Complications of Interventional Pain Management Techniques

69

Marco Araujo and Dermot More O'Ferrall

Key Points

- The most common reported complications are medication-related misuse, pneumothorax, spinal cord injury, and nerve damage.
- Intrathecal injection of 10 ml of preservative-free normal saline can reduce the potential for post-dural-puncture headache after a dural puncture.
- Other causes of headache following epidural steroid injection include intracranial or subdural hematoma, epidural abscess, meningitis, and pneumocephalus.
- Frequently, the ligamentum flavum is adherent to the dura above C5 spinal level.
- Injection of particulate steroids can lead to anterior spinal cord syndrome. Use of nonparticulate steroids and inferoposterior foraminal needle placement reduces the risk of paraplegia after transforaminal epidurals.
- The use of lateral fluoroscopic guidance for trigger point injections of the thoracic wall musculature reduces the risk of pneumothorax.
- Radiofrequency needle placement close to the nerve root can cause severe postoperative dysesthesia and nerve root and spinal cord injury.
- Right-sided SGB may cause sinus arrhythmias, while left-sided SGB can cause left ventricular dysfunction in patients with preexisting left ventricular disease.
- Contrast volume should be maximum of half (0.5) ml/disc in cervical discography.
- Warfarin should be stopped five (5) days prior to neuraxial procedure, and the INR should be less than 1.4 before proceeding.

Introduction

Several textbooks cover the techniques, indications, contraindications, and the mechanism of action of the interventional pain management techniques, but only few textbooks have focused on the complications and on their consequences. Interventional pain management has evolved tremendously since the first described therapeutic nerve block, performed by Tuffer in 1899 [1, 2]. The combination of Interventional Pain Physicians with small amount of experience in the field and the recent significant increase in the utilization of interventional diagnostic and therapeutic techniques raises the potential for increased complications.

Unfortunately, there are major limitations in the analysis of complications. Historically, physicians have a tendency to report no poor outcomes; therefore, only few complications are reported. Health privacy issues and fear of litigation prevent several physicians from reporting the complications of interventional techniques. Furthermore, the complications may be reported to different databases, making the analysis even more difficult.

The American Society of Anesthesiologists (ASA) Closed Claims Project Database can provide valuable information on the adverse outcomes in chronic pain management from 1970 through December 2000 [3]. During this time period, 284 chronic pain management claims were reported. 276 (96 %) claims were related to interventional pain management techniques including nerve blocks, epidural steroid injections, trigger point injections, tendon or joint injections, neuroablation procedures, and neuromodulation implant techniques. 78 % claims were related to nerve blocks and

M. Araujo, M.D., FACIP (✉)
Pain Clinic Advanced Pain Management,
4131 W. Loomis Rd Ste 300, Greenfield, WI 54301, USA
e-mail: sirmarcoarauvo@hotmail.com

D.M. O'Ferrall, M.D.
Pain Clinic Advanced Pain Management,
4131 W. Loomis Rd Ste 300, Greenfield, WI 53221, USA
e-mail: doferrall@wi.rr.com

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injections. The most common complications were pneumothorax and spinal cord-nerve injury [3]. There were 18 (6 %) claims for paraplegia or quadriplegia with four caused by epidural abscess, eight caused by chemical injury from injection into the spinal cord, and six caused by epidural hematoma. Even more alarming, 5 % of claims were related to brain damage, while 4 % were related to death.

While the overall incidence of significant complications in interventional pain medicine is low, some catastrophic complications do occur as ASA Close Claims Project Database shows. Physicians need to be familiar with current literature and to be aware of potential complications. With the advent of interventional pain medicine as a recognized subspecialty of medicine, more formal and standardized interventional training must occur in the academic setting, which will hopefully reduce the likelihood of complications [2–6]. This chapter will focus on procedure-specific complications and on ways to improve safety and minimize complications, by addressing issues pertinent to the patient, the physician, the nursing staff, the equipment, and the medications utilized.

Procedure-Related Complications

As the practice of pain medicine grows, there is a need for greater awareness of potential injuries to patients. Interventional pain management physicians and staff must explain clearly these complications in layman's terms to the patient in order to reduce the occurrence of claims. Written preoperative instructions explaining the procedure and potential complications should be given and signed by the patient prior to the procedure, allowing time for its review. The *informed* consent prior to all procedures should include a discussion about the indication, complications, risks, and available alternative therapies. Ideally, additional consent should also be obtained prior to utilizing medication for off-label, non-FDA (Food and Drug Administration)-approved use.

Epidural Injection

Absolute contraindications to epidural steroid injections include local or systemic infection and bleeding diathesis. Severe central spinal stenosis may be a relative contraindication, and caution must be taken if the injection is being performed interlaminarly at the severe spinal stenosis level. Pregnancy may be a contraindication if fluoroscopy is used.

The documented incidence of dural puncture is anywhere from 0.5 to 5 % in the literature, although this is unacceptably high, especially with the use of fluoroscopy [7–9]. Potential complications of dural puncture include spinal headache, subdural hematoma, and potential for spinal anesthesia or spinal-neural injury. When the rate of cerebral spinal fluid (CSF) loss exceeds CSF production, a downward shift of the brain in the skull may occur, placing traction on the meningeal nerves and subdural veins resulting in spinal headache or subdural hematoma, respectively. Post-dural-puncture headache may follow dural puncture in up to 75 % of cases [10].

If, while performing an interlaminar epidural injection, an inadvertent dural puncture is obtained and confirmed with injection of contrast, producing a myelogram, then without needle movement, an intrathecal injection of 10 cc of preservative-free normal saline can reduce the potential for post-dural-puncture headache significantly [11]. The injection should be performed at another level, or via a different route, such as transforaminal, but without local anesthetic because of the potential for spinal anesthesia.

One epidural blood patch can result in complete, almost instantaneous relief of spinal headache in up to 75 % of patients. If the first epidural blood patch was not successful, the second epidural blood patch can relieve the spinal headache in up to 95 % of patients [12]. Dural puncture brings the risk of subdural hematoma, which can be seen intracranially or spinally [13–15].

It is important to understand that there are many, potentially serious causes of headache following epidural steroid injection, including intracranial or subdural hematoma, epidural abscess, meningitis, pneumocephalus, and spinal headache from dural puncture. A thorough history and physical examination will usually yield a diagnosis, although occasionally imaging studies will be warranted. An epidural abscess, subdural or epidural hematoma resulting in spinal cord compression, needs to be recognized early, and surgical intervention within 8 h is mandatory in order to prevent a permanent neurological injury (Fig. 69.1a, b) [16–25]. Epidural abscess, bacterial meningitis, and aseptic meningitis have all been described [17, 23, 26, 27]. Pneumocephalus produces an immediate and severe headache when patient is allowed to sit. Pneumocephalus is diagnosed with CT scan, and the headache usually resolves as the air is absorbed, over a period of 5–7 days.

Other documented complications of interlaminar epidural injections include arachnoiditis, intrinsic spinal cord injury, spinal anesthesia, transient paralysis, arterial gas embolism, and transient blindness [28, 29]. Controversy exists over whether arachnoiditis can complicate epidural steroid injection [19, 20].

Anatomy

Understanding the anatomy of the epidural space is important. It is triangular in shape, and 1–2 mm in depth in the upper cervical spine, with 3 mm in depth in the lower cervical

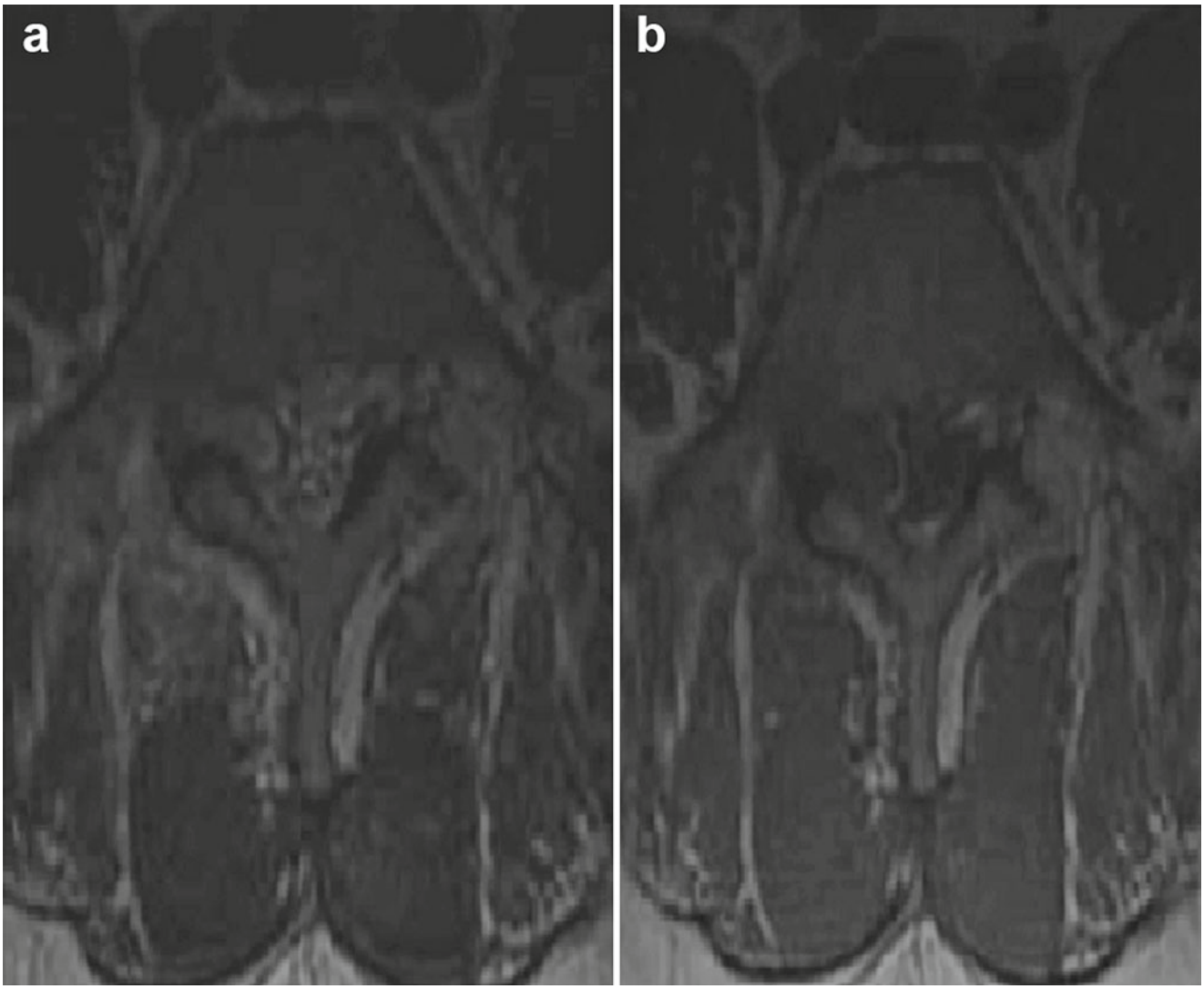

Fig. 69.1 (**a**, **b**) Epidural abscess seen on the above T2 and T1 axial images of the lumbar spine resulting in compression of the exiting right L5 spinal nerve. It occurred following a right L5/S1 intra-articular zygapophysial joint injection

spine, this increases to up to 5 mm in the upper thoracic spine and is 5–6 mm in depth in the midlumbar spine. Thirty-four percent of the time, the ligamentum flavum is adherent to the dura above C5 [30].

Recommendation

The needle entry point for cervical interlaminar epidural steroid injections should be at the C7/T1 level or below, and the epidural space should be entered in the midline where depth is greatest. The needle should be anchored at the skin with the nondominant hand and advanced with the dominant hand.

When the epidural space is identified with the loss of resistance technique, a catheter should be thread to the appropriate level and contrast injected to confirm the correct level, no vascular uptake and an epidurogram (Figs. 69.2 and 69.3) [31–34]. One should minimize the volume injected to 2–3 cc, and the solution should be injected slowly. AP, oblique, and lateral fluoroscopic views should be taken to document unequivocal epidural spread of contrast prior to injection of medication. Contrast should be injected under live fluoroscopy to confirm no concomitant vascular uptake (Fig. 69.4). Sedation should also be minimized because oversedation may cause loss of communication and the ability to monitor the patient. Oversedation also increases the potential for unintentional patient movement or startle and increases the potential for cardiopulmonary complications. It is generally accepted in the pain medicine community that oversedation or deep monitored anesthesia care (MAC) should not be utilized because it increases the potential for catastrophic complications as spinal cord trauma.

The advantage of this technique is to reduce the chance of dural puncture, spinal anesthesia, and spinal cord injury.

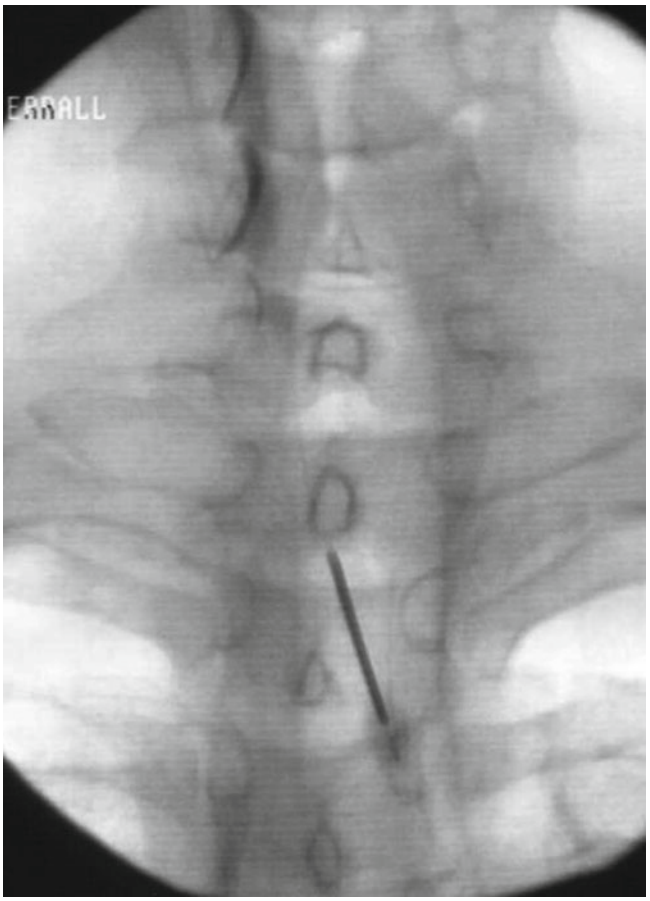

Fig. 69.2 AP fluoroscopic image of a cervical interlaminar epidural steroid injection with a catheter thread to C6/7 in a patient with a left C7 radiculopathy. Note needle entry at T2/3

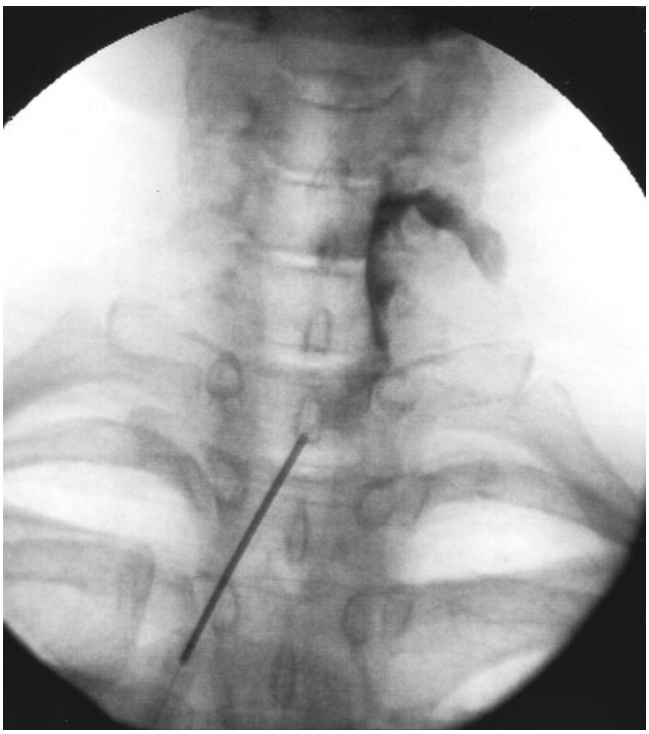

Fig. 69.3 AP fluoroscopic image of a cervical interlaminar epidural steroid injection with a catheter thread to C5/6 in a patient with a right C6 radiculopathy. Note needle entry at T1/2

Entering the epidural space at the midline position, where there are fewer epidural veins, will also reduce the potential risk of epidural hematoma.

Transforaminal epidural steroid injections are felt in general to be safe, although the prevalence of complications remains underreported [35]. Complications from the transforaminal approach are similar to interlaminar epidural steroid injections but also include the catastrophic complication of anterior spinal cord syndrome. This can follow inadvertent injection into the radiculomedullary artery (Adamkiewicz) in the lumbar or thoracic spine or cervical radicular artery in the cervical spine. Locked-in syndrome or brain stem infarct may follow unrecognized vertebral artery injection during cervical transforaminal injection (Fig. 69.4).

In the thoracic and lumbar spines, two unfortunate circumstances need to be present. Firstly, the artery of Adamkiewicz (radicular medullary artery) needs to be present at the symptomatic level and, secondly, undetected arterial penetration with subsequent injection. The artery of Adamkiewicz usually arises on the left between T7 and L4 but may be as low lying as S1 on the left or right. It runs with the spinal nerve in the anterosuperior aspect of the foramen and therefore may be penetrated inadvertently at this site [36, 37].

Proposed theories for this include intravascular injection of particulate steroid, resulting in spasm or thrombosis, which results in anterior spinal cord infarction because of the absence of collateral circulation. In the cervical spine, the sole vascular supply to the anterior spinal cord again comes from the anterior spinal artery, and the feeding radicular arteries are highly variable in number, location, and side. Similarly, the presence of a radicular artery at the symptomatic level, and undetected interarterial injection, can result in anterior spinal cord infarction and quadriplegia [38–47].

Strategies to reduce the chance of this catastrophic complication include the following: (1) understanding the fluoroscopic anatomy; (2) understanding contrast flow patterns; (3) optimizing interventional skills; (4) use of extension tubing and injection of contrast under live fluoroscopy to avoid the need to recannulate the needle after contrast is injected; (5) use of digital subtraction imaging; (6) use of nonparticulation solution such as dexamethasone and betamethasone; (7) in addition, some experts have recommended using blunt tip needles, as these are less likely to

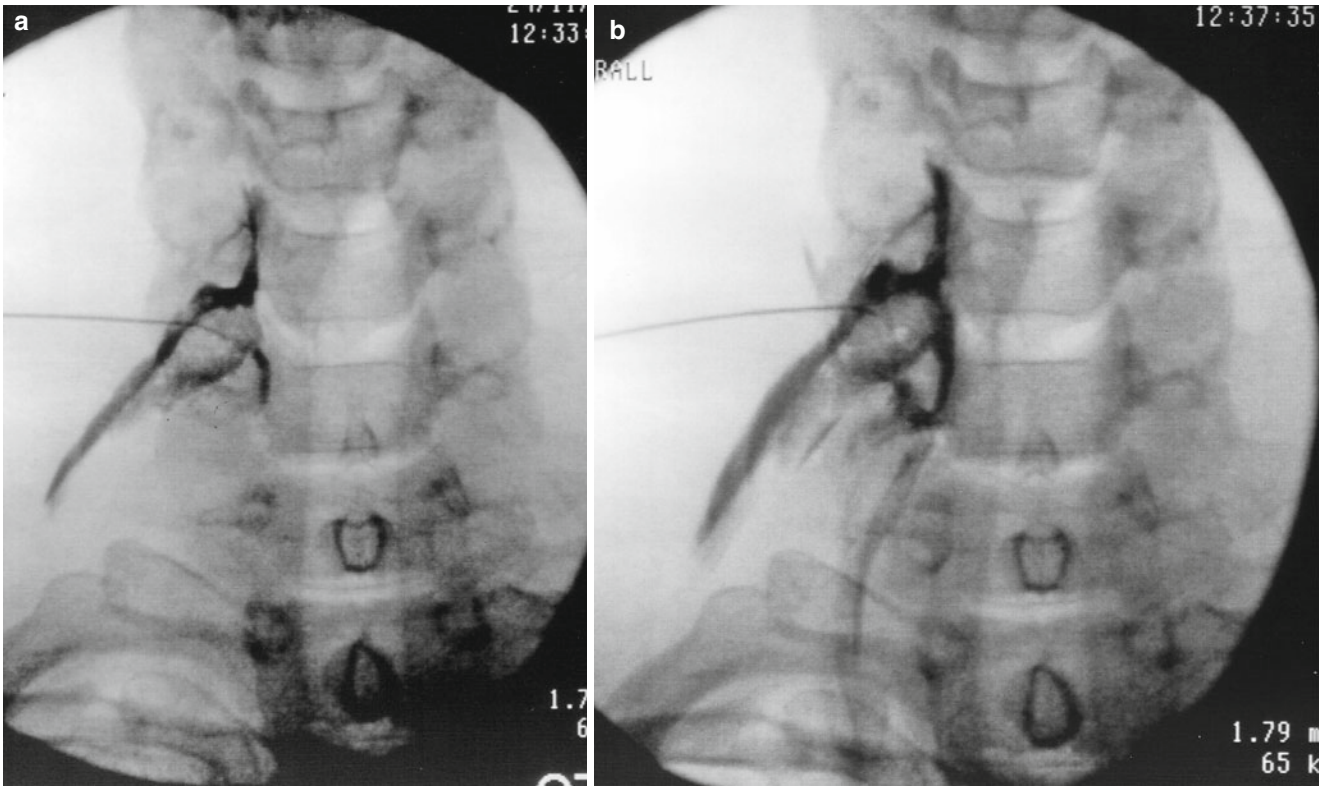

Fig. 69.4 (**a**) AP fluoroscopic image of a right C5/6 transforaminal epidural steroid injection. (**b**) AP fluoroscopic image of a right C5/6 transforaminal epidural steroid injection. Please note the vascular uptake not seen on the previous image is apparent with contrast injection under live fluoroscopy

penetrate an artery [48, 49]; and (8) needle placement in the posteroinferior aspect of the foramen (lumbar, thoracic) to avoid the artery of Adamkiewicz which runs with the spinal nerve in the anterosuperior aspect of the foramen.

Trigger Point Injection

Trigger point injections are generally considered to be fairly straightforward; however, some catastrophic complications have been described in cases without fluoroscopy. In a closed claims study, the second most common cause of pneumothorax behind intercostal nerve block was trigger point injection, being responsible for 21 % of cases [5].

Other documented complications include local infection, cellulitis, hematoma, epidural abscess, pneumothorax, spinal anesthesia, spinal cord injury, anaphylaxis, and death.

Use of fluoroscopy for trigger point injections in the cervical or thoracic area will help reduce needle misplacement, either into the epidural, subdural, subarachnoid space, or into the spinal cord, which has occurred with trigger point injections of paraspinal muscles. The use of lateral fluoroscopic guidance for trigger point injections of any posterior thoracic wall musculature will document needle depth and prevent pneumothorax by remaining superficial to the ribs [50–52].

Zygapophysial Joint Injection/ Medial Branch Block

In general, lumbar zygapophysial (facet) joint injection is a safe procedure, although complications similar to epidural steroid injections have been described. These include infection with resulting cellulitis or epidural abscess, epidural hematoma, intravascular injection, dural puncture, spinal anesthesia, spinal cord trauma, neural trauma, chemical meningitis, and pneumothorax. Vertebral artery damage or injection is a potential risk with cervical facet joint injections [53–59]. With the use of fluoroscopy and contrast injection in experienced hands, serious complications should not occur. In the cervical spine, a posterior parasagittal approach to the medial branch nerves or posterior approach to the interarticular z-joint injection is safer than a lateral approach (Fig. 69.5). A lateral approach brings the contents of the spinal canal potentially into the path of the needle, especially if

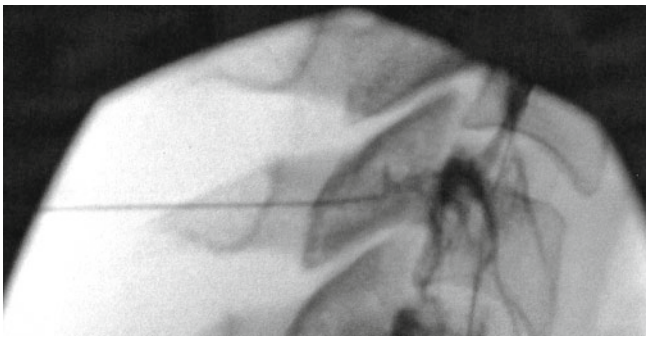

Fig. 69.5 Lateral cervical spine fluoroscopic image of C4 medial branch block showing vascular uptake

the clinician is unable to eliminate parallax and get a true lateral fluoroscopic image. Potential for going through and through a facet joint is real if needle depth is not checked frequently as the needle is advanced. Ideally, under tunnel vision, the periosteum of the adjacent articular process should be intentionally contacted prior to entering the joint to confirm depth and then the needle rotated into the joint. This will help prevent the needle going through the joint to the adjacent tissue [60].

Stellate Ganglion Block

Many techniques have been described for stellate ganglion block, some of which are without fluoroscopic guidance [61–63]. Multiple complications have been described, most of which have occurred from nonfluoroscopically guided injections that have resulted in inadvertent needle placement into the vertebral artery, adjacent disc, neurotissue, esophagus, intrathecal space, or pleura. These complications have included seizures from intravascular injection, spinal anesthesia, cervical epidural abscess, brachial plexus block, intercostal neuralgia, locked-in syndrome, pneumochylothorax, pneumothorax, reversible blindness, hoarseness, dysphagia, and death [64–74]. These complications can be reduced or hopefully eliminated with a technique described by Abdi et al. [75].

Under ipsilateral oblique fluoroscopic guidance, the respective endplates are squared off, and the C-arm is obliqued until a crisp C7 uncinate process is visualized. Then a 25-gauge spinal needle is advanced down, under tunnel vision, to the base of the uncinate process at the junction of the vertebral body. Under live fluoroscopic guidance with extension tubing, injection of contrast is performed to confirm appropriate nonvascular contrast flow. The needle will lie anterior to the vertebral artery, posterior to the common carotid artery, and lateral to the esophagus. A total of 5 cc should be adequate to obtain stellate ganglion blockade.

Discography

In experienced hands, discography is safe, whether that be in the cervical, lumbar, or thoracic spine. Understanding indications and contraindications to discography is important. Coagulopathy and active infection are general contraindications, but central spinal stenosis, myelopathy, and large disc protrusion are contraindications to cervical or thoracic discography [76].

Potential and described complications pertinent to all three areas include superficial infection, epidural abscess, discitis, or nerve root injury. In the cervical or thoracic spine, the potential for spinal cord injury exists. Quadriplegia has been described following epidural hematoma, epidural abscess, and from subdural empyema [77–84]. It has also occurred secondary to cervical disc herniation from disc pressurization at discography. Keeping the contrast volume in cervical or thoracic discography to a minimum is also important, with less than 0.5 cc/disc usually sufficient for cervical discography.

While infection is a real concern, the administration of preoperative intravenous antibiotics, intradiscal antibiotics, and/or a coaxial needle technique has been described in the literature to be able to reduce the incidence of infection (Fig. 69.6).

A coaxial needle technique has been shown to reduce the chance of discitis from 2.7 to 0.7 % in 220 patients [85]. Preoperative intravenous cefazolin has been shown to reduce the chance of disc infection from 1 to 4 % down to 0 %. Utilizing cefazolin in a concentration of 1 mg/cc intradiscally resulted in no intradiscal infections of 127 patients [86, 87].

The prophylactic antibiotics commonly utilized do not prevent anaerobic discitis, which may occur with the anterior approach to cervical discography, where esophageal penetration is possible. Utilizing a right anterolateral (oblique) approach reduces the chance for esophageal perforation and consequent potential anaerobic discitis. Auscultation of the carotid artery should be performed and ultrasound ordered if carotid bruits are heard prior to discography if an oblique approach is utilized, because of the potential of the needle traversing the carotid and dislodging an unstable plaque.

Patients with discitis usually present with pain and fever, 3 days to 2 weeks post-discography. Erythrocyte sedimentation rate, white cell count, and C-reactive protein are usually positive within the first week. It may take anywhere from 2 to 5 weeks for a bone scan to become positive. MRI with or without gadolinium is now considered the gold standard imaging study. If discitis is suspected, infectious disease consultation, disc biopsy, and culture should be taken. IV antibiotics should be started, and consideration should be given for surgical exploration and/or bracing.

Many of the complications reported with lumbar discography were reported prior to 1970, with many of them

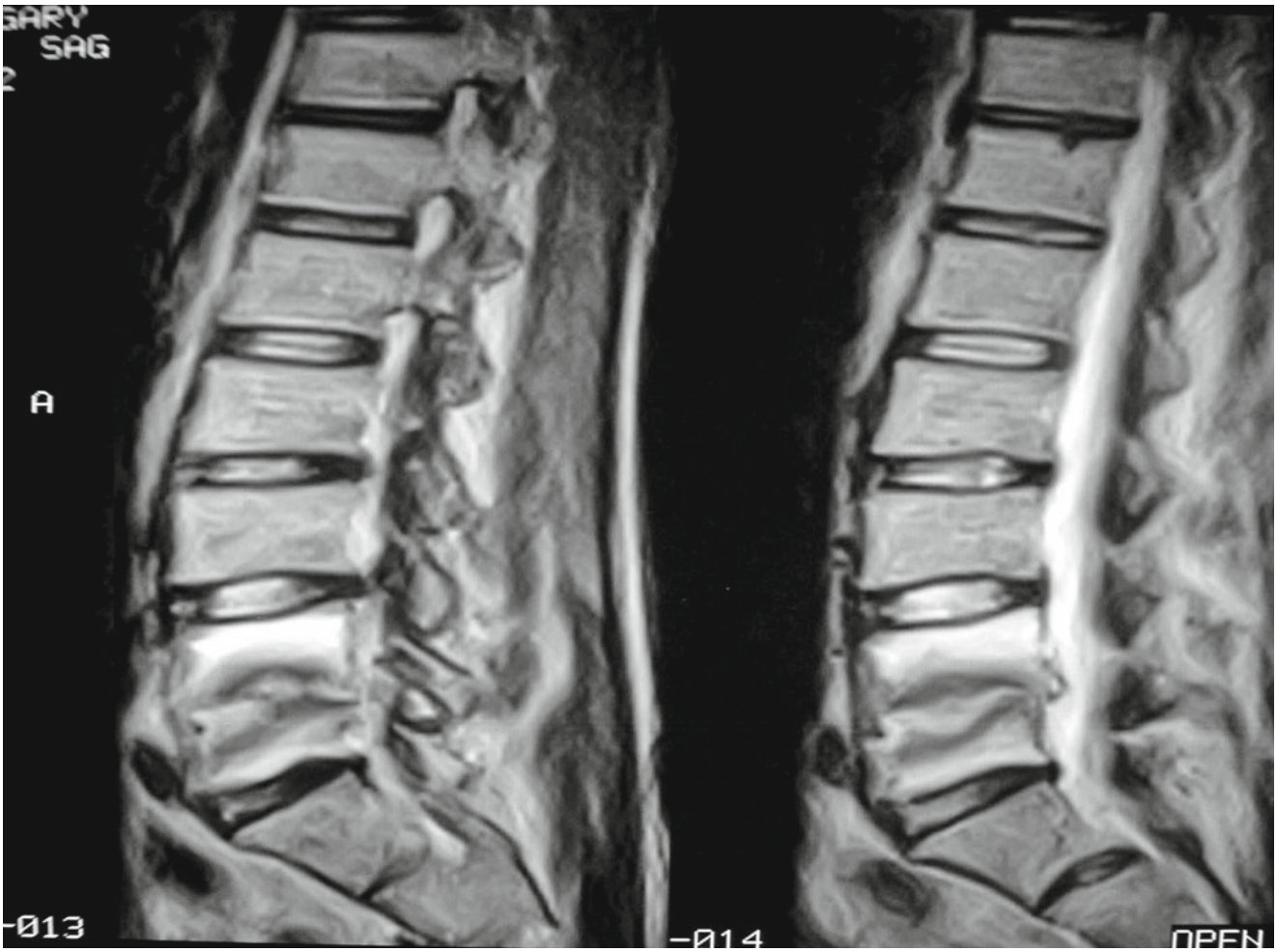

Fig. 69.6 T2-weighted MRI scan of lumbar spine demonstrating L4/5 discitis

in the 1950s. Today with preoperative intravenous antibiotics, intradiscal antibiotics, and a coaxial needle technique, with extrapedicular, extradural fluoroscopically guided approach, these complications should be minimal [88, 89].

If a posterior transdural approach to a disc is planned, then it is important not to utilize intradiscal cefazolin because of the potential for intractable seizures with inadvertent intrathecal cefazolin injection. Therefore, in a patient with previous posterolateral intratransverse bony fusion mass, when posterior transdural approach is considered, or if inadvertent dural puncture occurs with extrapedicular, extradural approach to the disc, then contrast should be mixed with another antibiotic besides cefazolin, such as ceftriaxone, gentamicin, or clindamycin [90].

Pneumothorax has been described as a complication of thoracic discography but could also occur with cervical discography at the C7/T1 level.

In general, cervical or thoracic discography, because of the more challenging technical aspects, and potential for more catastrophic complications, should only be performed by highly skilled and experienced interventionalists.

Summary

It is important to know the literature on current technical standards, modify practice accordingly, and understand that many complications are never published. History and physical examination should be performed on all patients prior to spinal injections. Physicians should review pertinent imaging studies, understand indications and contraindications of procedures, and obtain informed consent. Knowledge of regional and fluoroscopic anatomy is important before attaining technical expertise in a supervised training environment. Familiarization with all contrast flow patterns under live fluoroscopy is imperative. Above all, understand that complications are inevitable, and it is imperative to identify and treat these problems promptly to minimize their impact when they occur and communicate these issues with the patient.

Patient Pertinent Issues

A thorough history and physical examination is vital on all patients prior to neuraxial blockade, regardless of practice set-up or referral pattern. Important points of the history of a patient undergoing an interventional procedure will be addressed.

Past Medical History

This should include any bleeding diathesis, any immune suppressive disorder, history of allergy, anaphylaxis or asthma, and whether they have valvular heart disease.

Medications

It is important to note whether the patient is taking any oral steroid, antibiotics, anticoagulants, or Glucophage, as these will impact patient outcome. Glucophage is generally considered safe in patients with normal renal function when a small amount of nonionic contrast is utilized. It should be temporarily discontinued in patients with impaired renal function undergoing procedures requiring larger amounts of contrast, as it may result in the patient developing lactic acidosis.

Patients taking oral steroids will not only be immunosuppressed but also at increased risk of potential side effects from steroids [91].

Anticoagulants will clearly put patients at risk for hemorrhagic complications. Knowledge of prescription and over-the-counter medications and herbal remedies is important in risk-stratifying patients.

Neuraxial blocks on patients with an active infection requiring antibiotics should be postponed because of the potential for bacteremia and introduction of bacteria to the epidural space.

Allergies

Knowledge of patient allergic to medications that may be utilized in a procedure such as steroid, local anesthetic, or antibiotics is important in reducing the chance of anaphylactic reaction. It is also important to document any known allergy to shellfish or iodine if contrast is to be utilized and any latex allergy, as these procedures need to be done, first case of the day, in a latex-free environment. (Gadolinium may be used in iodine-allergic patients, although there is a documented cross allergy to gadolinium.)

Review of Systems

Thorough review of systems should help rule out any occult coagulopathy, infection, cord compression, malignancy, or pregnant state.

Social History

This should include any prior litigation as even more thorough documentation and informed consent may be required.

Physical Examination

A general but also procedure-specific physical examination should be performed. Attention should be paid to whether the patient is hemodynamically unstable or febrile, as elective procedures should be rescheduled in that event.

A thorough neurological examination is important to establish as a baseline, especially in the event of an adverse neurological outcome. Knowledge of a carotid bruit and subsequent Doppler study result is vital in patients undergoing procedures, in which the carotid artery may be penetrated, such as cervical discography, as the potential for dislodging a mobile thrombus is real. A thorough cardiopulmonary assessment is important in patients undergoing conscious sedation.

Imaging Study

Interventional pain physicians should be to the spine, what the cardiologist is to the heart. They should be comfortable with not only the medical and interventional management of these patients but as good, if not better, than the radiologist in interpreting pertinent spinal imaging studies. Reviewing the imaging prior to procedure in all patients is important [30, 76].

The Nurse

Time should be taken to train nursing staff and allied health professionals in interventional pain medicine, as they play a vital role in reducing significant complications.

Probably the most important *checklist* that medical assistants, nurses, and surgical technicians should review with all patients includes:

1. *Allergies* – Knowledge of nonmedication (shellfish, latex, iodine) and medication allergies is imperative as outlined above.

2. *Pregnancy* – Documentation of the last menstrual period and a pregnancy test if there is any concern should be required if fluoroscopy is utilized.
3. *Anticoagulants* – Prescription anticoagulation or over-the-counter medication or herbal remedies taken by the patient, which have potential for impairing normal coagulation, need to be known. This will be discussed in more detail later.
4. *Diabetes* – If the patient is a diabetic, knowledge of their finger-stick blood glucose is important, as they may be hypoglycemic if fasting or at risk of hyperglycemic complication if steroid injection is planned.
5. *Fever* – Elective spinal injections should be postponed in a febrile patient, as the risk of infectious complication increases.
6. *Fasting* – Knowledge of the last time a patient ate or drank is important if conscious sedation is anticipated.
7. *Side* – The side of the patient's symptoms should be marked with an X to help reduce one of the more common preventable surgical errors.

This *checklist* should be issued to all staff members who interact with the patient and should be communicated to the physician in the operating room prior to each procedure.

Nurse/Surgical Technician Preparation

If the physician is not drawing up the medications for injection, then appropriate education and training of the surgical staff is vital in reducing medication errors. Medication should be drawn up by a surgical technician with nursing supervision. All syringes should be labeled, and clearly, sterile precautions must be followed.

If you practice in a setting that is used by different specialists, such as a radiology suite at a hospital, it is important that the physician reviews all the medications prior to each procedure, to ensure no medication error. Specifically, that preservative-free local anesthetics are utilized (for epidural injections), and nonionic contrast that is safe for intrathecal use, such as Omnipaque or Isovue, and not an ionic contrast medium that may be used for urologic or gastrointestinal imaging.

Appropriate sterile preparation is mandatory and should include povidone-iodine preparation, allowing it to dry. In patients with iodine allergy, chlorhexidine gluconate and/or isopropyl alcohol may be used. For more invasive procedures such as implant or discography, some practices utilize a triple scrub, including isopropyl alcohol, chlorhexidine gluconate, and povidone-iodine. While sterile towels are adequate for draping an area for most procedures, in the case of more invasive spinal procedures, full-body draping with iodine-impregnated fenestrated adhesive biodrapes, sterile towels, and half sheets should be used [92, 93].

Patient Monitoring

Appropriate perioperative monitoring is important for all procedures and should include IV access, pulse oximetry, cardiac monitoring with ECG tracing, and blood pressure and heart rate monitoring. A fully stocked, regularly updated crash cart should be easily accessible. ACLS-trained personnel should be available. Mock codes should be run at least quarterly. This will help minimize the impact of an adverse reaction or complication.

In the postoperative patient recovery room, trained staff knowledgeable in recognizing post-procedural complications should be available. Such complications include hypotension, vasovagal reactions, sensory motor blockade, excessive somnolence, respiratory suppression, and cardiovascular complications.

Depending upon the procedure and the amount of sedation utilized, patients will be in a monitored postoperative setting, anywhere from 20 min to 8 h, until discharge criteria are met. These include an alert, oriented patient who is hemodynamically stable, with stable cardiovascular and neurologic examination and ambulating as well as expected, with someone else to drive them home if they have had sedation.

Physician

Physicians from numerous subspecialties have converged on the field of interventional pain medicine, all with varying levels of training and competence. Until recently, the standard interventional pain training occurred in the fellowship setting. Interventional pain medicine, now a recognized subspecialty of medicine, will soon have formal residency training programs.

There are still physicians performing interventional pain techniques that were learned at weekend courses. While these courses are helpful, they are by no means sufficient. A thorough understanding of spinal anatomy and how that relates to fluoroscopic anatomy is vital. Unfortunately, at these conferences, the optimum fluoroscopic image is already set, and physicians may struggle with reproducing this in their clinical practice. Contrast flow patterns are not generally taught, and therefore, the ability to recognize vascular uptake or to differentiate between a myelogram, epidurogram, or subdural contrast flow is not learned.

Physicians should be cognizant of all potential complications pertinent to a given procedure being performed. The mindset of anticipating complications will hopefully lead to earlier recognition, a more prompt and appropriate response, and minimize the effect of that complication. It is inevitable that a complication will occur to every interventionalist. How it is dealt with will frequently determine the outcome.

The physician should not be afraid to reschedule the procedure if difficulties are encountered with a particular procedure on a given day. If, for example, while performing a cervical transforaminal epidural steroid injection, vascular uptake is noted despite repositioning the needle multiple times in the foramen, the appropriate course of action may be to reschedule the patient or consider an interlaminar approach.

The minimum experience level required for certain procedures is somewhat controversial. Clearly the level of expertise required to perform an uncomplicated interlaminar lumbar epidural steroid injection on a healthy patient is far less than that required for a cervical transforaminal epidural steroid injection. Cadaver courses may help develop some of those skills, but supervised training in the clinical setting is strongly advised.

Equipment

The physician should be familiar with all equipment that may be required for a given procedure. They should be able to operate all the equipment independently and problem solve in the event of equipment malfunction. Reliance on company representatives or surgical technicians may result in operator error and avoidable complication. The physician should know how to run the fluoroscope and obtain optimal fluoroscopic images and minimize radiation exposure to all personnel.

Needle

Three basic types of needles are utilized in interventional pain practice, including a ramped needle such as a Tuohy needle which is utilized for interlaminar epidural steroid injections, a Quincke or standard spinal needle, which is used for most common spinal injections, and the third type, a pencil-point needle, which is used far less frequently (Fig. 69.7). The pencil-point needle was developed to reduce the incidence of post-dural-puncture headaches for patient undergoing spinal anesthesia and is not used frequently in interventional pain procedures.

Understanding the needle dynamics and bevel control is vital to facilitate precise needle placement. The direction of needle deviation is governed by the design of the needle tip (Fig. 69.7). Ramped needles (Tuohy) deviate away from the ramp. Pencil-point needles (Sprotte or Whitacre) only deviate a minimal amount, although not in a specific direction. Beveled needles (Quincke) consistently deviate away from the bevel. Experienced interventionalists usually accentuate this natural tendency of the beveled needle by placing a 15-degree curve, just proximal to the distal end of the needle.

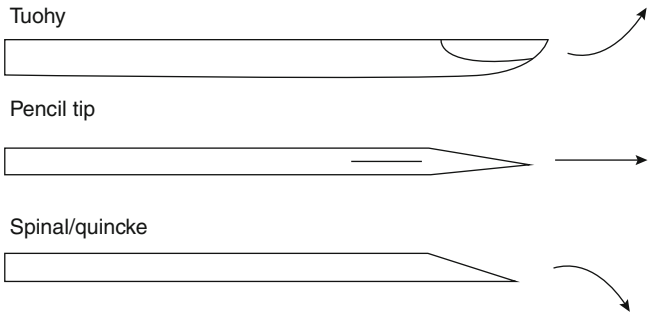

Fig. 69.7 Examples of needle types and deviation direction: Tuohy/ramped utilized for interlaminar epidurals. Pencil tip utilized for spinal anesthesia and lumbar punctures. Spinal/Quincke utilized for most interventional procedures

The degree to which a needle deflects depends on the density and distance of tissue traversed, the needle type and gauge, with 25-gauge needles deflecting more than 22 gauge [94–98].

Regardless of what needle is utilized, a two-handed needle technique should be used on all interventional procedures, with the nondominant hand anchoring the needle at the skin, and the dominant hand advancing the needle. Anchoring the needle at the skin will prevent inadvertent excessive needle advancement in the case of a patient making a sudden move which, in the case of a thoracic or cervical interlaminar epidural steroid injection, may result in spinal cord injury.

Complications resulting from interventional pain procedures have raised the issue of safety of blunt versus sharp needles for doing these procedures [45]. Some experts have recommended using blunt tip needles, rather than traditional sharp needles when performing transforaminal ESIs, with the hope of reducing the catastrophic complications of vascular penetration and anterior spinal cord infarction. This may occur with inadvertent and unrecognized injection of medication into an artery, such as radiculomedullary artery (Adamkiewicz), which may be encountered with thoracic or lumbar transforaminal injections. It may also occur with penetration of a cervical radicular artery with cervical transforaminal epidural steroid injections. Blunt needles have been unable to directly puncture the renal artery or penetrate the spinal nerve in animal models and are therefore felt by some to be safer [40, 99, 100].

Needle Placement

It is very important for the interventionalist to understand the concept of a three-dimensional object, such as the spine, being projected in two dimensions on the fluoroscope. The principle of direction, depth, direction is vital. Once the fluoroscopic working view is obtained and needle entry point determined, then the needle is directed in the sagittal or coronal plain with the needle advancing in the caudad/cephalad

or medial/lateral direction. Needle depth is then checked by switching the fluoroscope to a different view, for example, by switching from an AP view to a lateral view. After assessing depth, the fluoroscope is then changed back to the original working view and redirected. Frequent checks of needle depth are vital to avoid potential needle misplacement with resultant potential complication.

Medications

The interventionalist should be very familiar with all medications utilized, including various steroid formulations, and which ones are deemed safe and appropriate for epidural use. Understanding the appropriate dosage, duration of action, potency, and side effect profile is important [19, 20, 101, 102]. This is beyond the scope of this chapter. Utilizing the smallest particle size steroid may help reduce the potential for vascular thrombotic complications. Betamethasone is of smaller particle size than triamcinolone and dexamethasone, respectively. Ideally steroid in solution and not suspension should be used.

If compounded medications are being utilized, be aware of the practices of your pharmacy, as US Pharmacopeia guidelines should be followed. There have been numerous deaths throughout the United States linked to contaminated compounded betamethasone, resulting from meningitis, encephalitis, and septic shock. If compounding medications are being utilized, it behooves the interventionalist to check the pharmacy's practice and track record.

Contrast agents are used for accurate localization of needle placement, to confirm no vascular uptake and to delineate pertinent anatomy and appropriate contrast flow pattern. Nonionic and ionic contrast agents are available. Nonionic contrast agents are more hydrophilic, and this reduces subarachnoid and intravenous toxicity. They also have a lower osmolality and produce fewer adverse effects. All epidural and intrathecal procedures should be performed with nonionic contrast agents. Commonly used nonionic contrast agents in interventional pain include iohexol (Omnipaque) and iopamidol (Isovue).

For patients who are iodine allergic and who require contrast, either gadolinium or premedication and nonionic iodinated contrast can be utilized. Premedication should include corticosteroid and an antihistamine combination, such as prednisone, 50 mg by mouth, 13, 7, and 1 h before injection with diphenhydramine (Benadryl) 50 mg IV or by mouth, 1 h prior to the injection. Other experts also include H2 blockers such as Zantac taken 1 h before and following the injection. If premedication with steroid alone is utilized, methylprednisolone, 32 mg orally, 12 and 2 h prior to the contrast agent is sufficient [103, 104].

It is generally accepted in the radiology community that it is safe to administer gadopentetate dimeglumine in patients with a known allergy to an iodinated contrast agent. In one study, however, 6.3 % of iodine-allergic patients experienced an adverse reaction to gadopentetate dimeglumine, and therefore, some degree of caution is still warranted [105].

Knowledge of anesthetic type, whether it be an amino amide, such as lidocaine or bupivacaine or an amino ester such as 2-chloroprocaine, as well as the usual concentration, onset, duration of action, and maximal single dosage is required. Caution should be exercised not to exceed the maximum dose which could occur, especially with larger procedures such as spinal cord stimulation or perhaps multilevel bilateral radiofrequency medial branch neurolysis.

Toxic CNS effects include confusion, convulsions, respiratory arrest, seizures, and even death. Other potential adverse reactions include cardiodepression, anaphylaxis, and malignant hypothermia. The patient should be monitored for signs of toxicity including restlessness, anxiety, incoherent speech, light-headedness, numbness and tingling of the mouth and lips, blurred vision, tremors, twitching, depression, or drowsiness. Injections in the cervical spine require the utmost care, as even a small dose of local anesthetic injected intravascularly may result in significant systemic toxicity and deaths have been reported [106, 107].

All local anesthetics injected into the epidural space should be preservative-free.

Resuscitative equipment and medication should be immediately available when local anesthetics are being utilized. Central nervous system toxicity by 1 % lidocaine has an onset at plasma concentrations of 5–10 mcg/ml which equates to slightly more than 400 mg (40 cc) of total bolus. Bupivacaine is about four times more toxic than lidocaine, with a toxic bolus of 100 mg (10 cc) [108].

Volume and Rate of Injection

There is some controversy as to the optimum volume for epidural injection. As a general rule in a young patient with no central or foraminal stenosis, large volumes of contrast can be injected safely without any neurocompressive complications. However, in the cervical spine in someone with multilevel moderate to severe central and foraminal stenosis, where limited run off is available, then compressive complications may occur with as small volume as 3 ml, especially if injected quickly.

As a general rule, target-specific epidural injections delivered transforaminally at the symptomatic level or interlaminarly with a catheter advanced to the appropriate level can be achieved with volumes of 2 or 3 ml. High volume, rapid epidural steroid injection can result in large increases of intraspinal pressure, with the risk of cerebral hemorrhage, retinal

hemorrhage, visual disturbance, headache, and compromise of spinal cord blood flow. A retinal hemorrhage has been described and felt to be secondary to a sudden increase in intracranial pressure from a rapid epidural steroid injection, resulting in increase in retinal venous pressure [109–114].

Fluoroscopy

Fluoroscopy should be used for all spinal injections, including discography, diagnostic intra-articular facet joint injections, diagnostic medial branch blocks, diagnostic sacroiliac joint injections, radiofrequency medial branch neurolysis, and all transforaminal epidural steroid injections. For these, no controversy should exist. Surprisingly, however, controversy still abounds regarding the need for fluoroscopy with interlaminar or caudal epidural steroid injections. This, despite the fact that needle misplacement occurs 25–40 % of the time with caudal injections and about 30 % of the time with interlaminar lumbar epidural injections, and up to 53 % of the time with cervical epidural steroid injections without fluoroscopy [115–117]. Fredman reported more than 50 % of blind lumbar epidural steroid injections were performed at the wrong level [118–120].

Surprisingly, the results of a national survey of private and academic practices demonstrated that for cervical interlaminar epidural steroid injections, only 39 % of academic practice versus 73 % of private practitioners utilize fluoroscopy [121].

There are multiple studies showing that negative aspiration is unreliable for vascular uptake and the high incidence of vascular penetration with transforaminal lumbar and cervical epidural steroid injections which if unrecognized could result in catastrophic spinal cord infarction [122–124].

The use of fluoroscopy and contrast injection can demonstrate precise needle placement at the correct level and appropriate contrast flow. Injection of contrast under live fluoroscopy with extension tubing can help confirm there is no vascular uptake prior to injection of medication.

Many of the published complications of interventional pain procedures including sympathetic blocks and trigger point injections are because of needle misplacement with *blind* techniques and are eminently avoidable with fluoroscopy. These will be discussed in more detail later in this and other chapters.

Unrecognized inadvertent subdural injection may occur in close to 1 % of injections without fluoroscopy [125]. A hard copy confirming accurate needle placement can also be kept in the file. Fluoroscopy should be used for all interventional spine procedures except during pregnancy.

Anticoagulation

Significant bleeding following interventional pain procedures is extremely rare but may have catastrophic outcome. These procedures carry an inherent risk of bleeding, but the real extent of this risk is unknown. Bleeding complications will increase with poor technique, the presence of high procedure or patient-associated bleeding risk factors, and anticoagulation. Many prescription or over-the-counter medications and even herbal remedies such as garlic, ginkgo, ginseng, and ginger may impair coagulation [126].

Published guidelines from European and American Anesthesiology societies exist but only define the risk of significant bleeding complications for neuraxial procedures in the presence of anticoagulation [127–129]. The incidence of spinal hematoma is rare. In fact, the published incidence is 1/150,000–1/190,000 for epidurals, and 1/220,000 for spinals [130–132].

The authors as well as the German and the Spanish Society of Anesthesiology recommend that aspirin and nonsteroidal anti-inflammatory drug (NSAID) should be held prior to elective spinal injections. In the presence of increased procedure and patient-related bleeding risk factors, aspirin should be held 7 days and NSAIDs for 72 h prior to these procedures. The American Society of Regional Anesthesia and Pain Medicine (ASRA) states this practice as controversial.

In general, little controversy surrounds ticlopidine which should be held for 14 days and clopidogrel which should be held for 7 days prior to neuraxial block [130–132]. Warfarin should be stopped 4–5 days prior to neuraxial procedure, and the INR should be less than 1.4 prior to proceeding according to ASRA guidelines.

Prophylactic or therapeutic dose low molecular weight heparins should be held at least 12 or 24 h, respectively, before an epidural. Understand, however, that there are newer, longer-acting LMWHs that may need to be held longer [133].

COX-2 inhibitors such as celecoxib and valdecoxib do not need to be stopped perioperatively.

The ASA recommends discontinuing herbal medicines for 2–3 weeks prior to elective surgery. The authors suggest that vitamin E and herbal medications like garlic, ginseng, ginger, and ginkgo may increase the patient risk for bleeding, and consideration should be given to stop them, especially if there is other associated patient or procedure-related risk factors present.

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