Anesthesia for surgery of the upper extremity can be accomplished safely and effectively by various methods. General anesthesia, brachial plexus block, intravenous regional anesthesia, and cervical epidural anesthesia all have their advocates. For upper extremity surgery in general, no single type of anesthesia has been demonstrated to be consistently safer or superior to any other type, and it is doubtful that this will ever change. Wide variations in surgical requirements, patients' desires and physiologic needs, and anesthesiologists' preferences all dictate that the choice of anesthesia is unique to every surgical situation. With this much variability, communication between patient, surgeon, and anesthesiologist is essential for selecting the best anesthetic for a particular circumstance. The information in this article is intended to enable the surgeon to more fully discuss anesthetic options with patients and anesthesiologists. Only brachial plexus blockade is discussed in detail because it is, by far, the most common choice of regional anesthesia for the surgical correction of Dupuytren's contracture. Intravenous regional anesthesia is not a suitable choice because of tissue staining caused by residual venous blood that is extruded when the anesthetic agent is injected. This staining can interfere with surgical exposure and dissection. Cervical epidural anesthesia provides both excellent operating conditions and prolonged pain relief and vasodilation; however, it is still infrequently used at present, and questions remain regarding its potential neurologic complications and its cardiovascular effects in older patients. This article, then, concentrates on the capabilities and limitations of the different types of brachial plexus blockade. It discusses the benefits of regional anesthesia and presents modifications of anesthetic agents and techniques that make it a safer and more effective form of anesthesia.

REGIONAL VERSUS GENERAL ANESTHESIA

Once the patient has been optimally prepared for Dupuytren's contracture surgery, the first anesthetic decision is to choose regional or general anesthesia. Physicians who prefer not to use regional anesthesia believe that regional anesthesia wastes valuable operating room time and, even in the best of hands, is frequently ineffective. They think that most patients do not want regional anesthesia and must be coerced or, at best, cajoled into permitting its use. Proponents of regional anesthesia, however, point out that regional anesthesia can also be a great time saver for a busy operating room. When anesthesia resources allow, upper extremity blockade can be safely performed in a properly equipped holding area between cases. With this advantage, the patients arrive in the
operating room with a complete block already established. If inadequacies in the block exist, peripheral nerve blocks can be added, or the team can proceed with a general anesthetic without waiting for the failed block to present itself.

Patient preference for regional anesthesia depends on past experiences, knowledge base, and the surgeon's attitudes. The literature is extremely limited on patient preferences. Thompson et al., in their series of 1,913 brachial plexus blocks, showed that of all patients having upper extremity surgery, one third chose regional anesthesia, one third chose general anesthesia, and the remainder were not committed and desired their surgeons to choose for them. Although it is primarily the responsibility of the anesthesiologist to educate the patient about anesthesia, the surgeon should also be involved. It is important that a positive attitude toward regional anesthesia be fostered in those patients who will benefit from it.

More patients would choose regional anesthesia if they knew more about it. Discussion of the following points during preoperative counseling is useful in informing the patient of the benefits of regional anesthesia:

1. There is no need for the loss of consciousness, which many patients find frightening.
2. Intravenous sedation is highly effective at reducing intraoperative awareness, anxiety, and recall.
3. There is no need for endotracheal intubation.
4. There is a reduced incidence of nausea, vomiting, and bowel and bladder dysfunction.
5. There may be less mental confusion following surgery, especially for older people. Mental status changes lasting for months or years have been reported following general anesthesia. Hole et al. found that 20% of patients receiving general anesthesia for total hip replacement had persistent postoperative mental status changes. No changes were found in patients who received epidural anesthesia. In a recent review, however, McLeskey discounts these findings and proposes that other factors such as magnitude and length of surgery have more effect on mental status changes than the type of anesthesia.
6. Because regional anesthesia outlasts surgery, there is more effective pain control in the immediate postoperative period, when it is most needed.
7. Discharge is usually earlier after using regional anesthesia in outpatient surgery.

For the patient to give an informed consent, the negative aspects of regional and general anesthesia should also be discussed (see complications). The information should always be presented in such a manner that the patient's confidence in either type of anesthesia is not undermined because general anesthesia will be used if the block is not successful.

There are other advantages to regional anesthesia that may be of more concern to the surgeon and anesthesiologist than they are to the patient:

1. Because anesthesia is limited to the surgical site, there is less disruption of the patient's physiology. Although there are no controlled studies to substantiate reduced morbidity and mortality, this reduction is highly suspected in certain high-risk patients with severe cardiac or pulmonary problems. There is also value in keeping patients awake so that problems such as angina, hypoglycemia, or cerebral insufficiency can be easily detected.

2. The degree of motor block during the operation can be selected to meet the needs of the surgery. Highly concentrated anesthetics produce a profoundly relaxed extremity. More dilute solutions, while still providing adequate anesthesia, will also allow the patient to move muscles and tendons on command. Dilute solutions, however, make for an anesthetic of shorter duration.

3. Upper extremity blocks cause a sympathetic block that produces vasodilation and increases blood flow to the fingers during the perioperative period. Blocks amenable to catheter placement can be maintained for prolonged periods and may be beneficial in replantation or microvascular surgery where vascular compromise may be present.

4. Patients requiring emergency surgery who have a full stomach avoid the risk of aspiration attendant with a general anesthetic.

5. Patients with airway difficulties can avoid the trauma of intubation; however, many anesthesiologists prefer general anesthesia for these patients and intubate them electively prior to induction. In this way, they avoid the possibility of an emergent intubation under less favorable conditions should a problem arise during or after the placement of the block.
CONTRAINDICATIONS FOR REGIONAL BLOCK

Not every patient is a candidate for regional anesthesia. Patients with a coagulopathy, psychosis, or progressive neurologic disease should not be considered unless the clinical condition clearly demands it. Injection through an area of infection or near an area of lymphatic drainage of an infection should also be avoided. Patients who are clearly frightened or otherwise reluctant to accept regional anesthesia should not be coerced. Finally, there are patients with peculiar or unstable personalities who may be difficult to work with or be unable to tolerate the operating room environment. These individuals can usually be identified by the surgeon, who should alert the anesthesiologist of their unsuitability.

BRACHIAL PLEXUS BLOCKS

Of the many regional anesthetic techniques available for surgery of the upper extremity, brachial plexus block is most frequently chosen for Dupuytren's contracture. The brachial plexus was first blocked in 1884 by Halsted, who used direct application of cocaine solution after surgically exposing the cords. A percutaneous technique was first described by Kulenkamp in 1911. Numerous techniques have subsequently been described, and the plexus can now literally be blocked anywhere along its course with varying degrees of success and choices of complications. The most common brachial plexus blocks in use today are the interscalene, axillary, supraclavicular, and subclavian approaches.

The underlying anatomic fact that allows blockade of the brachial plexus at these points is the existence of a single fascial sheath that envelops the plexus and its associated vascular structures. Proximally, as soon as the individual nerve roots emerge from their respective foramina at C5 through T1, they are sandwiched between the anterior and middle scalene muscles, which are themselves invested by a fusion of the prevertebral fascia. As the plexus passes distal to the scalenes, this fascia forms a tube that accompanies it through the axilla and into the distal third of the arm. Winnie credits Erikson and Scarby with demonstrating the patency and continuity of this "perivascular" sheath by injecting contrast material distally in the axilla and noting its spread up the sheath to the proximal structures.

Using a similar technique, Winnie defined the relationship between the volume of anesthetic agent used and the extent of the blockade to be expected at each of the three sites. For example, using the axillary approach, 20 mL does not extend proximally beyond the level of the coracoid process and should not be expected to block structures exiting the sheath early, such as the musculocutaneous or axillary nerves; however, 40 mL will spread consistently from the axilla to the first rib and will block the sensory and motor functions of the entire extremity. With 60 mL, the agent extends up through the interscalene space and provides a block of the cervical plexus. Conversely, using the most proximal approach, the interscalene technique, an injection of 20 mL of contrast material is seen to remain in the upper portion of the interscalene space. This amount will effectively block the lower cervical plexus and roots of the upper brachial plexus. Little diffusion is noted to reach the roots of the inferior brachial plexus. Consequently, anesthesia is usually absent in the distribution of C8 and T1. At least 40 mL is required to fill the proximal sheath enough to provide coverage of all the roots of the brachial plexus. Likewise, using the supraclavicular approach, 40 mL is also the volume required to consistently bathe the plexus. The amount will spread proximally to the interscalene space and distally into the axilla.

CAPABILITIES AND LIMITATIONS OF ANESTHETIC AGENTS

These anesthetic volume dose requirements for brachial plexus blocks become important to the surgeon when determining the amount of motor blockade and the duration of action required to complete the proposed surgery. Each of the commonly used anesthetic agents has its own unique characteristics and toxicity (Table 1). In general, those agents that provide dense, long-acting anesthesia are also the most toxic in the required dose. For short procedures re-
Table 1. Anesthetics Commonly Used for Brachial Plexus Blockade

<table>
<thead>
<tr>
<th>AGENT</th>
<th>ONSET (min)</th>
<th>DURATION (h)</th>
<th>MAXIMAL DOSE (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lidocaine</td>
<td>15-25</td>
<td>1-3</td>
<td>5 w/o epi</td>
</tr>
<tr>
<td></td>
<td>1.0%-1.5%</td>
<td></td>
<td>7 with epi</td>
</tr>
<tr>
<td>Mepivicaine</td>
<td>15-30</td>
<td>2-3</td>
<td>5.5 w/o epi</td>
</tr>
<tr>
<td></td>
<td>1.0%-1.5%</td>
<td></td>
<td>7 with epi</td>
</tr>
<tr>
<td>Bupivicaine</td>
<td>20-25</td>
<td>4-12</td>
<td>2.5 w/o epi</td>
</tr>
<tr>
<td></td>
<td>0.25%-0.5%</td>
<td></td>
<td>3 with epi</td>
</tr>
<tr>
<td>Chloroprocaine</td>
<td>15-20</td>
<td>0.5-1</td>
<td>11 w/o epi</td>
</tr>
<tr>
<td></td>
<td>2.0%</td>
<td></td>
<td>15 with epi</td>
</tr>
</tbody>
</table>

requiring little muscle relaxation, or for providing only a sympathetic blockade, dilute solutions of anesthetic agents are adequate, and even larger volumes than 40 mL may be safely given. For a dense, long-lasting block, 40 mL doses of the most concentrated anesthetic may come close to or exceed the seizure threshold for some patients. To avoid this problem, clinicians have looked for ways to decrease the toxicity of anesthetic agents or to increase their effectiveness.

**IMPROVING ANESTHETIC AGENTS**

The addition of a vasoconstrictor such as epinephrine or neosynephrine to certain anesthetic agents both decreases the toxicity and lengthens the duration of action. In a 1:200,000 concentration (5 μg/mL), epinephrine decreases the rate of uptake of the agent from the tissues, thereby both allowing a larger initial dose and prolonging the length of block. Furthermore, the addition of epinephrine may help to avoid intravascular injections by producing a sentinel tachycardia from a small test dose. Care must be taken in patients with coronary artery disease, however, because cardiac output has been noted to increase 20% after brachial plexus blocks with 1:200,000 epinephrine because of the systemic uptake of the epinephrine.

Anesthesiologists have also tried various mixes of agents, usually an amide with an ester (tetracaine with carbocaine, chlorprocaine with bupivicaine), hoping to decrease their combined toxicity while obtaining the presumed advantages of both. Although studies attempting to substantiate the value of such mixtures have been largely contradictory, their use is wide-spread and continues to gain considerable anecdotal support.

The use of heavy premedication with barbiturates or benzodiazepines has been advocated to raise the seizure threshold and allow the use of larger doses of more concentrated agents. This action has been criticized by others who claim that diazepam merely masks the initial signs of central nervous system toxicity while having little effect on the seizure threshold.

The use of an indwelling catheter in the brachial sheath is a mechanical method of improving the duration of brachial plexus blockade. The ability to give repeat injections through the catheter allows the use of less concentrated and shorter-acting agents. Smaller doses of agent can be used, and the doses can be given incrementally over a longer time, thereby keeping plasma levels low. The catheter can be left in the sheath as long as surgical anesthesia, postoperative analgesia, or vasodilatation is desired. Although a catheter cannot be used for an axillary block when a tourniquet is needed for surgery, the technique can be used in the supraclavicular or subclavian approaches. The indwelling catheter technique, however, is more difficult to perform than the needle technique and is not widely used.

**DECREASING LATENCY TIME**

One of the major criticisms of plexus anesthesia is its prolonged latency time. Onset of complete surgical anesthesia routinely takes 20 minutes and may take up to 1 hour. Several methods have been attempted to intensify anesthetic agents so that smaller concentrations would provide quicker and denser anesthesia. Additives such as KCl and dextran have been marginally successful, and have largely been abandoned. Carbonization and the addition of sodium bicarbonate are two methods that have recently received attention and a resurgence of popularity.

**CARBONATED ANESTHETIC AGENTS**

In 1971, Bromage demonstrated that in brachial plexus blockade, the use of 2.2% carbonated lidocaine (lidocaine in which carbon diox-
ide had been dissolved) decreased latency time by 42% when compared with the usual commercial preparation of an equally potent lidocaine hydrochloride. Sukhani and Winnie repeated the study in 1987 using the subclavian technique and equipotent concentrations of 1.1% lidocaine carbonate and 1% lidocaine hydrochloride, which are more consistent with recommended dosage. Epinephrine, 1,200,000, was added to both solutions immediately prior to injection. The latency of anesthesia to distal distributions of C8 and T1 was reduced by 45% from 18 minutes to 10 minutes. The density of the block produced by the carbonated lidocaine was greater, and produced complete motor block in 54% of the patients compared with 31%. The duration of the block was not affected.

The mechanism of action by which carbon dioxide enhances the diffusion of the anesthetic base across the neural sheath is not understood. The increased intensity of the motor and sensory block can be explained by the phenomenon of “ion trapping.” When the carbon dioxide dissociates from the anesthetic base, it rapidly diffuses across the neural membrane and produces a drop in the intracellular pH. This ionizes the uncharged free base that has diffused across the cell membrane. These newly ionized cations cannot easily move back across the membrane as they would ordinarily in their uncharged form. The lowered intracellular pH therefore provides for a one-way trip and thereby concentrates the cations within the cell. Because only the cationic form of the anesthetic is active, this trapping action produces a concentration of the active anesthetic at the intraneuronal receptor sites. Sukhani and Winnie also propose a direct stabilizing effect of carbon dioxide on the nerve membrane itself.

In a separate study, Sukhani and Winnie also demonstrated that using a carbonated lidocaine agent with the interscalene approach is effective in increasing the spread of block as well as in decreasing the latency time. Lidocaine carbonate produced surgical anesthesia of the entire upper extremity in 87% of the cases as compared with 53% with lidocaine hydrochloride.

ALKALINIZATION OF LIDOCAINE

An alternative to using carbonated lidocaine, which is not readily commercially available in the United States and is difficult to prepare by the user, is the use of pH-adjusted or “alkalinized” lidocaine. The first clinical report of decreased latency time after alkalinization was by Gross in 1910. In 1983, Galindo noted that when local anesthetics were alkalinized to a physiologic pH of 7.0 to 7.4 with sodium bicarbonate, there was a shortening of the latency time and a prolongation of anesthesia. DiFazio et al next compared different mixtures of lidocaine used for epidural anesthesia. Concentration varied from 1.37% to 1.5%, and pH varied from 4.6 to 7.2. The latency times for the pH-adjusted mixtures were significantly less, and the final spread of anesthesia was greater. The effect was more pronounced in those mixtures in which the pH was higher and the concentration greater. DiFazio et al noted that in a salt solution such as a local anesthetic, raising the pH was the effect (predicted by the Henderson-Hasselbach equation) of increasing the percentage of nonionized base and decreasing the ionized form. By changing the pH of lidocaine from 6 to 7, the percent of nonionized base changes from approximately 1% to 11%. The nonionized base is much more lipid soluble and easily penetrates the nerve membrane. Once it is in the cells, dissociation to the active ionized form takes place (to a degree depending on the intracellular pH) and the anesthetic action begins.

Increasing the pH of an anesthetic solution, then, promotes greater and more rapid diffusion across the cell membrane by increasing the lipid soluble fraction of the anesthetic agent. Commercial anesthetic agents, especially those that contain epinephrine, are all acidic in order to maintain solubility and stability in transport. A faster-acting lidocaine solution can be prepared by using commercially available lidocaine and adding epinephrine, 5 µg/mL, and sodium bicarbonate, 1 mEq/10 mL, immediately prior to the injection.

ALKALINIZATION OF BUPIVCAINE

Although lidocaine with epinephrine is fast acting, its use is not appropriate for many procedures because of its moderately short duration of action (approximately 2 hours; Table 1). Bupivacaine, 0.5%, has a much longer duration (4 to 12 hours); however, its disadvan-
tages are that it has a much longer latency time and that it is more toxic. The recommended dose is limited to 3 mg/kg. Bupivicaine is cardiotoxic and may cause cardiac arrest at higher doses. Attempts to improve the performance of bupivicaine by increasing its pH have been inconsistent. Hilgier compared brachial plexus (subclavian technique) bupivicaine with epinephrine at pHs of 3.9 and 6.4 and found that the onset was faster and the duration prolonged. Bedder et al repeated the study using bupivicaine without epinephrine at pHs of 5.5 and 7.1 and found no clinical advantage of adjusting the pH. Alkalinization of bupivicaine may cause precipitation and should be limited to the addition of 1 mEq of sodium bicarbonate per 20 mL of prepared solution. The chance of precipitation and the uncertain advantages of pH-adjusted bupivicaine make it an uncommonly used agent among most anesthesiologists.

EXERCISE

Okasha et al reported that exercise decreases latency. Using 1.5% lidocaine and supravacular blocks, he studied the effect of postinjection exercise on the speed of onset of sensory and motor block. After a 25-mL injection of 1.5% lidocaine, subjects were required to open and close their hand in a rapid and forceful manner for 5 minutes. The time required for the onset of analgesia for the control group and the exercise group was 14 and 6 minutes, respectively. Time required for complete motor paralysis for the groups was 29 and 13 minutes, respectively. The duration of block was unchanged. Okasha theorizes that the charged ionic form (the active form) of the anesthetic agent is permeable to the nerve sheath primarily through the open sodium channel and binds more strongly to the closed than the open conformation. Hand movements cause repetitive opening and closing of the channels, thereby providing intraneural access to the charged form. Okasha notes that exercise is a cheap, effective, and safe method to enhance the onset of local anesthetic action. Such a method deserves further study and comment.

CHOICE OF BLOCK

The choice of brachial plexus block depends on the site of the proposed surgery and individual patient characteristics. Blocks at different sites predictably block specific nerves more regularly than others. Lanz et al used a 50-mL volume of bupivicaine at the interscalene, supravacular, subclavian, and axillary approaches, and noted the resulting sensory and motor blockade (Table 2). Sensory blockade was determined using a sharp, dull, or absent pinprick rating system and, therefore, cannot be considered to be equivalent to surgical anesthesia. The following observations were made and are consistent with the practice choices of experienced anesthesiologists.

1. The interscalene technique blocks the lower cervical and upper brachial roots more frequently and should be used for surgery of the clavicle, shoulder, and upper arm.

2. The supravacular and subclavian approaches block all the nerves of the brachial plexus equally and can be used effectively for surgery on the upper arm, elbow, forearm, and radial aspects of the hand.

3. The axillary approach predictably blocks the lower segments of the brachial plexus and is a good choice for surgery of the forearm and hand, especially in the median and ulnar distribution.

Of the four choices mentioned, only the

<table>
<thead>
<tr>
<th>Approach</th>
<th>Nerves Blocked</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Supravacular</td>
</tr>
<tr>
<td>Axillary</td>
<td>15</td>
</tr>
<tr>
<td>Interscalene</td>
<td>90</td>
</tr>
<tr>
<td>Subclavian</td>
<td>45</td>
</tr>
<tr>
<td>Supravacular</td>
<td>30</td>
</tr>
</tbody>
</table>

Anesthesia for Dupuytren's Contracture

The interscalene approach would appear not to be an acceptable choice for anesthesia for Dupuytren's contracture. Sukhani and Winnie\textsuperscript{26} contend that when using carbonated lidocaine, the spread is extended so that even surgery on the hand can be successfully performed. Kuflik et al\textsuperscript{13} successfully used commercially available lidocaine and bupivacaine for interscalene blocks for surgery of the hand in patients with rheumatoid arthritis who were not able to abduct their arms far enough to allow placement of the axillary block needle. They reported that satisfactory anesthesia was obtained for various procedures on the arm and hand and that 3 of 4 Dupuytren's contractures were successfully relieved by using a larger volume of agent and supplementing with a separate block of the ulnar nerve. They also noted that because it is performed proximal to the axillary lymph nodes, it can be used in the presence of infection or malignancy.

### SUCCESS RATE

It is difficult to establish an accurate estimate of the success rate of the various approaches to the brachial plexus. Because each study or review has its own variable to examine or criteria by which to judge success, comparison is often murky. Additionally, the level of experience of the physicians is often not clear, and the site of surgery is not always the most appropriate choice for the block. Most authors report a success rate of approximately 80\% (Table 3). Success usually means that the proposed surgery was completed without resorting to supplementary nerve blocks or general anesthesia.

Efforts to improve success rates with peripheral nerve stimulators generally have not been successful.\textsuperscript{5, 10, 12} Although many clinicians advocate their use and obtain excellent results with them, their popularity is decreasing. With the axillary approach, the nerve stimulator has the same success rate as the transarterial nonparesthesia technique or the technique in which paresthesias are elicited by the needle tip only.\textsuperscript{10, 30} The experience and skill of the practitioner who performs the block and selects the correct site for the block are more important than the technique used.

### SUPPLEMENTARY NERVE BLOCKS

The only generally accepted method of decreasing the rate of failed blocks is the judicious use of supplementary peripheral nerve blocks. In separate reviews, Schuind et al\textsuperscript{21} and Thompson et al\textsuperscript{27} salvaged more than 10\% of their blocks with one additional peripheral block. The rate of failure to block a particular nerve can be approximated from Table 2. Because brachial plexus blocks are slow to set up, an inadequate block is frequently not recognized until after the patient is draped and prepared for the surgery. At this point, it is generally the responsibility of the surgeon to augment the block. Median, radial, and ulnar nerves are accessible at the wrist or elbow. The musculocutaneous nerve can be blocked as the nerve pierces the coracobrachialis muscle. These blocks are described in detail in standard anesthesia texts.

Tourniquet pain can be a problem when the upper arm is not adequately anesthetized. Winnie\textsuperscript{26} reports success in decreasing tourniquet pain by blocking the intercostal and medial brachial cutaneous nerve in the axilla. Even in blocks in which the patient feels no discomfort from the surgery, tourniquet pain can be so severe that general anesthesia must be induced.
COMPLICATIONS

It is an unfortunate fact of medicine that, even in the best and most careful of hands, complications invariably occur. Patients must be informed of the potential complications they face when undergoing regional anesthesia. They should understand that the presence of a complication does not necessarily imply that the block was performed improperly or negligently. Patients who have been properly informed of the risks are more likely to accept poor outcomes than those who have not been adequately counselled. How much detail is necessary for adequate counseling is a matter of judgment and should be individualized for each patient.

The most common risks of regional anesthesia include the following:

Failed or Incomplete Blocks

These blocks require supplementation of general anesthesia. Details have been discussed already.

Allergic Reactions to Anesthesia

Reactions to amides (lidocaine, mepivacaine, and bupivacaine) are extremely rare. Reactions to esters (chloroprocaine) are more common and are attributed to para-amino benzoic acid (PABA), an ester metabolite. Patients who are sensitive to PABA-containing sunscreen agents should not receive ester anesthetic agents. Many more patients give a history of being allergic to “all the caines” than who actually are allergic to them. A careful history can usually elicit previous symptoms of tachycardia and anxiety, especially following dental injections. These symptoms do not constitute an allergic reaction, but instead are due to rapid vascular uptake of epinephrine-containing agents. Reports of urticaria, rash, flushing, hives, wheezing, and hypotension are more ominous. Although such reactions may result from preservatives in the agent rather than the agent itself, there is no reliable way to make such a determination. Skin testing is not a useful method of determining local anesthetic allergies and may, in itself, be fatal. If it is decided to proceed with the use of local anesthetics in a patient with a questionable allergic history, an amide agent without preservative should be used, and the patient should be prophylactically pretreated with $H_1$ and $H_2$ histamine antagonists.

CNS or Cardiovascular Reactions to Anesthetic Overdose

Careful attention to recommended doses provided in Table 1 will decrease the likelihood of such reactions occurring simply from normal vascular uptake from the tissues. The risk of accidental intravascular injection is always present because of the close approximation of the arterial and venous system within the same sheath that contains the plexus. The first signs of overdose toxicity are tinnitus, metallic taste, and circumoral numbness. These may or may not be reported after a test dose when the agent is deposited intravascularly. If the serum concentration of agent continues to rise, confusion and dysarthria follow. CNS irritability is seen next. Twitching of small facial and digital muscles may be followed by a frank seizure. Treatment varies depending on the patient’s physiologic requirements and ranges from merely supporting ventilation with mask oxygen, to induction of general anesthesia with endotracheal intubation. Intravascular injection of a sufficient quantity of bupivacaine is followed by cardiovascular collapse, and possibly asystole, which requires especially intensive and prolonged resuscitative efforts. The transarterial axillary block technique in which the axillary artery is pierced by the needle and the agent is deposited on one or both sides of the artery has not been associated with a higher rate of CNS complications.

Hematoma

Hematomas are infrequent and rarely cause significant sequelae in patients with normal clotting mechanisms. Anti-coagulated patients or patients with prolonged bleeding times are at risk, however. Normal clotting studies should be obtained prior to the block, even when the patient is receiving only prophylactic doses of subcutaneous heparin.
Neural Damage

Mechanical and chemical trauma have been implicated in neural damage. The technique in which paresthesias are purposefully elicited has been implicated by Selander et al.\textsuperscript{23} who compared the transarterial approach to the paresthesia-seeking approach in performing axillary blocks. They reported an exceptionally high 2.8% rate of transient neurologic sequelae from the paresthesia method compared with a 0.8% occurrence with the transarterial approach. To most clinicians, Selander's rate seems very high. In a more comforting review of 1,913 brachial plexus blocks in which paresthesias were also sought, Thompson et al.\textsuperscript{27} reported an occurrence of only 3 cases of neural damage, none of which required treatment. In general, searching for paresthesias appears to be safe when appropriate care and equipment are used. Recommendations include the use of short-beveled needles that are less likely than the long-beveled needles to cut or spear the neural structures.\textsuperscript{24} The "immobile needle" technique should also be used.\textsuperscript{29} In this technique, the needle is not directly attached to the syringe but, instead, is attached indirectly by means of a length of intravenous extension tubing. The syringe is handled by an assistant, and the anesthesiologist has both hands free to position and immobilize the needle. Finally, if intense pain upon injection is noted, intraneural injection should be suspected, and the needle should be repositioned.

Chemical neuritis most frequently results from the accidental use of anesthetic agents that contain preservatives such as methylparaben. Because these agents are intended only for local field blocks and are not always clearly labeled, care must be taken to ensure that the correct agent is used. Raggi\textsuperscript{19} notes transient chemical neuritis resulting from the use of high concentrations of bupivacaine with epinephrine.

Pneumothorax

Although possible with other approaches, pneumothorax most frequently results from the supraclavicular approach. Estimates of frequency range from 0.5% to 6% and decreased as the experience of the anesthesiologist increased.\textsuperscript{2} Pneumothorax results from a small tear in the visceral pleura and the slow escape of air into the intrapleural space. Symptoms do not generally appear for 2 to 6 hours and may take up to 24 hours.\textsuperscript{29} Most do not require treatment. Thompson et al.\textsuperscript{27} reported the occurrence of ten pneumothoraces in 1,248 supraclavicular blocks (0.8%). All were admitted for observation, but only 4 required chest tube placement. Whether more pneumothoraces would be discovered if all patients received chest roentgenograms after 24 hours has not been determined. The disadvantages of supraclavicular or subclavian blocks in patients with emphysema or other pulmonary problems may outweigh the advantages.

SUMMARY

Despite the potential complications of brachial plexus blockade, it remains a reliable and safe form of anesthesia for surgery of the upper extremity. The site of the surgery dictates which of the four approaches to the brachial plexus should be used. When the choice matches the site of surgery, the blocks should be successful in approximately 80% of cases. When supplemented with an additional peripheral block, the success rate is greater than 90% using the axillary and supraclavicular approaches. The duration of the blocks varies from 1 to 12 hours, depending on the choice of anesthetic agent. The addition of epinephrine to the anesthetic agent decreases the rate of tissue uptake of the drug, thereby both lengthening the duration of the block and decreasing the toxicity of the agent. Alkalinizing lidocaine with sodium bicarbonate decreases the latency time and increases the intensity and spread of the block. Surgeons should be aware of the advantages and capabilities of regional anesthesia and should discuss anesthesia options with patients and anesthesiologists.

REFERENCES


6. Cunningham NL, Kaplan JA: A rapid onset long acting regional anesthetic technique. Anesthesiology 41:5090, 1974


Address reprint requests to
Charles L. Gandy, MD
Department of Anesthesia
Arlington Hospital
1701 North George Mason Drive
Arlington, VA 22203
Comment on "Anesthesia for Dupuytren's Contracture"

This article is an extremely comprehensive, authoritative and well-informed contribution to the literature on upper-limb anesthesia. Encyclopedic in its compass, there is very logically an early banishment of other forms than regional anesthesia, leaving the reader then to assess the relative values of the various forms of brachial plexus blockade to obtain the optimal conditions for the surgery of Dupuytren’s contracture.

Intravenous regional anesthesia has often lured hand surgeons by its technical simplicity into a “do-it-yourself” situation, but this technique is here dismissed out of hand. This dismissal is to be commended additionally because it will avoid the precipitous discharge of a patient after the instant recovery of sensation after tourniquet release. Postoperative observation for several hours is essential after Dupuytren’s contracture surgery.

Too good to shorten editorially, this article may need to be interpreted by its surgical readers to allow better appreciation of the axillary approaches. Thus, it is to be hoped that catheterization for long-duration administration will not be needed for Dupuytren’s contracture surgery, most of which is completed in 1 to 2 hours. A light general anesthetic by mask may be added to gain time for the final phase if necessary. Skin grafts taken from other parts, such as the groin, will of course need quite separate local anesthetic injections.

Heavy premedication is not wise because not only does the anesthetist often need the patient’s cooperation in reporting paresthesia with some techniques, but also the surgeon may need to discuss some details immediately before entering the operating room. Perioperative diazepam comforts most patients quite safely and the surgeon as well if the patient becomes too talkative.

A brief review is warranted of the very real advantages of regional over general anesthesia for this type of hand surgery. It can be made effective in almost every instance if peripheral (distal) nerve blocks are judiciously added. It is safe in ill and elderly patients who can be encouraged to breathe oxygen or move legs during surgery. It minimizes the delay between operations by the use of holding rooms where more than one patient can be given the regional blockade, with its necessary time to work, while the surgeon is finishing his previous procedure. Personal experience of using two adjacent operating rooms and the routine use of brachial plexus blockade by experienced anesthetists literally eliminated change-over delay for the surgeon, who could pass directly from one completed operation to the next patient fully prepared in the next operating room without delay.

The peaceful postoperative phase with no possible finger movements during recovery means that the risk of haematoma is minimized. There is minimal general physiologic aftermath, but beware of too early a discharge from the hospital because a pneumothorax after a supraclavicular block is a real, if rare, risk.

Actual neural damage is extremely rare with axillary block but was not unknown in the supraclavicular approach when the trainee anesthetist was taught to feel for the first rib with the needle tip! Of course, it was not difficult then to imagine a fine needle point becoming slightly bent by this contact and, on being withdrawn across or through a nerve trunk, inflicting actual fascicular lacerations and a permanent intraneural scar. This damage caused
neuroma pain, often to a disabling degree, with clinical wasting of the intrinsic muscles of the hand over the ensuing months.

It is the clear conclusion of this article that interscalene blockade is not advisable for Dupuytren's contracture surgery and that supraclavicular blockade has a slightly but sufficiently greater risk of complications than does the axillary approach. Hence, axillary brachial blockade, with or without supplementary peripheral ulnar and sometimes median nerve block, is the anesthesia of choice for Dupuytren's contracture.

JOHN T. HUESTON, MD
Guest Editor