Radiologic investigation of low back pain

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Low back pain is one of the commonest disorders, yet is the most confusing. The cost in work-time lost and in the search for and treatment of its many causes amounts to billions of dollars annually. The traditional techniques for anatomic visualization have been plain-film radiography and myelography, but they have limitations. The development of computed tomography and magnetic resonance imaging have substantially improved anatomic imaging. However, invasive procedures, such as discography, percutaneous nerve-root blocking and percutaneous facet injection, may be helpful in patients with disabling pain in whom noninvasive methods give negative findings, show abnormalities that do not correlate with the symptoms or identify multiple sites of disease. The invasive procedures are believed by some to be associated with too many complications. We have attempted to clarify the strengths and weaknesses of the currently available methods of investigating low back pain and the indications for their use.

Les douleurs lombaires, pour être très fréquentes, n'en constituent pas moins une question fort confuse. Les coûts de l'absentéisme qu'elles entraînent, de la recherche de ses causes et du traitement de celles-ci représentent chaque année des milliards de dollars. Leur étude anatomique repose traditionnellement sur la radiographie sans préparation et la myélographie, qui ont leurs limites. Si la tomographie informatisée et la résonance magnétique donnent de bien meilleures images, il reste utile de recourir à des méthodes envahissantes, telles la discographie et l'infiltration percutanée des racines nerveuses et des facettes articulaires, devant un malade rendu infirme par la douleur chez qui les méthodes non envahissantes ou bien sont négatives ou bien démontrent soit des altérations sans rapport avec les symptômes, soit des localisations multiples. D'après certains cliniciens le recours à ces méthodes envahissantes est suivi d'un nombre excessif de complications. Aussi avons-nous cherché à faire ressortir les avantages et les désavantages de chacune des méthodes actuelles d'exploration et ses indications.

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Low back pain is second only to sore throat as the commonest reason to visit a physician, and in fact 80% to 90% of the population will experience this problem at some time.[1] It accounts for 40% of all absences from work, decreases the productivity of those affected and is the most expensive disorder in terms of work-time lost and the cost of investigations and therapy among people 30 to 60 years of age.[1,2]

The diagnosis and treatment of low back pain are complicated by the difficulty in precisely identifying the cause and by the nonspecificity of the pain in many cases.[3] This is reflected in the multiplicity of terms used to describe the condition and the many treatments that are available.[3] There is often no anatomic change in the tissues that can be detected with the use of imaging.

Despite the confusion in regard to terminology and classification, most of the patients with acute low back pain respond to a conservative regimen of rest and analgesics.[4,5] In some cases, however, the condition does not respond or deteriorates, and further investigation is required. We reviewed the capabilities and limitations of currently available imaging techniques and methods of investigation.

Pathophysiologic features

The causes of low back pain are generally

poorly understood, and physical signs and symptoms are notoriously inaccurate in localizing the problem.[6] Despite these limitations low back pain can generally be classified into either mechanical or neurogenic, which can help in selecting the appropriate diagnostic tests.

Mechanical pain may be localized or may radiate as far as the knee. It is often exacerbated by extension and relieved by rest, and the neurologic findings are normal. Neurogenic pain usually radiates past the knee and is accompanied by neurologic findings. In many cases the two types of pain are combined, and it may be impossible to differentiate them.[7]

Although there are many causes of low back pain, few can be identified with the use of current imaging techniques. Acute mechanical pain accounts for over 90% of the cases and is most often a result of ligamentous or muscle strain. Conservative treatment is effective, and radiologic investigation is unnecessary. Attention has centred on the herniation of an intervertebral disc as a cause of neurogenic and chronic mechanical pain since the original description by Mixter and Barr[8] in 1934. Disc herniation may compress nerve roots, and bulging degenerative anuli can cause chronic pain that originates in the sensory fibres of the anulus, the posterior longitudinal ligament and the meninges. In 1980 Carrera and Haughton[9] implicated degenerative disease of the facets and the posterior bony elements as a cause of chronic mechanical pain and sciatica. This pain may be indistinguishable from that due to disc herniation, and the two entities often coexist. Tumours, infectious discitis and postoperative scarring are not as common but can result in debilitating pain.

Investigative methods

The standard methods of anatomic imaging range from basic radiography to magnetic resonance imaging (MRI). Invasive procedures, such as discography, percutaneous nerve-root blocking and percutaneous injection of the facet, are used in some centres and are usually performed by a radiologist.

Anatomic tests

Plain-film radiography: Plain films of the lumbar spine are routinely ordered in patients with acute mechanical and neurogenic pain in the lower back. However, their rate of detecting abnormal findings is very low, and the cost is high. In 1984 over 7 million films were obtained, at a cost of more than $500 million, in the United States, and the incidence of unexpected positive findings has been reported to be as low as 1 in 2500 cases.[10,11] The most common surgically remediable cause of low back pain — disc herniation — cannot be seen on plain films. The only findings that may affect therapy are rare lesions such as tumours, infection and ankylosing spondylitis.

This overused form of examination is not innocuous: the standard anteroposterior, lateral and oblique views deliver 11 rad to the skin and one of the highest doses of any radiologic examination to the gonads. The oblique views, which contribute greatly to the dose of radiation, have been found to detect such unexpected pathological features as spondylolysis in only 5% to 10% of cases.[2,12] If radiography is performed the views should be only anteroposterior and lateral.

In cases of chronic pain the films show classic signs of degeneration, such as narrowing of the disc space, end-plate sclerosis, disc calcification and the vacuum disc phenomenon, wherein gas forms in the disc as the disc degenerates; however, there has been no correlation between these findings and symptoms,[13] and therefore further tests are required.

Computed tomography (CT): In patients with chronic mechanical and neurogenic back pain the lesions that are commonly seen on CT scans and can be treated are degenerative disc disease and hypertrophic bony disease of the facets and posterior neural arch. High-resolution axial CT scans are ideal for imaging intervertebral discs, nerve-root foramina and the bony neural arches. Although CT scanning is relatively insensitive to the primary internal derangement associated with disc degeneration, it is very sensitive to such morphologic changes as anular bulging, herniation of the nucleus pulposus, calcification, the vacuum disc phenomenon and end-plate sclerosis.[14] The accuracy rate for detecting disc herniation in people with neurogenic pain is almost 96%,[15] and it is especially high in cases of distal lesions beyond the axillary sleeve (Fig. 1).[16] False-negative results can occur, most often when the wrong level is scanned or the degree of disc herniation is underestimated. Lesions in the discs of the upper lumbar region and in the conus medullaris may be missed if the region is not scanned; however, if the level has been accurately identified or at least generally localized, CT scanning is the ideal examination for detecting disc and bony lesions.

Facet joints play a key role in the production of mechanical back pain and sciatica. Plain-film radiography has traditionally been used to screen for degenerative bony disease, but CT scanning is more sensitive and can better estimate the severity of the disease.[17,18] The final stage of the degenerative process is spinal stenosis: the size of the spinal canal is reduced because of disc bulging and ligamentous and bony hypertrophy. CT scanning can show all three components and can direct surgical intervention.[19]

Major disadvantages of CT scanning are the high radiation dose (approximately 10 rad to the skin for a routine three-level study of the lumbar region), the limited field of view and the need for computer reformatting if views other than the axial plane are desired.

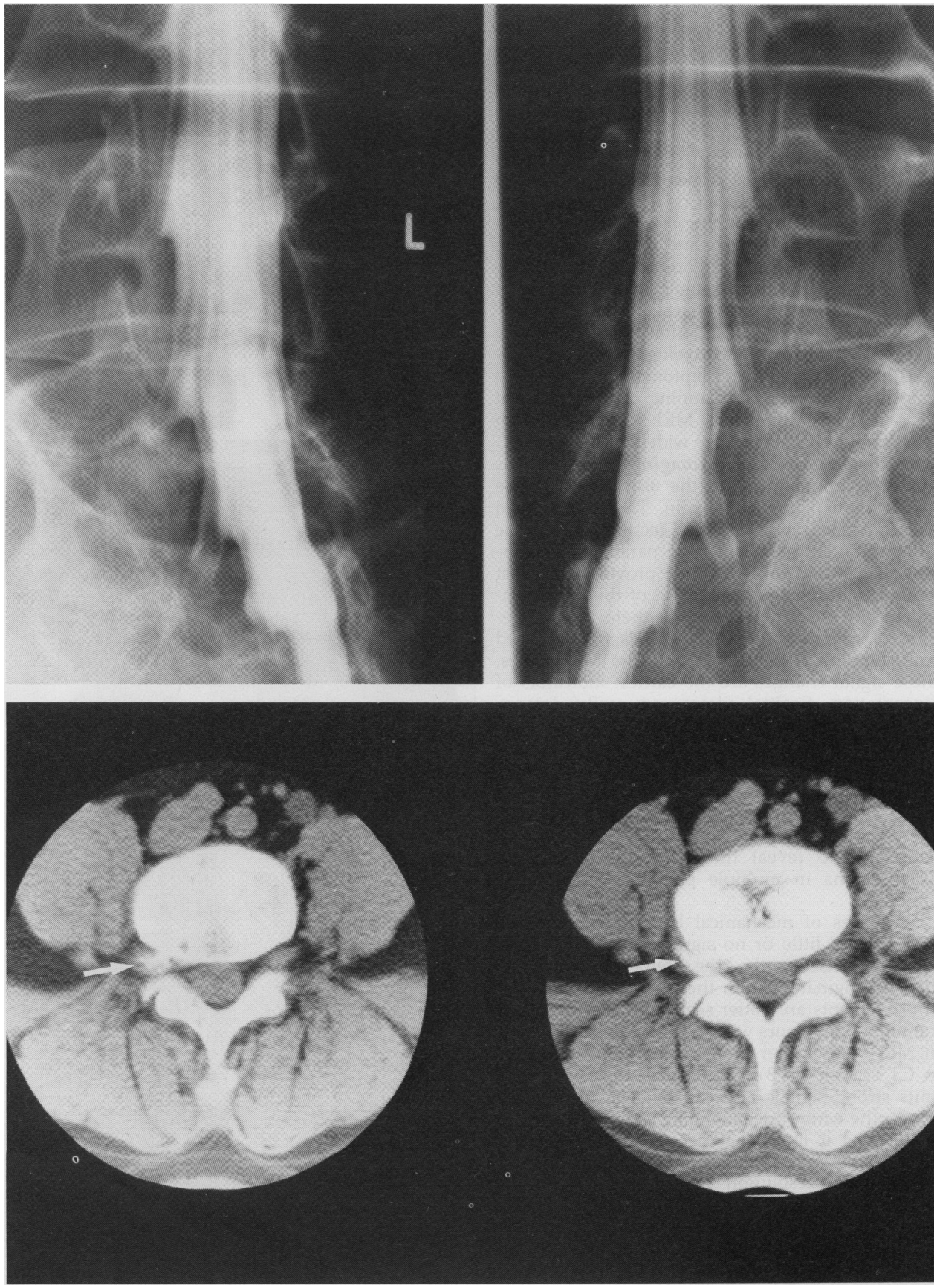

Fig. 1 — Top: Oblique views of lumbar region on myelograms obtained with water-soluble contrast medium in 50-year-old woman with right-sided sciatica; no nerve-root deformity is evident. Bottom: Axial computed tomography (CT) scans at level of fourth and fifth lumbar vertebrae, showing calcified lateral disc herniation (arrows) and nerve-root compression outside axillary sleeve.

Myelography: As CT scanning and MRI become more widely available in Canada the role of myelography in the investigation of neurogenic pain will change. Myelography with the use of nonionic, water-soluble contrast media is helpful in examining the lumbar subarachnoid space and can accurately detect disc and bony lesions in 60% to 87% of cases.[20] The upper lumbar and conus medullaris regions are seen better with myelography than with CT scanning. However, comparisons between CT scanning and myelography have shown that the former is more accurate in detecting discogenic and neurogenic pain.[20-22] In cases of nonlocalizable or atypical neurogenic pain myelography or MRI may be superior to the relatively focused CT examination. Myelography may show signs of arachnoiditis and leptomeningeal carcinomatosis better than CT scanning or MRI can, but this will likely change as MRI with gadolinium enhancement becomes more widely available.[23]

Magnetic resonance imaging: Experience is rapidly accumulating with the use of MRI in the investigation of low back pain. There have been recent advances in surface-coil technology, cardiac gating, gradient refocusing and paramagnetic contrast agents, and MRI currently provides the most accurate morphologic evaluation of the intervertebral disc.[24] As discs degenerate there is derangement of nuclear protein that leads to decreased water binding and signal loss in the MR images. These signal changes are the earliest indicators of degeneration. Sagittal views can easily demonstrate disc bulges and herniations as well as intervertebral foramina and nerve roots (Fig. 2). The results of early comparison studies have shown that MRI is at least equal to CT scanning and is superior to myelography in accurately detecting disc lesions; MRI has the advantage of being able to reveal the conus medullaris and cauda equina in multiple planes without radiation.[25]

In cases of mechanical back pain related to bony disease little or no signal is generated from bone.[26] Consequently the hypertrophic bony changes originating from the facet joints and posterior elements are better seen with the use of CT scanning. Bony spurs will be shown as signal voids on MRI scans rather than as high-density lesions on CT scans (Fig. 3). Cartilage in the facet joints emits strong signals and can be seen in multiple planes; the earliest degenerative changes may thus be detected if the signal decreases.[18,26] However, CT scanning shows better bone detail and slightly better spatial resolution than MRI does and is probably still superior for investigating purely mechanical pain.

Radionuclide bone scanning: This method does not play a significant role in the investigation of most cases of low back pain. It is the most sensitive technique for detecting early signs of neoplastic or inflammatory disease;[27] however, these entities are rare, and the test is hampered by poor spatial resolution and low specifici-

Fig. 2 — Top: Axial CT scan at level of fourth and fifth lumbar vertebrae, showing large posterolateral disc herniation (arrow) on left side in 47-year-old patient with left-sided sciatica. Middle: Axial magnetic resonance (MR) image at same level, showing disc herniation (arrow). Bottom: Sagittal view of MR images, first and second echoes, showing disc herniation at several levels (arrows).

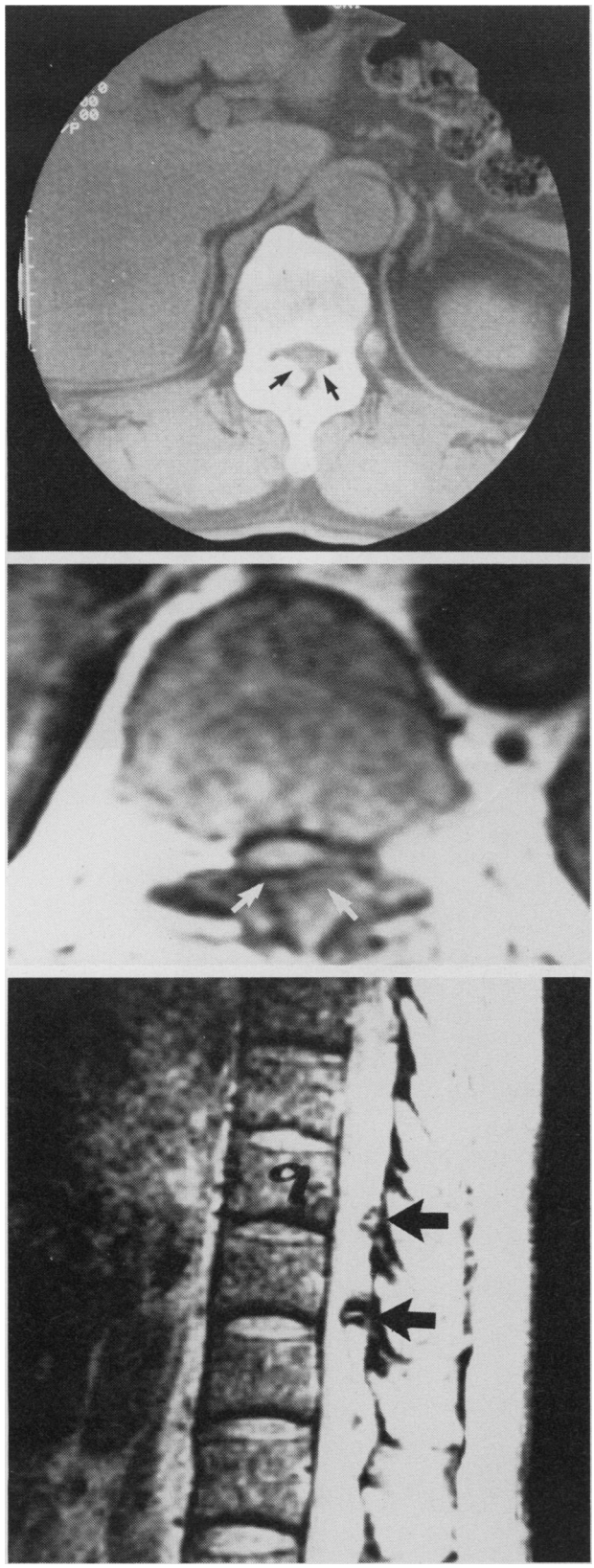

Fig. 3 — Top: Axial CT scan at level of 10th and 11th thoracic vertebrae, showing spinal stenosis (arrows) due to hypertrophic degenerative bony disease in 45-year-old man with low back pain and weakness in both legs. Middle: Axial MR image, showing bony lesions as low signal masses (arrows). Bottom: Sagittal MR image, showing bony lesions (arrows) causing posterior extradural compression of thecal sac.

ty. Radionuclide bone scanning should be used to screen for tumours or infection in unusual or atypical cases.

Epidural venography: This procedure, popular in the late 1970s, has become obsolete with the advent of high-resolution CT scanning. It involved transfemoral catheterization of the lumbar epidural veins and opacification of the internal vertebral plexus. Herniated discs were seen as filling defects in the ventral epidural space.[28]

Invasive tests

Many of the causes of mechanical and neurogenic pain can be detected by means of clinical assessment and the appropriate anatomic imaging techniques. However, some causes may be more complex and cannot be confirmed with the use of the previously described techniques. For example, standard anatomic test findings may be negative or equivocal, may correlate poorly with clinical findings or may reveal multiple levels of disease and uncertain levels of symptoms. Invasive tests may be helpful in these cases.

Discography: Controversy has surrounded the role of discography in the investigation of low back pain since the procedure was first described, by Lindblom, in 1948.[29] A positive result depends on exact replication of the symptoms through injection of a contrast medium directly into the nucleus pulposus of the disc in question. The many proponents have stated that the test is necessary to determine the extent of surgery in multilevel disease and that myelography, CT scanning or MRI may show the presence of disease but not whether it is symptomatic.[30,31] In many Canadian centres where CT scanning and MRI are unavailable discography may be the only follow-up test available after myelography.[32]

The more numerous opponents have stressed that discography is very subjective, invasive and technically demanding.[33,34] Incorrect needle placement can rupture the anulus, and the needle itself can replicate the pain of disc herniation. Faulty injection of the contrast medium can simulate the radiographic appearance of disc herniation and thus makes the films meaningless; false-positive results have been reported in up to 40% of cases.[35]

The consensus seems to be that CT scanning and MRI should be performed first if available. Discography should be done only in problem cases and only by experienced operators with very close clinical correlation.

Percutaneous nerve-root blocking: This procedure involves injection of bupivacaine hydrochloride directly into a lumbosacral nerve-root sheath immediately beyond its exit from the intervertebral foramen (Fig. 4). The patient is asked to determine if the pain resolves for the next 3 to 4 hours. It has been found that patients can identify the abolishment of their pain better than the reproduction of it, as in the use of discography. In

one study symptomatic nerve roots in the cervical region were correctly identified in 83% of the cases.[36] Similar results have been demonstrated in the lumbar region (R.G.H.: personal observation). In the hands of an experienced operator the needle placement is straightforward, and the procedure takes 10 minutes or less. Percutaneous nerve-root blocking is believed to be very useful in establishing the spinal level in patients with radicular pain.

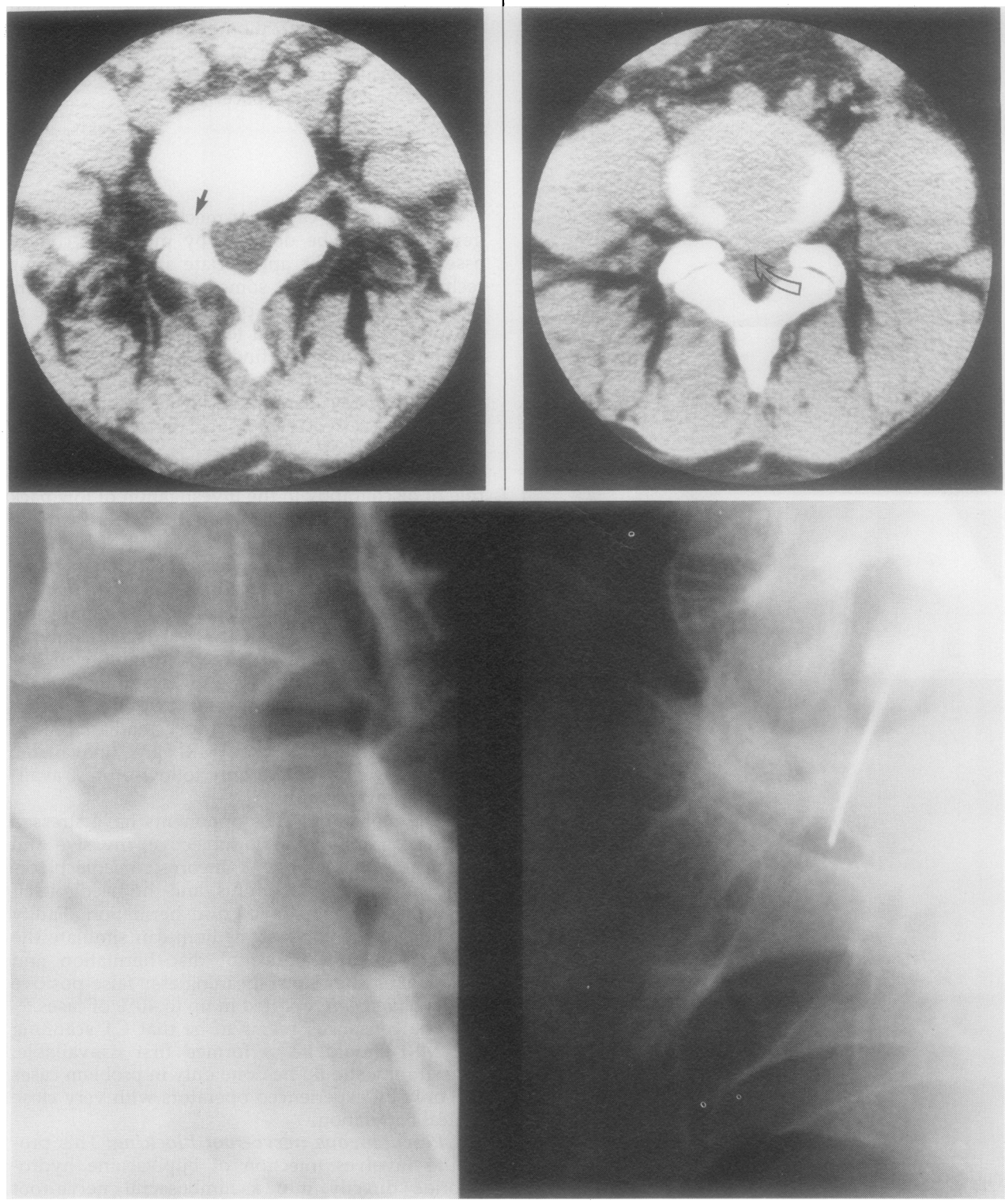

Fig. 4 — Top left: Axial CT scan at level of fifth lumbar and first sacral vertebrae, showing prominent lateral osteophyte with foraminal stenosis and nerve-root compression (arrow) on right side in 53-year-old woman with low back pain and right-sided sciatica. Top right: Axial CT scan at level of fourth and fifth lumbar vertebrae, showing large central and right-sided disc bulge (arrow). Bottom: Percutaneous nerve-root block at level of fifth lumbar and first sacral vertebrae, showing correct needle position just inferior to pedicles at these levels; lesion at level of fifth lumbar vertebra was found to be symptomatic.

Percutaneous injection of the facets: The facets play a key role in the pathogenesis of chronic mechanical pain and may also be the source of neurogenic symptoms. Percutaneous injection of the facets was first used to relieve mechanical facet pain but now may help in differentiating facet from discogenic pain. Injection of a local anesthetic and a steroid directly into the facet can relieve pain initially in up to 60% of patients and for 6 to 12 months in 30% to 46%.[37] Although data on long-term follow-up are lacking, the procedure is easy, and the results are often dramatic.

Conclusions

Low back pain is a complex problem, and the strict imaging protocols may not be flexible enough to suit each case. Some general conclusions, however, can be drawn from the clinical experience.[3] Plain-film radiography seems to have a very limited role in the diagnosis of low back pain and a minor role in identification of the cause of chronic pain. CT scanning is the most widely available and most effective noninvasive technique for demonstrating discogenic and bone-related pain. Myelography is reliable but will likely diminish in popularity as CT scanning and MRI become more widely available. Myelography and MRI have the advantage of being able to survey the entire cauda equina and conus medullaris in atypical cases in which a tumour is suspected. In the hands of an experienced investigator invasive techniques, particularly percutaneous nerve-root blocking, have a useful role in cases of radicular pain that cannot be localized by means of the noninvasive anatomic methods. Percutaneous injection of the facets should be considered in patients with acute and chronic mechanical pain, particularly those who do not respond to conservative treatment.

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