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Imaging in Regional Anesthesia and Pain Medicine

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Case presentations demonstrating use of imaging in regional anesthesia and pain medicine:

Epidural abscess. A patient who developed an epidural abscess following epidural analgesia for labor and delivery will be presented, and the evaluation and management of this complication will be reviewed.

Radiography following lumbar fusion. The radiographic appearance of the lumbar spine following lumbar surgery and implications for regional anesthesia will be discussed.

Computed tomography and the anatomy of celiac plexus block. The anatomy of celiac plexus block as seen on CT will be reviewed.

Lumbar epidurography. Normal and abnormal findings on epidurograms as well as the appearance of epidural vs. intrathecal contrast will be reviewed.

Cervical transforaminal injection of steroids. The rationale, anatomy, technique, efficicacy, and complications of this evolving technique will be reviewed.

Introduction

This presentation stems, in part, from Dr. Rathmell's experience as Associate Editor for the Imaging Section of the Journal Regional Anesthesia and Pain Medicine. The Imaging Section was created by David L. Brown, the Journal's immediate past Editor-in-Chief, and the first article appeared in the January/February 2000 issue. The goal of this section of the Journal is to highlight the use of new and emerging imaging modalities in the practice of regional anesthesia and pain medicine. We have published numerous Imaging articles on topics ranging from epidural abscess following epidural analgesia to CT-guided celiac plexus block. We wholeheartedly encourage any of you with interest and experience in the use of imaging modalities to prepare articles for the Imaging Section.

Epidural Abscess following Epidural Analgesia

Epidural abscess most often arises in association with systemic infection, but rarely occurs following epidural analgesia. Left untreated, the expanding abcess can lead to irreversible neurologic sequelae including paraplegia. Important diagnostic features present in all cases were severe back pain, local back tenderness, fever, and leukocytosis. Neurologic deficits often begin with urinary retention or loss of rectal sphincter control followed by progressive paresis and sensory deficit below the level of spinal cord compression. Until recently, definitive diagnosis relied on myelography where intrathecal placement of radiocontrast material demonstrated obstruction to flow. With the advent of computed tomography (CT), combined CT-myelography supplanted the use of traditional myelography CT-myelography directly revealed the extent of compromise of the vertebral canal as well as any extension of the infection into adjacent bony structures. More recently, gadolinium-enhanced MRI has become the established imaging technique in the diagnosis of spinal infections. MRI allows direct multiplanar imaging, is useful in detecting marrow infiltration, and can readily discern intradural extension of the infection. Indeed, addition of the intravenous contrast agent gadolinium-diethylenetriamine pentaacetic acid (Gd-DPTA) allows delineation of epidural abscess from the adjacent compressed thecal sac. Precise delineation of the extent of spread of the infection is critical in planning therapy – small, isolated abscesses can be safely managed with intravenous antibiotics alone while more extensive spread mandates surgical drainage. In these patients who present with neurologic deficits, rapid investigation and surgical drainage of the abscess are essential for complete recovery. While epidural abscess is rare, maintaining a high index of suspicion in those patients presenting with worsening back pain after epidural analgesia can lead to early recognition and successful treatment.

Regional Anesthesia after Lumbar Fusion

Many anesthesiologists view prior lumbar surgery as a contraindication to regional anesthesia. However, the anatomical changes following different types of lumbar surgery depend on the type of surgery that was performed, and many surgeries have no impact at all on the posterior spinal elements.

Scoliosis is lateral curvature of the vertebral column. Scoliosis is more common in females. The most common form is idiopathic, but it may be secondary to neuromuscular disease (muscular dystrophies, polio) or associated with specific syndromes (osteogenesis imperfecta, Marfan's syndrome). Severe scoliosis may interfere with childhood lung development and cause restrictive lung disease and right heart failure. This will generally occur only with curves of greater than 90∞. Childhood screening and early corrective surgery have significantly lessened the prevalence of cardiopulmonary sequelae of scoliosis. Corrected thoracolumbar scoliosis is the most common major musculoskeletal disorder seen in pregnant women. Surgical management of scoliosis often involves the placement of hook, screw and rod construct to correct the spinal curvature and placement of bone graft to obtain fusion. The type of hardware used depends on the level and degree of the spinal abnormality. Harrington rods use small metal hooks placed under the bony lamina which then utilize distraction to stabilize and even correct the curvature. Harrington rods are now rarely used as more modern constructs with multiple hooks provide better correction of the curve with more initial stability and less chance of hardware complications such as hook displacement. Because of residual back pain and degenerative disease of the lower lumbar vertebrae, our patient had also undergone L4-SI fusion with placement of autologous bone graft. A characteristic sequence of vertebral body rotations and displacements occurs with scoliosis. The patient's radiograph demonstrates the typical vertebral body alignments. A review of the radiographs demonstrates a lumbar curve convex to the left with lateral deviation of the vertebral bodies from the midline. The spinous processes are rotated to the right. The interlaminar spaces at L_{1-2}, L_{2-3}, L_{3-4}, and L_{4-5} remain widely patent, thus guiding our approach to spinal placement.

Epidural analgesia is more difficult after corrective spinal surgery. Unsuccessful identification of the epidural space, multiple attempts prior to successful placement, unintentional dural puncture, failed block, and unusual block distributions can all occur. These difficulties are likely secondary to scarring or obliteration of the posterior epidural space from surgical dissection, anatomic interference from bone graft or surgical instrumentation, or vertebral rotation as discussed above. Scarring or obliteration of the epidural space is less problematic with spinal anesthesia. A basic understanding of the anatomic changes following different types of lumbar spine surgery and examination of the plain radiographs can help the anesthesiologist to plan for effective regional anesthetic techniques in such patients.

Computed Tomography and the Anatomy of Celiac Plexus Block

Neurolytic celiac plexus block is often used to treat pain associated with intraabdominal malignancy. We utilized computed tomography to assist in needle placement during the two cases described in this report. While the majority of cases can be carried out using fluoroscopic guidance alone, CT allows excellent visualization of the anatomic structures that lie in close proximity to the target site during NCPB. The celiac plexus is comprised of a diffuse network of nerve fibers and multiple ganglia that lie over the anterolateral surface of the aorta at the T12/L1 vertebral level. Presynaptic sympathetic fibers travel from the thoracic sympathetic chain toward the ganglion, traversing over the anterolateral aspect of the inferior thoracic vertebrae as the greater (T5-T9), lesser (T10-T11), and least (T12) splanchnic nerves. Neurolysis of the splanchnic nerves can be carried out by placing needles over the anterolateral surface of the T12 vertebral body. In this location, the needle tips lie posterior to the diaphragmatic crura and spread of solution will be retrocrural. To directly ablate the celiac plexus, the needles must be advanced through the diaphragm until they lie adjacent to the anterolateral surface of the aorta. This can be accomplished by advancing two separate needles adjacent to the anterolateral surface of the aorta or using a single needle advanced through the aorta. Using transcrural needle placement in either a transaortic or paraaortic location, the spread of solution will remain below the diaphragm in a plane anterior to the aorta.

Complications of CPB that might be avoided by use of CT imaging include hematuria, intravascular injection, and pneumothorax. Computed tomography allows visualization of the structures that lie adjacent to the celiac ganglion. The kidneys extend from between T12 and L3 with the left kidney slightly more cephalad than the right. The aorta lies over the left anterolateral border of the vertebral column. The celiac arterial trunk arises from the anterior surface of the aorta at the T12 level and divides into the hepatic, left gastric, and splenic arteries. Using the transaortic technique, caution must be used to avoid needle placement directly through the axis of the celiac artery as it exits anteriorly. While the celiac artery cannot be seen directly on fluoroscopy, intra-arterial placement will be apparent by continued aspiration of blood even as the needle is advanced and can be confirmed by contrast injection. The celiac artery can be seen directly during CT-guided celiac plexus block. The inferior vena cava lies just to the right of the aorta over the anterolateral surface of the vertebral column. The medial pleural reflection extends inferomedially as low as the T12-L1 level.

The best imaging modality for NCPB remains in question, however there is now general agreement that radiographic guidance is useful to assure proper placement of NCPB. A knowledge of the anatomy pertinent to celiac plexus block will prove invaluable during either fluoroscopic or CT guidance. In some circumstances, CT imaging can help to understand the unique anatomy of individual patients and prove useful in carrying out successful NCPB.

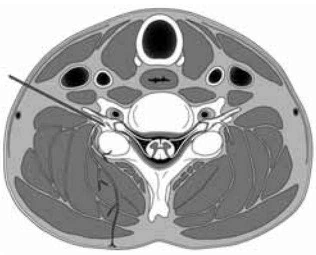
Lumbar Epidurography

Epidurography consists of injecting an opaque contrast medium between the vertebrae and the dura mater. This technique has been used to assist in the diagnosis of traumatic lesions of the lumbar spine, delineate the cause of sciatica, and in experimental studies aiming to better characterize the anatomy of the epidural space. The use of fluoroscopy during epidural steroid injection has become much more commonplace in recent years. Indeed, one recent report found frequent misplacement and maldistribution of epidural steroid solutions using epidurography in patients with failed back surgery syndrome. In this report, we preset several images that show the characteristic appearance of epidurograms as seen during routine epidural steroid injection.

The characteristic appearance of the epidurogram in the AP view is has contrast along the lateral aspects of the vertebral canal and surrounding the exiting nerve roots. The contrast remains outside of the thecal sac. During myelography, or inadvertent intrathecal injection during ESI, contrast outlines the lumbar nerve roots within the thecal sac as they travel laterally toward the neural foramina. Lateral epidurograms appear as a characteristic “double stripe” or “railroad track” with one line of contrast seen along the anterior surface of the dural sac just posterior to the vertebral bodies and a second line of contrast along the posterior surface of the dural sac. Intrathecal contrast seen in the lateral view during myelography again outlines the lumbar nerve roots within the thecal sac.

Clinicians who incorporate fluoroscopy into their practices should be familiar with the characteristics of contrast spread during both epidural and intrathecal injection. While many clinicians have already adopted fluoroscopy as a useful tool to direct needle placement during a number of procedures, the usefulness of this tool in improving patient outcomes has yet to be demonstrated. Further research is needed to better delineate the abnormalities that can be identified using epidurography and assess the effectiveness of fluoroscopically-guided ESI in improving outcomes.

Cervical Transforaminal Injection of Steroids



Cervical radicular pain is pain perceived in the upper limb caused by irritation of a cervical spinal nerve. It affects about one person per 1,000 population per year, and is most often caused by a disc herniation or foraminal stenosis. Its natural history can be favorable, but not all patients recover naturally. Many remain severely disabled, and require treatment.

Surgery is the mainstay of treatment. For relieving cervical radicular pain, surgery has a good reputation, but scientifically it is based only on multiple observational or descriptive studies. However, surgery is not without risks, and constitutes a major undertaking for patients.

Conservative therapy, typically including graduated exercise and oral analgesics, is supported only by observational studies, which have not controlled for natural history or non-specific effects of treatment. Some have reported complete resolution of pain and neurologic dysfunction in as many as 80% of cases but others attested to resolution of radiculopathy in fewer than 40%. The controlled studies that have been conducted have shown no significant benefit for traction, or exercises.

The failure of conventional, conservative treatments to provide a cure for cervical radicular pain fostered the development of alternatives. Prominent amongst these has become transforaminal injection of steroids.

Rationale

The rationale for injecting steroids is that they suppress inflammation of the nerve, which, in many instances, is believed to be the basis for radicular pain. The rationale for using a transforaminal route of injection rather than an interlaminar route is that the injectate is delivered directly onto the target nerve. This ensures that the medication reaches the site of the suspected pathology in maximum concentration.

Anatomy

At typical cervical levels, the ventral and dorsal roots of the spinal nerves descend in the vertebral canal to form the spinal nerve in their intervertebral foramen. The foramen faces obliquely forwards and laterally. Its roof and floor are formed by the pedicles of consecutive vertebrae. Its posterolateral wall is formed largely by the superior articular process of the lower vertebra, and in part by the inferior articular process of the upper vertebra and the capsule of the zygpophysial joint formed between the two articular processes. The anteromedial wall is formed by the lower end of the upper vertebral body, the uncinate process of the lower vertebra, and the posterolateral corner of the intervertebral disc. Immediately lateral to the external opening of the foramen the vertebral artery rises closely in front of the articular pillars of the zygapophysial joint.

The spinal nerve, in its dural sleeve, lies in the lower half of the foramen. The upper half is occupied by epiradicular veins. The ventral ramus of the spinal nerve arises just lateral to the intervertebral foramen, and passes forwards and laterally onto the transverse process. Radicular arteries arise from the vertebral artery and the ascending cervical artery, and accompany the spinal nerve and its roots to the spinal cord.

Technique

Cervical transforaminal injections can be performed with the patient lying in a supine, oblique or lateral decubitus position, depending on operator-preference and patient-comfort. The position must allow adequate visualization of the cervical intervertebral foramina in AP, lateral, and oblique planes.

The critical first step is to obtain a correct oblique view of the target foramen. In this view the foramen is maximally wide transversely, and the anterior wall of the superior articular process projects onto the silhouette of the lamina. Through a puncture point overlying the posterior half of the target foramen, a needle is passed into the neck. Its tip should always lie over the anterior half of the superior articular process, lest it be inserted prematurely and too far into the foramen. Once the needle has reached the superior articular process, the needle is then readjusted to enter the foramen tangential to its posterior wall, opposite the equator of the foramen. Above this level, the needle may encounter veins; below it, the needle may encounter the spinal nerve and its arteries.

Using an AP view, the tip of the needle should finally be adjusted to lie opposite the sagittal midline the articular pillars. Insertion beyond this depth risks puncturing the dural sleeve or thecal sac. The final position should be checked and recorded on an oblique view, which documents placement against the posterior wall of the foramen, and on an AP view, which documents depth of insertion.

Under direct, real-time fluoroscopy in the AP view, a small volume of non-ionic contrast medium (1.0 mL or less) is injected. The solution should outline the proximal end of the exiting nerve root and spread centrally toward the epidural space. Real-time fluoroscopy is essential to check for inadvertent intra-arterial injection, which may occur even if the needle is correctly placed. Intra-arterial injection is manifest by very rapid clearance of the injected contrast. Contrast medium may also fill epiradicular veins, which are recognized by the slow clearance of the contrast, characteristic of venous flow.

Only a small volume of contrast medium (1.0 mL or less) is required to outline the dural sleeve of the spinal nerve. As it spreads onto the thecal sac the contrast medium will assume a linear configuration. Rapid dilution of the contrast medium implies sub-arachnoid spread, which may occur if the needle has punctured the thecal sac or a lateral dilatation of the dural root sleeve into the intervertebral foramen. Once the target nerve has been correctly outlined, a small volume of a short-acting local anesthetic and corticosteroid are injected.

Indications

The indication for cervical transforaminal injection of steroids is for the treatment of cervical radicular pain with or without radiculopathy. The difficulties in making this diagnosis have been reviewed elsewhere. The only constant feature of cervical radicular pain is pain in a dynatomal distribution (the distribution of referred symptoms caused by cervical root irritation), which may resemble the distribution of classic dermatomal maps for cervical nerve roots, but not infrequently is provoked outside of the distribution of these classic dermatomal maps. Confidence in the diagnosis is enhanced if the patient also has radiculopathy, but this may not always be the case. Paraesthesiae, segmental numbness, weakness, and loss of reflexes are reliable and valid signs of radiculopathy that allow the diagnosis to be made clinically, without recourse to investigations. Disc protrusion and foraminal stenosis are the most common causes, but diagnostic imaging is required to exclude tumors and other infrequent causes such as infection, trauma, or inflammatory arthritides.

Efficacy

Published studies point towards efficacy of cervical transforaminal injections of corticosteroids. They suggest that some 30% of patients can obtain partial, but lasting, relief of their pain, and a further 30% can obtain complete relief. However, these studies were observational studies without any comparison treatment. Their outcomes may be due to the natural history of cervical radicular pain syndromes or non-specific treatment effects.

Cervical epidural steroids placed by the interlaminar route have also been advocated for the treatment of radicular pain. The reported studies have been retrospective, often with short or unstated periods of follow-up. They attest to variable efficacy, with 0% to 29% of patients obtaining complete relief of pain, and between 0% and 40% of patients achieving at least 75% relief after 6 months. There have been no studies published to date comparing translaminar versus transforaminal approaches to epidural steroid injection.

Complications

Some investigators have reported no complications resulting from the use of cervical transforaminal injection of steroids. This has not been the case in other hands. The literature reports one case of fatal spinal cord infarction attributed to a transforaminal injection of corticosteroids. As well, I am aware of three other cases in Australia, another in Europe, and eleven in the USA, in which patients have suffered severe neurologic sequelae, including spinal cord or brainstem infarction. These cases have not appeared in the literature either because they are still sub judice, or because lawyers and patients have declined to have their case records released into the medical literature.

In some of the unpublished cases, it seems that steroids have been injected into the vertebral artery. Correct needle placement should ensure that the needle is not in the vertebral artery; and due attention to the flow of a test dose of contrast medium would reveal if it is.

In the published case, and in most of the unpublished cases, no radiographic records are available to establish exactly where the needle was placed. In these cases, the basis for neurological complications remains unclear. The leading conjecture has been that, somehow, a radicular artery was compromised.

These cases provide circumstantial evidence of the mechanism of spinal cord injury following cervical transforaminal injection of steroids. Material can be injected inadvertently into radicular arteries. It seems feasible that particulate matter in depot preparations of corticosteroids might act as an embolus and if it enters an artery that happens to be a critical reinforcing supply to the anterior spinal artery, the spinal cord would be infarcted. Large caliber vessels that reinforce the anterior spinal artery are variable in incidence and in location and can occur anywhere from C3 to C8.

Discussion

A compelling evidence-base for conservative treatment of cervical radicular pain is lacking, and patients with severe pain may fail to benefit from conservative therapy. The choice then lies between surgery and transforaminal injection of steroids.

There have been no controlled studies of cervical transforaminal injection of steroids. Consequently their efficacy has not been established. Nevertheless, the encouraging results of observational studies render transforaminal injection of steroids an option. The singular disadvantage of cervical transforaminal injection of steroids is the risk of serious complications. Were it not for the risk of spinal cord injury, cervical transforaminal injection of steroids would probably find a place in the management of cervical radicular pain, even in the absence of controlled studies.

There is clearly a need for better data on the efficacy of cervical transforaminal injection of steroids as well as surgery for radicular pain. To this end, a comparison of surgery and cervical transforaminal injection of steroids in a pragmatic trial is warranted. There is also a need for accurate data on the incidence of complications from either treatment.

It is disappointing that lawyers, the practitioners involved, and their patients have not released the available material concerning complications. That information could shed light on how the complications occurred. Intra-arterial injection might prove not to be the mechanism of injury. Nevertheless, practitioners who elect to continue using this procedure should be conscious of the hazards, and ensure that their technique is optimal.

Critical to the safety of cervical transforaminal injection of steroids is an understanding of the anatomy of the cervical intervertebral formina and their contents, coupled with disciplined and accurate imaging. Under correct, oblique views, the needle must always remain in contact with the posterior wall of the foramen. This avoids contact with the spinal nerve, its roots, and their accompanying vessels. Aspiration prior to injection is an unreliable means of detecting intravascular needle placement, perhaps due to the small caliber of the vessels in this region. Injection of a test dose of contrast medium is important to the safe execution of the procedure. Whereas previously this was used to indicate correct location of the injection, and to exclude intrathecal injection, it now also serves to identify inadvertent intra-arterial injection. This must be done under real-time imaging, because spot films taken after the injection may fail to demonstrate contrast medium that has been rapidly cleared.

Summary

Based on the encouraging results of uncontrolled studies, cervical transforaminal injection of steroids is being used to treat patients with cervical radicular pain who do not improve with conservative therapy. There is a need for better data on both efficacy and safety as this treatment carries a risk of serious complications, including spinal cord injury. Critical to the safety of this technique is an understanding of the anatomy coupled with disciplined and accurate use of imaging.

References

1. Rathmell JP, Roland T, DuPen SL. Management of Pain Associated with Metastatic Epidural Spinal Cord Compression. Reg Anesth Pain Med 2000; 25: 113-116.
2. Rathmell JP, Garahan MB, Alsofrom GF. Epidural Abscess following Epidural Analgesia. Reg Anesth Pain Med 25:79-82, 2000.
3. Viscomi CM, Rathmell JP, Monsey RD. Radiographic appearance of the lumbar spine following lumbar fusion. Reg Anesth Pain Med 2000; 25: 286-290.
4. Rathmell JP, Gallant JM, Brown DL. Computed tomography and the anatomy of celiac plexus block. Reg Anesth Pain Med 2000; 25: 411-416.
5. Rathmell JP, Torian D, Song T. Lumbar epidurography. Reg Anesth Pain Med 2000; 25:540-545.
6. Field J, Rathmell JP, Stephenson JH, Katz NP. Neuropathic pain following cervical epidural steroid injection. Anesthesiology 2000; 93: 885-888.
7. Tarver JM, Rathmell JP, Alsofrom GF. Lumbar discography. Reg Anesth Pain Med 2001; 26:263-266.
8. Rathmell JP, Aprill C, Bogduk N. Cervical transforaminal injection of steroids. Anesthesiology 2004;100:1595-600.

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