knee replacement surgery. Anesthesia & Analgesia 1998; 87:93-7.