To
John Edward Steinhaus
Mentor and Friend
For some readers, the title of this book will immediately raise the question: Why construct a textbook that deals solely with complications? To answer this inquiry, we must refer to the maxim that each of us was taught on the very first day of our medical training: *Primum non nocere*. The discipline of regional anesthesia has seen a major expansion in the last 20 years as a result of better understanding of human anatomy and physiology, and the availability of sophisticated and reliable technology. More and more enthusiastic clinicians apply different regional techniques with great skill and the intention to provide satisfactory anesthesia and analgesia for more than merely the time of surgery. However, such accomplishments may be commended only if associated morbidity is minimized.

Dr. Brendan Finucane is both an accomplished clinician and able teacher who has devoted his career to the advancement of safe regional anesthesia. Who better than him to be charged with the task of assembling a group of fellow illustrious experts to dissect this subject? Regional anesthesia has a very safe record, as is shown in this book. Nevertheless, Dr. Finucane and his colleagues challenge our assurance of these laurels, reminding us that there is no space for complacency because any bad outcome can be disastrous for the patient, family, and medical community. In this book, every aspect of the practice has been scrutinized, with an emphasis on educating the reader to the potential risks associated with frequently performed techniques. I have no doubt that this collection will continue to be the major source not only for the anxious trainee, but also for the experienced and seasoned clinician, who will welcome the wealth of information it provides on every provision of regional anesthesia.

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In 1999, Churchill Livingstone published, what I thought was the first text on *Complications of Regional Anesthesia*. I was subsequently reminded by Daniel C. Moore that Charles C. Thomas published a book with an identical title in 1995. Dr. Moore generously forgave me for this oversight and provided me with a signed copy of his book which I will always treasure. By the time this edition is complete, eight years will have elapsed since my first edition, and there have been some interesting new developments in regional anesthesia in the intervening period.

What is new about this edition? The contents is expanded by approximately 20% and includes four new chapters along with updating of all the existing ones. The chapter on central neural blockade has been split into two separate chapters, *Complications Associated with Spinal Anesthesia* and *Complications of Epidural Anesthesia* and I have included a new chapter on prevention, *Avoiding Complication of Regional Anesthesia*. The final chapter is entitled *Medicolegal Aspects of Regional Anesthesia* and is quite a provocative treatise on this important topic. Once again I have made an effort to invite individuals from all over the world to be part of the volume, and my success in that goal is in part highlighted by the inclusion of a dedicated chapter, *International Morbidity Studies on Regional Anesthesia*. This section features the perspective of authors from Canada, the United States, Scandinavia, and France.

Reflecting our primary goal as clinicians, the most consistent theme throughout the book is prevention of complications (most of which can be anticipated) and ensuring the highest quality patient care. We, the authors of the chapters, have stressed the importance of proper patient selection, thorough preoperative evaluation, meticulous attention to sterile technique, and careful, deliberate handling of the needle. We emphasized the importance of knowing when to stop. We stressed the importance of patient comfort. The purpose of the exercise of regional anesthesia is defeated if, in the process of performing these techniques, the patient is injured.

In a book of this nature, repetition is difficult to avoid; however, in the process of editing this text I did my best to minimize duplication. Even when there was repetition, the various contributors stressed different aspects of the topics presented. The book is extensively referenced and quite inclusive and up to date. It is my hope that the text will be found extremely useful, and I always welcome the constructive feedback of my colleagues.

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April 2007
I would like to express my deep gratitude to all of the contributors to this text. I am impressed by the quality of the material presented and their willingness to abide by all of the rules imposed. I would like to thank Beth Campbell for her editorial assistance during earlier phases of this project and Stacy Hague and Barbara Chernow for their assistance during the final phase. I thank Patricia Crossley and Marilyn Blake for assisting me with this effort. I thank my illustrator Steve Wreakes for his timely response to my many requests to reproduce illustrations. Last, but not least, I thank my wife Donna who tolerated my solitude for many months as I toiled to complete this project.

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The author of this chapter, Professor John McIntyre (Figure 1-1), is unfortunately no longer with us. He died tragically in a pedestrian accident, very close to the University of Alberta Hospital and to his home, in the spring of 1998.

When I contemplated a second edition of this book, I read his chapter again very carefully and I was just as impressed as I was when I read his first draft. First of all, he is an excellent writer; second, there is great wisdom in his words. He really understood our discipline and even though he did not claim any great expertise in regional anesthesia, he understood the issues better than most people. Even though 8 years or so have gone by since the first edition, Professor McIntyre’s contribution is by no means outdated; therefore, I had no hesitation including this chapter in the new edition. Those of us who knew John well miss his humor, enthusiasm and zest for life, and his constant thirst for new information. I took the liberty of making some minor editorial changes to the text with permission from his family. Each time I read his chapter, I learn something new from it.

Professor McIntyre walked the halls of the University of Alberta Hospital for close to 50 years, where he taught 10 generations of residents. He touched the hearts and minds of many people and his influence transcends time.

Respectfully,
Brendan T. Finucane, MB, BCh, BAO, FRCA, FRCPC

Every patient wishes to receive anesthesia care that is safe, in other words, “free from risk, not involving danger or mishap; and guaranteed against failure.” The anesthesiologist will present a more realistic view to the patient. The personal view of the hoped-for care will be one in which the clinical outcome is satisfactory and has been achieved without complication (defined as “any additional circumstances making a situation more difficult”) because performance has deviated from the ideal. By this standard, most deviations are trivial or easily corrected by a perfect process, and outcome for the patient and a reasonably stress-free life for the carers are objectives for all anesthesiologists.

The general objective here is to provide information that helps the clinician to minimize complications that may be incurred during the course of regional anesthesia practice. This information is presented under the following headings:

• Complication anticipation
• Equipment
• Behavioral factors and complications

† Deceased.
Complication Anticipation: Recognizing Precipitating Factors

The Preanesthetic Visit: Patient History

Some anesthesiologists have a preconceived plan for regional anesthesia before they visit the patient; others gather information before considering what method of anesthesia is appropriate. The following paragraphs about the relationship between regional anesthesia and pathology are intended to aid recognition of potential complications for the patient under consideration and planning of anesthesia to avoid them.

The Nervous System

Fundamental issues to be settled during the preoperative visit are how the patient wishes to feel during the procedure and the anesthesiologist’s opinion of how well the patient would tolerate the unusual sensations, the posture, and the environment. Whatever decision is made about pharmacologic support, it is absolutely essential that every patient has a clear understanding of reasonable expectations, once a plan has been made, and of the importance of revealing his or her own customary mood-altering medications. This is a convenient occasion to inquire about the patient’s and relatives’ previous experiences with local, regional, and general anesthesia.

Information should be sought regarding the presence of any degenerative axonal disease involving spinal cord, plexus, or nerve to be blocked and symptoms of thoracic outlet syndrome, spinal cord transection, and lumbar lesions. Strong proponents of regional anesthesia have stated that a wide range of conditions – multiple sclerosis, Guillain-Barré syndrome, residual poliomyelitis, and muscular dystrophy – are unaffected, although difficulty in a patient with Guillain-Barré syndrome has been reported. However, there are reports of permanent neurologic deterioration in patients with unidentified preexisting problems. Spinal anesthesia is an effective way of obtunding mass autonomic reflexes in patients with spinal cord transection above T5, but a mass reflex has been described in a patient with an apparently appro-
Regional Anesthesia Safety

Chapter 1

It must be concluded that the uncertainty of outcome when regional anesthesia is used in patients with established neurologic disease demands that the technique be used only when it is clearly advantageous for the patient. It is prudent to seek out symptoms of unrecognized neurologic abnormality when planning which anesthesia technique will be used. Parkinson’s disease and epilepsy are not contraindications to regional anesthesia, provided they are habitually well controlled by medications, which should be continued during and after the operative period.

Thus far, the concerns addressed have largely involved the possibility of long-term neuronal damage and uncontrolled muscle activity, but the rapid changes in intracranial pressure during lumbar puncture can be dangerous. The lumbar extradural injection of 10 mL of fluid in two patients increased the intracranial pressure from 18.8 to 39.5 mm Hg in the first patient and from 9.3 to 15.6 mm Hg in the second patient. Among patients at risk are those with head injuries, severe eclampsia, and hydrocephalus.

A history of sleep apnea is more a reminder of the need for meticulous monitoring than a contraindication to regional anesthesia. In any case, patients may not recognize their own sleep apnea experiences. They are more likely to know of snoring, daytime hypersomnolence, and restless sleep.

The Respiratory System

Preoperative pulmonary function tests do not identify definitive values predictive of hypoxia during regional anesthesia, but for practical purposes, if there are spirometric values <50% of predicted, risk is increased. It is certainly so if the values are: FEV < 1.0 L, FVC < 15–20 mL/kg, FEV/FVC < 35%, PEF < 100–200 L/min, and Pco₂ > 50 mm Hg. Avoidance of the airway manipulation associated with general anesthesia and preserving coughing ability are advantageous for the patient with asthma or chronic obstructive pulmonary disease. Unfortunately, that can be more than offset by a magnitude of motor blockade that decreases vital capacity, expiratory reserve volume, maximum breathing capacity, and the ability to cough, all of which can result from anesthesia for abdominal surgery. If for some reason the patient is particularly dependent on nasal breathing, as babies are, a block that is complicated by nasal congestion due to Horner’s syndrome will cause respiratory difficulty.

Clinical assessment decides the need for acid-base and blood gas measurements. Hypoxia and acidosis enhance the central nervous system and cardiotoxicity of lidocaine. In the neonate, these effects are accentuated by poor compensation for metabolic acidosis.

The Cardiovascular System

Cardiac disease has profound implications for regional anesthesia, as it has for general anesthesia. Among the systems classifying the degree of cardiac risk, Detsky’s modification of the Goldman index is useful (Table 1-1). However, this risk assessment is not patient specific, and there are individual asymptomatic patients with significant coronary artery disease that is unlikely to be detected. Also, chronic and relatively symptom-free chronic valvular dysfunction may lead to sudden and severe circulatory collapse. There are many potential causes of myocardial infarction in patients undergoing extracardiac surgery, as there are for other cardiovascular complications. The role of dipyridamole-thallium scintigraphy and ambulatory (Holter) electrocardiography (ECG) has attracted interest; however, physiologic changes that can occur in a patient during the operative period and subsets of patients to whom a specific test applies have yet to be identified with certainty.

When assessing the patient with cardiovascular problems for regional anesthesia and debating the addition, or perhaps sole use, of general anesthesia, the anesthesiologist must make predictions. These are the ability to satisfactorily control preload and afterload, myocardial oxygen supply, and demand and function. If one or more of
these deviate from optimal limits, will the rate of change that may occur exceed the rate at which the therapeutic management can be developed?

The cardiac dysrhythmias of particular interest are the array of clinical disorders of sinus function (sick sinus syndrome). These are often associated with reduced automaticity of lower pacemakers and conduction disturbances. Local anesthetic drugs that diminish sinoatrial node activity, increase the cardiac refractory period, prolong the intracardiac conduction time, and lengthen the QRS complex, will, in sufficient quantity, aggravate sinus node dysfunction.

It is important to realize that the pharmacokinetics of drugs are influenced by certain cardiac defects. Patients with intracardiac right-to-left shunts are denied protection by the lungs, which normally sequester up to 80% of the intravenous drug. If this is reduced, the likelihood of central nervous system toxicity is increased.21,22

### Table 1-1. Detsky’s Modified Multifactorial Index Arranged According to Point Value

<table>
<thead>
<tr>
<th>Variables</th>
<th>Points</th>
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<tbody>
<tr>
<td>Class 4 angina*</td>
<td>20</td>
</tr>
<tr>
<td>Suspected critical aortic stenosis</td>
<td>20</td>
</tr>
<tr>
<td>Myocardial infarction within 6 months</td>
<td>10</td>
</tr>
<tr>
<td>Alveolar pulmonary edema within 1 week</td>
<td>10</td>
</tr>
<tr>
<td>Unstable angina within 3 months</td>
<td>10</td>
</tr>
<tr>
<td>Class 3 angina*</td>
<td>10</td>
</tr>
<tr>
<td>Emergency surgery</td>
<td>10</td>
</tr>
<tr>
<td>Myocardial infarction more than 6 months ago</td>
<td>5</td>
</tr>
<tr>
<td>Alveolar pulmonary edema ever</td>
<td>5</td>
</tr>
<tr>
<td>Sinus plus atrial premature beats or rhythm other than sinus on last preoperative electrocardiogram</td>
<td>5</td>
</tr>
<tr>
<td>More than five ventricular premature beats at any time before surgery</td>
<td>5</td>
</tr>
<tr>
<td>Poor general medical status†</td>
<td>5</td>
</tr>
<tr>
<td>Age over 70 years</td>
<td>5</td>
</tr>
</tbody>
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*Sources: Detsky et al.16 Copyright 1986, American Medical Association. All rights reserved; Detsky et al.17 Copyright 1986, Blackwell Publishing. All rights reserved.

†Canadian Cardiovascular Society classification for angina.

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†Canadian Cardiovascular Society classification for angina.

The Gastrointestinal Tract

It is essential that the anesthesiologist obtain reliable information about the food and drink the patient has or will have taken. An elective patient will have received the customary institutional management, which may include one or more of the following: anticholinergic, histamine-receptor blocker (H2), antacid, and benzamide derivative. Based on knowledge up to 1990, the following proposals have been made. First, solid food should not be taken on the day of surgery. Second, unrestricted clear fluids should be permitted until 3 hours before scheduled surgery.23,24

In a study of the effect of epidural anesthesia on gastric emptying, measured by the absorption of acetaminophen from the upper small intestine, it appeared that block of sympathetic innervation of the stomach (T6–10) did not affect gastric emptying; however, epidural injection of morphine at the T4 level delayed emptying. Nevertheless, with the onset of high spinal anesthesia, antiperistaltic movements and gastric regurgitation may occur and the ability to cough is reduced during a high blockade.
Thus, the value of peripheral neural blockade for a patient with a potentially full stomach cannot be overestimated: subarachnoid and epidural anesthesia do not protect a patient from aspiration. Similarly, paralysis of a recurrent laryngeal nerve, a complication of blockades in the neck region, facilitates aspiration of gastric contents.

In a wide variety of abnormal circumstances, including trauma and near-term pregnancy, it is impossible to predict on the basis of the passage of time what the stomach contains. If the stomach is not empty, there are other vital considerations. In the presence of the blockade, the patient must be able to protect himself from aspiration; alternatively, in the presence of a failed blockade, it must be possible to administer a general anesthetic safely or to abandon the surgical procedure or delivery. Obstetric procedures usually brook no delay, and so it is mandatory that at some time well before the anticipated delivery date, the airway problems of pregnant patients be identified and plans made to cope with any eventuality.

The Hematologic System

Clotting Mechanisms

A regional anesthesia technique in which a hemorrhage cannot be detected readily and controlled by direct pressure is contraindicated in patients with a coagulation disorder, which might be attributed to diseases such as thrombocytopenia, hemophilia, and leukemia, or to drugs. Drugs having primary anticoagulant effects include unfractionated heparin, low-molecular-weight heparin, coumadin, and aspirin. Other drugs that to some degree influence coagulation are nonsteroidal antiinflammatory medications, urokinase, phenprocoumon, dextran 70, and ticlopidine.

Laboratory measurements determine the presence of a significant coagulation defect. Anticoagulation during heparin therapy is most often monitored by the activated clotting time. This method is not specific for a particular part of the coagulation cascade, and for diagnostic purposes a variety of other tests are used: prothrombin (plasma thromboplastin) time, activated partial thromboplastin time, platelet count, and plasma fibrinogen concentration. Even in combination, however, these fail to provide a complete description of the status of the coagulation system. It is possible that viscoelastic methods are a convenient technique to monitor perioperative bleeding disorders.26

Once a detailed history of drug use and laboratory measurements is available, a decision regarding the potential complications of central neural blockade, with or without catheter insertion, may be necessary, as may the influence of an anticoagulated state on postoperative developments.

Clinical experiences with these dilemmas have been comprehensively reviewed,27,28 the conclusion being that performing epidural or spinal anesthesia in patients treated with drugs that may jeopardize the normal responses of the clotting system to blood vessel damage is a concern. It is clear that major nerve-blocking techniques can be used in some patients who have received or will be receiving anticoagulant drugs. This success is not only dependent on an appreciation of the properties of different anticoagulant managements and a skilled regional anesthesia technique, but also very careful postblockade monitoring. Thus, the advantages of the regional block envisaged must be carefully compared with other anesthesia techniques for the patient and the overall patient care available.

“Histaminoid” Reactions

Histaminoid refers to a reaction whose precise identity – histamine, prostaglandin, leukotremia, or kinin – is unknown. Few patients would recognize that term, and it is wiser to inquire of “allergy or sensitivity experiences.” This is particularly valuable information if the patient describes a situation that the anesthesiologist has
contemplated repeating. The patient’s story should not be discounted by attributing the reported events to epinephrine or a misplaced injection. The dose or rate of administration does not affect the severity of a histaminoid reaction. Additionally, many studies have shown that reactions occur more often in patients with a history of atopy but that a history of allergy is not predictive of severe clinical anaphylaxis. The patient’s history, or lack of it, is important and may guide the anesthesiologist away from certain drugs; however, an unexpected reaction will challenge some anesthesiologists, somewhere, sometime, and that complication will demand immediate recognition and treatment.

**Pseudocholinesterase Dysfunction**

If a patient’s red cell cholinesterase is deficient or abnormal, drugs metabolized by that enzyme, such as 2-chloroprocaine, will be broken down more slowly, lowering the toxicity threshold.

**Methemoglobinemia**

Drugs predisposing to methemoglobinemia are aniline dyes, nitrites, nitrates, sulfonamides, and antimalarial medications. It may also be associated with hemoglobinopathies and glucose-6-phosphate dehydrogenase deficiencies. The local anesthetics benzocaine, lidocaine, and prilocaine can contribute to methemoglobinemia.

**Muscle Disease**

Inquiries about muscular dystrophy, myasthenia gravis, and malignant hyperthermia are part of the preanesthetic evaluation, regardless of the contemplated anesthetic technique (Chapter 20). These details are significant for regional anesthesia, too, because malignant hyperthermia can still occur. Any drug that releases calcium from the sarcoplasmic reticulum, such as lidocaine, should perhaps be avoided. Although it has been stated that neither amide nor ester-linked local anesthetics are contraindicated in such cases, there seems to be some uncertainty.

If the patient has a muscular dystrophy it is important to know because of associated problems that may be present, such as ECG abnormalities, but regional anesthesia is not contraindicated and may indeed be the technique of choice.

**Diabetes**

Diabetic patients usually announce their disease, but some leave the anesthesiologist to find out (Chapter 18). It is important that the anesthesiologist does, because although neural blockade may be the technique of choice in some respects, the peripheral neuropathy and autonomic dysfunction associated with the disease have implications, particularly if they are in the area to be blocked. The preanesthetic symptoms and signs should be carefully documented.

Notably, a central conduction block limits the normal physiologic response to hypoglycemia and a diabetic patient can be unduly sensitive to the normal insulin regimen. This may complicate postoperative care.

**Miscellaneous Medications**

Neural blockade complications clearly caused by drug interactions are rare, but possibilities can be taken into account during anesthesia planning and in diagnosing any complications detected later.

**Aspirin**

Aspirin therapy, because of its antiplatelet activity, may increase the risk of hematoma, which, associated with central blockade, is potentially tragic. The effect of the
drug on platelets is irreversible and lasts 7–10 days; thus, some assessment of platelet function should be made in aspirin-treated patients. Presently, measurement of the bleeding time is the only practical test of in vivo platelet function. It may return to normal 72 hours after discontinuation of the drug, but in vitro platelet aggregation tests require much longer. If the bleeding time is 10 minutes or more, the clinician must weigh the relative disadvantages for that patient of other forms of anesthesia and analgesia.

**Quinidine and Disopyramide**

Laboratory studies showed that lidocaine metabolites and the metabolites of several antiarrhythmic agents had little effect on lidocaine protein binding. However, bupivacaine, quinidine, and disopyramide caused a significant increase in the lidocaine free fraction. These effects could cause unexpected drug-related complications.

**Benzodiazepines**

Diazepam enhances the cardiovascular toxicity associated with bupivacaine and verapamil. Benzodiazepines mask the early signs of systemic toxicity, so that the first evidence of problems may be cardiopulmonary depression.

**Verapamil**

Verapamil increases the toxicity of lidocaine and bupivacaine in mice, and cardiovascular collapse in patients has been reported.

**Nifedipine**

Nifedipine increases the toxicity of bupivacaine in dogs.

**The Preanesthetic Visit: Physical Examination**

The routine preoperative examination for anesthesia is described in many textbooks. The following paragraphs address matters that, although interesting at any time, are particularly important for the anesthesiologist contemplating performing a neural blockade. Positive answers to the following questions are not necessarily contraindications to regional anesthesia; indeed, they may support its selection, but they do indicate matters that must be given particular consideration.

**Positioning for the Block**

- Is the patient so large or heavy that a dangerous strain may be placed on tables, stools, and assistants unless special precautions are taken?

**Blood Pressure**

- Is the patient hypertensive or hypotensive?

**Oxygenation**

- Is the patient hypoxic?

**Blood Volume**

- Is the patient hypovolemic?

**Infection**

- Is there dystrophic skin or infection at the site of needle entry or infection in the needle track?
- Is there systemic infection in the body?
Previous Surgery

- Are there scars anywhere indicating previous trauma or surgery that the patient has not mentioned?

Abdominal Masses

- Is an abdominal mass present that could impair venous return or respiration?
- Is there a uterus gravid beyond the first trimester that could impair venous return and influence the spread of subarachnoid injections?

Venous Access

- Will venous access for medications or fluids be easily obtained?

The Upper Airway

- In an emergency situation, can the anesthesiologist easily take control of the patient’s airway, ventilate the patient, and prevent aspiration?

Technical Difficulty Performing the Proposed Block

- Will arthritis, amputation, or obesity hinder positioning the patient?
- Does obesity obscure bony landmarks?
- Is arthritis likely to hinder neural access?
- Are spinal defects, abnormalities of vertebral fusions, or foreign bodies present to hinder neural access?
- Can the arm be moved into a suitable position?
- Is there a hindrance to positioning a tourniquet?

Lymph Glands

- Are there axillary or femoral lymph glands in the needle path for the proposed block?

Evaluating the Hemodynamic Status of the Limb

- Will a cast or other hindrance prevent monitoring of peripheral blood flow in a limb?

Conclusion

Surprises for an anesthesiologist in the block room are usually stressful, potentially hazardous for the patient, and may delay the operating room schedule. It is cautionary to realize that, in complex processes, whether medical care or industry, dangerous situations result from a sequence of events. Failure to obtain a certain item of information at the preanesthetic visit can be compounded by related events in the surgical or dental suite and the recovery area. The preoperative visit is the opportunity to plan the patient’s anesthetic, be it a technique of regional anesthesia, general anesthesia, or a combination. A structured interview and examination is one facet of safe regional anesthesia practice.

Equipment

The objective for any attempted neural blockade is to produce the anesthesia required, and thus a major complication is block failure. Neural blockade may fail for pharmacologic or pharmacokinetic reasons, because the anesthesiologist lacks mental imagery of the anatomy, manual dexterity, or tactile sensitivity. Well-designed equipment does not make the user skilled, but it can diminish the complication of “failed spinal” and other complications associated with needle placement. The following is a collation of
published data criteria believed to influence successful identification of the location for the anesthetic and of the complications associated with these attempts.

**Spinal Needles**

**Clinical Reports**

The size of needles ranging from 18 to 25 gauge do not affect the success rate for subarachnoid tap, and Whitacre 25 and 27 gauge, Quincke 25 gauge, and Sprotte have been used satisfactorily. Thinner needles (29 and 30 gauge) have a greater tendency to deviate during their passage through ligamentous tissues, and an introducer through which those needles can be passed is essential. Cerebrospinal fluid (CSF) spontaneous flow through a 29-gauge needle appears extremely slowly, if at all, even if the hub is clear plastic instead of metal. Similarly, injection of fluid can be accomplished only slowly, and drug distribution may be affected.

Spinal anesthesia in children can safely be done with 22- or 25-gauge spinal needles or the hollow stylet from a 24-gauge Angiocath.

Headache is primarily a complication of spinal tap in adults. An extensive and critical analysis of clinical reports concluded that the smallest-gauge needle with a noncutting tip reduces its likelihood. Thus, choice of needle gauge is a compromise because using a very fine needle is more difficult. It has been suggested that when avoiding headache is paramount, Quincke or Whitacre 27 gauge are the needles of choice. The waiting times for appearance of CSF with the patient in a lateral position using these needles were 10.8 ± 6.9 and 10.7 ± 6.8 seconds, respectively.

**Laboratory Reports**

Laboratory reports address the technical problems about which clinicians speculate and some complications to avoid. The conclusions are summarized next.

**Changing the Needle Direction During Insertion**

Deliberate change of direction of a needle is customarily done by almost complete withdrawal and subsequent reentry, and inadvertent deviation during advancement is misleading. A laboratory model demonstrated the occurrence of needle deviation and the influence of needle point design and gauge. It was least with pencil-point spinal needles and greatest with bevelled spinal needles. The needle deviation with bevelled needles was consistent in direction as well as degree, in contrast to pencil-point tip configurations. Thus, rotating a bevelled needle during insertion and redirectioning may hinder future identification of the epidural or subarachnoid space.

**Resistance to Penetration of the Dura Mater**

The human dura mater is relatively resistant to penetration by a long, bevelled 21-gauge (80 × 0.8 mm) Quincke-Babcock needle. After entering the epidural space (anatomically believed to vary from 1 to 7 mm in depth), depending on the site of insertion, the needle advanced 7–13 mm within it. This tenting of the dura mater is believed a potential hazard in the thoracic and cervical region because the spinal cord could be impacted.

**Detection Time for CSF after Dural Puncture**

Features that determine the effective use of spinal needles include rapid detectability of CSF, and low resistance to injectate. Experiments with a wide variety of needles revealed that all Becton-Dickinson needles had a zero detection time. The Quincke “Spinocan” 26 gauge and Portex pencil-point had the greatest delay, which at an
artificial CSF pressure of 20–50 cm H₂O was approximately 8 seconds. The calculated relative resistance to flow through the needles varied from 0.21 (Becton-Dickinson Whitacre 22 gauge) to 2.91 (Quincke, Spinocan 26 gauge).

**Rate of CSF Leak Through a Dural Puncture**

The rate of CSF loss through a dural puncture site can be measured in an in vitro model, and experiments demonstrated that, although more force was required to pierce the dura, CSF leakage from pencil-point needles was significantly less than that from Quincke needles of the same external diameter. The authors concluded that the Whitacre 27-gauge needle lacks a clear advantage over the 25-gauge needle, which may be easier to use.

**Needle Orifice Shape and Unintended Extra Dural Injection**

A needle whose distal orifice is partially in and partially outside the subarachnoid space may deliver CSF from the hub, but only part of the injectate will be delivered subarachnoidally. The 22-gauge Whitacre needle is preferable to long-orifice needles such as 22-gauge Sprotte, Quincke, and Diamond point.

**Epidural Needles**

A suitable needle has the following characteristics: 1) easy penetration of ligaments, 2) minimally traumatic penetration, 3) minimal difficulty locating the epidural space, and 4) a lumen that facilitates epidural catheter placement. There are three needles that largely incorporate these features.

**Tuohy Needle**

The distal end is curved 20 degrees to direct a catheter into the epidural space. It must be introduced into the epidural space at least to the depth of the orifice. After a catheter has been inserted, it cannot be withdrawn without a serious risk of transection.

**Crawford Needle**

This needle lacks a curved end and so must approach the epidural space obliquely if a catheter is to be inserted. It does not have to penetrate as deeply as the Tuohy needle into the space.

**Whitacre Needles**

Whitacre epidural needles have a blunt tip to reduce the likelihood of dural puncture. The eye of the needle is located laterally, so the distal end must be inserted well into the epidural space.

Needle sizes appropriate to the ages of children are as follows: until 6 to 7 years, 20 gauge; from 7 to 10 years, 19 gauge; over 10 years, 19 or 18 gauge. A 16- or 18-gauge needle is customarily used in adults.

**Combined Spinal and Epidural Techniques**

The development of combined spinal and epidural (CSE) techniques since their inception in 1937 has been recently reviewed. There are various techniques, and conventional epidural, long spinal needles, catheters, and special devices can be used. The double-segment technique involves the insertion of an epidural needle and a spinal needle one or two segments below. The single-space technique (SST) requires an epidural needle insertion followed by a spinal needle through its lumen once the epidural anesthesia solution has been injected. There are technical complications associ-
ated with the combined use of these devices as well as the individual ones, and sets specifically designed for SST have been designed.

**Double-Lumen Needles**

In this technique, a Tuohy needle has a parallel tube as a guide for a thinner spinal needle. There are two types – a bent parallel tube and a straight parallel tube. The bent parallel tube consists of a curved 20- to 22-gauge spinal needle of the same length as the Tuohy needle. The straight tube is fixed on the side of a Tuohy needle; the point of the guide is situated 1 cm behind the eye of the Tuohy needle. Spinal needles of normal length can be used. The double-lumen concept allows insertion of the epidural catheter before positioning of the spinal needle.

Another device is a conventional Tuohy needle to which has been added an additional aperture at the end of the longitudinal axis. It is through this that a spinal needle on its way to the subarachnoid space will exit. Favorable clinical reports of CSE techniques have been supplemented by laboratory studies of flow characteristics of long spinal needles and the risk of catheter migration from the epidural space.

**Flow Characteristics of Long Spinal Needles**

The 120-mm, 26-gauge Braun Spinocan needle was compared in vitro with the 120-mm, 27-gauge Becton-Dickinson spinal needle. A pressure of 10 cm H₂O caused fluid to drop from the needle after 330 ± 14.8 and 129 ± 20.7 seconds, respectively. Clinical study findings were 33.5 and 10.85 seconds, respectively. The internal diameter of the 26-gauge needle is 0.23 mm and of the 27-gauge needle, 0.25 mm. The gauge value indicates the outer size, not the lumen.

**Catheter Migration**

An epiduroscopic study of cadavers demonstrated that the risk of epidural catheter migration through a dural puncture hole was very small. It was much less likely if the hole had been made by a 25-gauge spinal needle than with a Tuohy needle.

**Complications Associated with Spinal and Epidural Catheters**

1. **Insufficient length** to reach from the exit site to the shoulder.
2. **Venous penetration.** The lumen must be sufficient for aspiration. A stylet in the catheter must not project out of the tip.
3. **Dural penetration.** The lumen must be sufficient for aspiration. A stylet in the catheter must not project out of the tip. A closed round-ended catheter with side openings makes penetration less likely.
4. **Kinking.** This is less likely with currently manufactured catheters and with the redesigned version of the Racz catheter.
5. **Knotting.** Interval marking of the catheter is a useful guide to the catheter length within the subarachnoid or epidural space and discourages coiling.
6. **Difficult withdrawal.** A clinical study of forces necessary for lumbar extradural catheter removal (range 1.57 ± 0.96 to 3.78 ± 2.8 N) and literature review indicated that the original approach to the space was inconsequential. However, the withdrawal force required was greater with the patient sitting than in the lateral position. Thus, the flexed lateral position was recommended for removal. This opinion is controversial. It has been recommended that the patient be in the same position used for insertion when it is removed.

**Devices for Peripheral Nerve Blockade**

Complications of nerve blockade include intravascular injection, intraneural injection, and failure to locate the nerve to be blocked. Breakage at a weak junction between
Intravascular needle placement may be impossible to detect by aspiration if the needle lumen is very fine, and a translucent hub is of little help. This has implications for resuscitation arrangements established for minor surgical or dental procedures performed in offices and clinics. Intraneural injection is unlikely, but needles with side-ports provide some protection from that event.

Paresthesias are unusual and unwelcome during the conduct of a central neural blockade, but peripheral nerves are often deliberately located by eliciting paresthesias with the needle, although this depends on the patient and is not absolutely reliable. The causal relationship between paresthesia elicited in this manner and neural damage is controversial, and no statistically significant clinical data indicate that such stimulation produces neuropathy. The animal experiments upon which claims for potential neuropathy are based did not represent clinical practice, although a clinician can never be absolutely certain that the tip of the needle is not actually within a nerve. Indeed, the sterile flexible infusion line between syringe and needle is there to help immobilize the needle when it is in position.

Concerns about mechanically produced paresthesia popularized the introduction of a nerve stimulator to locate the nerve. The needle should ideally be insulated by Teflon coating in order to enhance opportunities to place the needle tip close to the nerve. Paresthesias may occur when the instrument is in use, but its purpose is to elicit visible contraction in a muscle served by the nerve to be blocked.

Ideally, the stimulator should have the following characteristics:

1. Constant current output
2. Clear meter reading to 0.1 mA
3. Variable output
4. Linear output
5. Clearly marked polarity
6. Short pulse width
7. Pulse of 1 Hz
8. Battery indicator
9. High-quality alligator clips
10. High- and low-output settings

Instruments designed for testing neuromuscular transmission do not usually indicate voltage or current at the site of stimulation and so are disadvantageous because they control only voltage, whereas it is current that causes a nerve to depolarize. It is possible to elicit a muscle response when the needle is some distance from the nerve unless the stimulus current is less than 0.5 mA. The concept is attractive and popular with some practitioners, but definitive evidence of its superiority over other methods is lacking and the occurrence of serious complications has been suggested.

Another technique to safely identify the site for injection is visualizing the anatomy by ultrasonography. Not only can this increase the likelihood of successful neural blockade, but it reduces the incidence of pneumothorax associated with the supraclavicular approach to brachial plexus blockade (Chapter 8).

Resuscitation Supplies

Cardiovascular failure, with or without respiratory failure, is a rare complication of regional blockade whether for head, trunk, or limbs. If competent treatment is not immediately available, however, the result will be permanent cerebral damage or death.

A standard text states:

Intravenous access and fluids, a tipping trolley, an oxygen supply, and resuscitation drugs and equipment must be available. The equipment must include an anesthesia machine as
a source of oxygen, a means of lung ventilation, a laryngoscope, oropharyngeal airways, cuffed endotracheal tubes, a stilette, and continuous suction. Thiopentone, diazepam, suxamethonium, ephedrine, and atropine should be immediately available.

Those are the basic requirements of the caregivers trained to provide advanced cardiopulmonary resuscitation and will be present when neural blockade is attempted in the hospital or a large clinic. They are just as necessary in the office where a minor procedure is to be done under neural blockade. Not only must equipment be there, but the persons present should be trained to use it. In light of the magnitude of the potential tragedy, they should be able to communicate with extramural help while continuing their efforts at cardiopulmonary resuscitation.

**Behavioral Factors and Complications**

The behavioral factors that lead to complications are of several categories. A lapse of safe habit is the routine failure to check effectively the identity and concentration of fluid to be injected. Another is the lack of a routine method of distinguishing between syringes. An unsafe habit could be the use of an air-filled syringe to identify the epidural space of a child. Other potential causes have been reviewed and in general are referred to as vigilance decrement, vigilance being a state of maximal and psychological readiness to react to a situation. These can be the cause of temporarily breaking a safe habit or creating an unsafe habit or of missing evidence of a complication. It is an important feature of complication avoidance that anesthesiologists be aware of these behavioral pitfalls and discipline themselves accordingly while establishing safe work scheduling.

**Effects of Sleep Deprivation**

Sleep deprivation can dramatically impair performance of monitoring tasks, whether the signals are presented in an auditory or visual mode – and particularly if the task is not cognitively exciting. A cumulative sleep debt incurred over days has a detrimental effect; however, there are wide individual differences in responses to acute or chronic sleep loss. Ideally, anesthesiologists should objectively establish their own limitations because an anesthesiologist who has been working most of the night may feel remarkably awake, perhaps euphoric, in the morning, although studies have documented reduced performance, and in the afternoons the situation will have further deteriorated. Napping is not necessarily helpful, particularly if it occurs during a period of REM sleep.

A recommendation supported by evidence from a variety of subjects, including anesthesiologists, for the anesthesiologist who has been working most of the night and is scheduled for a full day’s work is this: “Do not work. If work is mandatory do not nap for only 2 hours. If 4 hours is possible, accept it but be prepared for some remaining performance decrement.”

**The Effects of Fatigue**

Hours of continuous cognitively challenging work result in fatigue. The effects of fatigue are accentuated by sleep deprivation and influenced by the position of the activity in the individual’s circadian rhythm. Published data support the contention that a fatigued anesthesiologist may be careless and less likely to detect perioperative complications or to respond optimally to evolving clinical situations.

**The Hazard of Boredom**

A task that is repetitious, uneventful, uninteresting, and undemanding is boring. In such a case, the anesthesiologist has too little work. It is a problem shared by many
other real life responsible tasks and results in inappropriate automatic behavior, vigilance decrement, inappropriate interest, and a general feeling of fatigue. Thus, the low-workload situation, similar to the high-workload state, can cause performance decrement, and thus complications, because evidence of their development is overlooked. Anesthesiologists periodically change their location in the operating room or converse with operating room companions, probably in an unconscious effort to maintain vigilance by increasing sensory input. An unsedated patient under regional anesthesia is sometimes a highly entertaining and educational source of information and social commentary, thus keeping the carer close by. During boring cases, the addition of occupations completely unrelated to patient care demand a time-sharing technique that must be learned, and even then their impact on an individual’s vigilance for clinically important matters is variable and very difficult to predict. Thus, reading or listening to personal music is controversial behavior in the operating room.

The Influences of Physical and Mental Factors

An anesthesiologist is sometimes anxious in the operating room, but when this is compounded by personal anxieties, planning, decision making, and monitoring may be adversely affected. Substance abuse reduces vigilance and psychomotor performance and there is strong evidence that hangovers from alcohol and marijuana have similar effects. Recent work suggests that pilots should wait at least 14 hours after drinking alcohol before flying, although it is constituent aromatic substances in some beverages that are more likely to cause a problem.

Work Environment

The physical environment for conducting hospital surgery under regional anesthesia is similar to that for general anesthesia in that monitor displays should be discernible from the variety of positions assumed by the anesthesiologist during the course of the procedure. Recently, verbal communications were found to be responsible for 37% of events that could have resulted in patient deterioration or death in an intensive care unit, supporting other anecdotal reports of communication errors. This confirms the need for an established routine to check the identity and concentration of fluids to be injected in every hospital or clinic location where neural blockades are done or existing blockades reinforced.

Small clinics and professional offices may differ from the hospital environment in one significant respect. In an acute emergency, persons performing cardiopulmonary resuscitation may be unable to communicate with outside help without discontinuing their lifesaving activity, and in some countries or states such behavior is illegal. Protection of patients demands an arrangement that avoids such a situation by ensuring a communication system that can be instantly and conveniently activated.

The “mental environment” in which neural blockade and surgery are performed is as important as the physical environment. It is salutary that anesthesiologists, who are sometimes confronted with injured patients who have suffered because the response to industrial production pressures was to ignore certain defenses against injury, can find themselves faced with the same decision as the industrial worker – and even under similar production pressures. These pressures may be temptations for personal gain or generated by surgeons, dentists, or institutional managers. A recent study concluded that pressure from internal and external sources is a reality for many anesthesiologists and is perceived, in some cases, to have resulted in unsafe actions being performed. The implication is that any effort to increase anesthesia and surgical productivity should be based on methods other than reducing safe practices. Any attempt to achieve it by introducing new technology should be accompanied by a careful analysis and, if necessary, education of the person using it.
Complication Recognition During Neural Blockade and Surgery

Sharing Human and Instrumental Monitoring

Regional anesthesia conducted expertly on the basis of a careful medical history and examination of the patient is safe, but complications can occur. Signs and symptoms, listed by body systems, are matched with the human and instrumental monitoring techniques used for their detection in Table 1-2.

Table 1-2. Complication Recognition

<table>
<thead>
<tr>
<th>Symptoms and signs to be detected</th>
<th>Detection methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nervous System events</strong></td>
<td></td>
</tr>
<tr>
<td>• Peroneal numbness and tingling</td>
<td>Patient: Assuming there is no language barrier, the patient may report any of these spontaneously but should be initially instructed to report any unusual sensation.</td>
</tr>
<tr>
<td>• Dizziness, tinnitus</td>
<td>Anesthesiologist: Communication with the patient and observation.</td>
</tr>
<tr>
<td>• Hearing impairment</td>
<td>Instrument: Instruments do not identify these sensations for the anesthesiologist.</td>
</tr>
<tr>
<td>• Headache</td>
<td></td>
</tr>
<tr>
<td>• Reduced vision</td>
<td></td>
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<tr>
<td>• Diplopia</td>
<td></td>
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<tr>
<td>• Taste in mouth</td>
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<tr>
<td>• Dysphagia</td>
<td></td>
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<tr>
<td>• Coughing and sneezing</td>
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<tr>
<td>• Nausea</td>
<td></td>
</tr>
<tr>
<td>• Throat numbness</td>
<td></td>
</tr>
<tr>
<td>• Dysphasia</td>
<td></td>
</tr>
<tr>
<td>• Pain and paresthesia</td>
<td></td>
</tr>
<tr>
<td>• Faintness</td>
<td></td>
</tr>
<tr>
<td>• Restlessness</td>
<td></td>
</tr>
<tr>
<td>Postural pressure or tension on</td>
<td>Patient: An unreliable source of information</td>
</tr>
<tr>
<td>peripheral nerves</td>
<td>Anesthesiologist: Power of observation</td>
</tr>
<tr>
<td></td>
<td>Instrument: Limited in application. A pulse oximeter at a limb periphery may indirectly indicate a threat to nerve or plexus.</td>
</tr>
<tr>
<td>Horner’s syndrome</td>
<td>Patient: Reports unusual feeling</td>
</tr>
<tr>
<td></td>
<td>Anesthesiologist: Observation</td>
</tr>
<tr>
<td></td>
<td>Instrument: –</td>
</tr>
<tr>
<td>Phrenic nerve paralysis</td>
<td>Patient: Reports unusual feelings</td>
</tr>
<tr>
<td></td>
<td>Anesthesiologist: Observation</td>
</tr>
<tr>
<td></td>
<td>Instrument: SpO₂ value may diminish</td>
</tr>
<tr>
<td>Recurrent laryngeal nerve block</td>
<td>Patient: Reports unusual feelings</td>
</tr>
<tr>
<td></td>
<td>Anesthesiologist: Observation</td>
</tr>
<tr>
<td></td>
<td>Instrument: –</td>
</tr>
<tr>
<td>Presence or absence of CSF in hub</td>
<td>Patient: –</td>
</tr>
<tr>
<td>of needle or dripping from it</td>
<td>Anesthesiologist: Observation. After dural puncture, the delay before the first drop of CSF appeared was approximately 11 seconds for a 27-gauge Becton-Dickinson spinal needle, and 33 seconds for a 26-gauge Braun needle. There is considerable variation among commercially available spinal needles. Such details regarding needles used for blocks other than central neural blockade are unavailable.</td>
</tr>
<tr>
<td></td>
<td>Instrument: –</td>
</tr>
<tr>
<td>Loss of resistance to injection</td>
<td>Patient: –</td>
</tr>
<tr>
<td>(epidural space detection)</td>
<td>Anesthesiologist: Observation</td>
</tr>
<tr>
<td></td>
<td>Instrument: Pressure variations in the injection system can be digitized and displayed to show an exponential pressure decline.</td>
</tr>
</tbody>
</table>

(Continued)
### Table 1-2. Continued

<table>
<thead>
<tr>
<th>Symptoms and signs to be detected</th>
<th>Detection methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blood reaching the hub of a needle and not pulsating</td>
<td>Patient: – Anesthesiologist: Observation. Note, blood will take substantially longer than CSF to pass through a spinal, or other, narrow bore needle. There will be interpatient variability. Thus, a “bloody tap” is evidence that the needle is in a vein or hematoma, but absence of blood is not necessarily definitive evidence that drug will not be injected intravascularly.</td>
</tr>
<tr>
<td>Cerebral function</td>
<td>Patient: Reports unusual sensation Anesthesiologist: Conversation or intermittent questioning of patient Instrument: –</td>
</tr>
<tr>
<td>Evidence of unexpected neural blockade</td>
<td>Patient: Report of unusual sensations and/or motor function Anesthesiologist: Observation of blockade area and the patient Instruments: Sphygmomanometer, ECG, pulse meter</td>
</tr>
<tr>
<td>Vagal stimulation</td>
<td>Patient: Faintness or loss of consciousness Anesthesiologist: Observations Instruments: ECG, pulse oximeter, pulse meter, sphygmomanometer</td>
</tr>
</tbody>
</table>

**Respiratory system events**
- Respiratory rate changes
- Tidal volume change
- Apnea
- Stertor
- Respiratory obstruction
- Dyspnea
- Bronchospasm

Patient: Dyspnea may be reported but in general patients seem unaware of the significance of respiratory changes, and, if they have been sedated, unaware of them. Anesthesiologist: Observations are valuable but are unlikely to assess function accurately or continuously. Instruments: Pulse oximetry is a late indicator of respiratory dysfunction, relative to end-tidal capnography. The stethoscope in the operating room or PARR is now more of a diagnostic tool to identify such things as atelectasis and pneumothorax than a monitor of respiration but a paratracheal audible respiratory monitor has been described.95

Erroneous gas delivery to patient

Patient: Comments may be made about odor. Anesthesiologist: Observation of patients behavior. Instrument: An FIO2 monitor with functioning alarms is quicker and more reliable than patient or anesthesiologist.

**Cardiovascular system events**

Hypotension

Patient: – Anesthesiologist: Sensing error is large

Hypertension

Instrument: Automated direct or indirect measurement