DIAGNOSIS AND TREATMENT OF PAINFUL NEUROLOGICAL DISORDERS CAUSED BY SPONDYLOSIS OF THE LUMBAR SPINE

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Investigation of the specific causes of radicular pain and neurological alterations in patients with spondylosis has resulted in a greater appreciation of the contributory role played by osteophytes. Involvement of the spinal cord and nerve roots in the cervical region has received ample recognition during the past 10 years and a well documented syndrome has been established; one that has often been confused with demyelinizing diseases, amyotrophic lateral sclerosis, primary and posterolateral sclerosis, neoplasm and myelopathies of a nonspecific nature. This report will focus attention on the results of compression of the cauda equina and lumbarcal nerve roots in lumbar spondylosis. Earlier papers have dealt with this subject in a fragmentary manner. This presentation will review all of the accumulated cases and experiences in the diagnosis and treatment.

Spondylosis, often referred to as arthrosis or osteophytosis, begins as a degeneration of the intervertebral disc relatively early in life. Progressive dehydration and fibrillation of the annular fibrocartilage is followed by a loss of turgescence with thinning and outward bulging of the annulus fibrosus. The connection of the spinal ligaments to the periosteum at the ring epiphysis is loosened with deposition of new periosteal bone between the elevated periosteum and the original corticalis of the vertebral body. Osteophytes formed in this manner may protrude into the spinal canal and intervertebral foramina and result in significant compression of the soft, neural structures traversing them. Progressive stenosis or a sudden protrusion of disc tissue into such constricted areas, even if small, may result in irreversible damage. In contrast to the cervical and thoracic spine, the absence of spinal cord below the 1st lumbar level makes it possible for a considerable degree of spondylosis to occur before neurological symptoms appear. Spurs on the anterolateral portions of the vertebral bodies are rarely symptomatic. However, the posterior and posterolateral protrusions cannot be ignored as a potential source of trouble. The true extent of stenosis of the spinal canal caused by osteophytes may not be fully appreciated on plain roentgenograms because of the presence of unossified osteoid tissue.

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in these structures. Myelography is a possible means of identification under such circumstances.

The syndrome produced by neural compression in the lumbar area is manifested by increasing disability, severe radicular pain being conspicuous. Weakness associated with atrophy, sensory alterations and, in advanced cases, profound and often irreversible loss of sphincter control may be found. The findings may simulate those caused by neoplasm and herniated discs in this area. The combination of a herniated disc at one level and significant spondylosis at the same or at an adjacent level may co-exist. To treat one and ignore the other may result in failure to relieve symptoms.

Unusual narrowing of the spinal canal has been encountered while exploring certain individuals suspected of having herniated discs. The ligamentum flavum, neural arches and articular processes were abnormally thickened, contributing to further stenosis of the canal. Initially, it was felt that the structural alterations were part of a general process of spondylosis of advanced degree. These alterations in many respects resembled those found during laminectomy in young achondroplastic dwarfs, representing a type of congenital malformation. Verbiest\textsuperscript{13,14} has described similar alterations, in otherwise normal individuals, which he refers to as "developmental narrowing." Schlesinger and Taveras\textsuperscript{16} reported on a similar group and recommended interpediculare measurements in multiple-root syndromes as a diagnostic aid. Variations of this character may render such individuals susceptible to critical injury of the neural structures by spurs or protruding disc tissue of relatively minor degree.

Gill\textsuperscript{13} has indicated that the individual with a transitional 5th lumbar vertebra also has a smaller neural canal at this level, approximating in size that of the 1st sacral segment. Since the canal of the transitional vertebra must accommodate the same nerve-root content as a normal 5th lumbar vertebra, a slight protrusion of disc tissue or a spur will quickly give rise to symptoms of nerve-root compression as in the achondroplastic or dyschondroplastic spine. The most effective treatment includes laminectomy and excision of the involved tissue whenever practicable.

Unlike the cervical syndrome, there are few reports describing the neurological changes produced by spondylosis in the lower portion of the spinal canal. Bailey and Casamajor\textsuperscript{1} presented 5 patients with "osteo-arthritis" of the spine and compression syndromes both in the dorsal and lumbar regions. They were among the first to emphasize the compressive effects of the yellow ligaments and in one of the surgically verified cases described the unusual thickening of the lamina referred to in 3 patients of this series.

In discussing a syndrome of cauda-equina radiculitis, Cramer\textsuperscript{6} noted marked "arthritis" changes in the lumbar vertebrae in 18 of 26 cases. In each of these patients, laminectomy revealed a red and swollen appearance of the caudal roots which was related to bony and arthritic changes, "spurs and hypertrophic spondylitis" and not to inflammatory disease per se. All showed temporary or more lasting improvement after laminectomy. The
clinical picture differed in no essential respect from that described in the present report.

PRESENTATION OF CASES

There were 14 patients in the present series; 8 were men and 6 were women. The age varied from 29 to 66 years. The majority were in the fifth and sixth decades of life. In all, low-back pain was the outstanding complaint, with radiation down one or both lower extremities in a radicular pattern. The duration of symptoms was from 3 weeks to as long as 10 years, with 1 patient presenting recurrent difficulty over a 20-year period. Four patients had symptoms between 1 and 3 years, 5 less than 8 months. During the interval preceding surgery, disability had increased despite rest in bed, traction, the use of various supportive devices and physical therapy. All were subjected to myelography and surgery.

Clinical Syndrome. Symptoms were bilateral in 9 patients; in 3 pain was more intense on one side than the other. In the remaining 5 patients, unilateral pain in the extremity dominated the clinical picture. In these, the syndrome could not be differentiated from the usual picture of a herniated intervertebral disc. Trauma could conceivably have been a precipitating factor in 4 patients; lifting a heavy object was the immediate cause of distress in 3, a fall with a back injury in 1. Most patients were unable to recall a specific event. Exacerbations had occurred spontaneously and with such frequency over an extended period that no useful information could be obtained in this regard. The majority of patients complained of increasing distress on standing and walking, on sitting and during postural changes. Coughing, sneezing and straining caused pain in about one-half of this group. Many had achieved some measure of relief with prolonged rest in bed, except for 1 patient whose symptoms were aggravated by this position. Exacerbations were abrupt in onset, rapidly progressing to total disability in those with bilateral symptoms. Occasional burning pain was present, spreading into the extremity from the low-back area. There were complaints of numbness and coldness, as well as severe, spasmodic cramping sensations in the lower part of the back and in the posterior areas of thigh and calf. Changes in sphincteric function were observed in 4 patients, all with bilateral difficulties. Such alterations extended from occasional incontinence with stress to total loss of control of rectum and bladder in 1 patient. Difficulty in initiating the urinary stream was a common disorder in those patients who did not progress to the greater state of disability.

Weakness of the distal musculature was present in the lower extremities of all patients with evidence of atrophy and occasional fasciculations. Bilateral foot-drop was observed once. Reflexes were depressed to absent in the lower limbs, the ankle jerks being most seriously affected. Sensory changes were less conspicuous, being absent in 5 patients, but evident in the remaining members of this group, the deficit involving either single or multiple dermatomes in an irregular pattern. Pain and touch were more
seriously disturbed than appreciation of position and vibration. The defect was found in the L5 and S1 dermatomes and included the remaining sacral areas, depending upon the severity of nerve-root compression. These findings varied from a mild subjective change to saddle anesthesia. Sensory alterations did not always follow the change in status of reflexes and were often disproportionate. The Lasègue maneuver was usually positive during acute exacerbations, when loss of lumbar mobility, flattening of the lumbar curve and spasm of paravertebral muscles were noted. When less acute, this test was surprisingly negative, even in the presence of considerable neurological deficit and varying discomfort.

Radiological Findings. Roentgenograms of the spine disclosed evidence of spondylosis at either single or, more often, multiple levels in the lower lumbar region. Interspaces were narrowed and osteophytes at the vertebral margins encroached upon the intervertebral foramina. Spondylolisthesis without spondylylosis was evident in the more advanced cases. In one, the body of L4 was dislocated anteriorly upon the body of L5, a complete block resulting within the spinal canal. Plain roentgenograms were described as “not remarkable” in 2 patients aged 29 and 49, an isolated spur being noted in another.

Myelographic evidence of a complete transverse block at single or multiple levels was apparent in 3 patients, incomplete in 5, deformities of the axillary pouch being present in the others. The oil would pool characteristically in the hollow of the vertebral bodies, being broken by the ridges formed by protruding disc tissue and osteophytes, yielding a stepladder or “washboard” effect (Fig. 1). In lateral exposures, the oil possessed a teardrop or sinuous, beaded profile. A toothed pattern was seen in the anteroposterior projection, the latter being caused by multiple nerve roots projecting into the narrowed column of oil (Fig. 1). The defects outlined the various bulges into the spinal canal at the level of the interspace, pinching off the column of oil against the overlying lamina and yellow ligaments investing the canal. In 6 patients, the alterations in the axillary pouches at the level of the interspace were the primary abnormalities. There was loss of the normal tented appearance of the axillary profile, leaving an irregular defect extending towards the midline (Fig. 2). The 3rd, 4th and 5th interspaces were the sites most seriously affected. On one occasion, the anteroposterior exposure on myelography showed no deformity. However, the lateral projection showed a spur of diagnostic significance (Fig. 3).

Cerebrospinal Fluid. In the presence of extreme narrowing of the canal, the defects described above crossed the midline, producing a complete block. During myelography, we attempted to insert the lumbar-puncture needle above the level of the suspected lesion. However, in 2 cases, it was inserted below the lesion and in 1 a Froin syndrome was present. The protein content of the fluid was 180 and 190 mg. per cent. Often, no fluid could be obtained when the needle was inserted at either the L4–L5 or L3–L4 interspace. In these cases, insertion of the needle at a higher level was successful,
advanced changes at the lower interspaces making it impossible to enter the dural sac. Spinal-fluid protein was normal or slightly elevated in the remaining cases, in which a lesser degree of obstruction was present, and in which the needle had been inserted above the level of greatest pathology.

*Operation.* This consisted of a decompressive procedure and was dictated by the severity of the alteration observed on myelography. It was performed in the crouch position in all patients. It was of considerable interest that the plain films of the spine often did not indicate accurately the extent of the ridge of tissue that traversed the canal. Myelography outlined the size and the type of the defect, and was far more reliable as a guide in planning the operation. A complete laminectomy was mandatory in those patients manifesting partial or complete block. Every effort was made to spare as much of the articular facets as possible. The success of the procedure ap-
Fig. 2. Myelogram of another 60-year-old physician with bilateral sciatica of a severe degree of 2 years' duration. There are notch-like deformities in the column of oil at the level of 3 interspaces in the anteroposterior projection and the typical sinuous pattern is shown in the lateral view.

Patient was relieved of pain and returned to practice for 1 year, then retired to a more sedentary life.

peared to depend on the adequacy of the decompression provided by removal of laminae, yellow ligament, and bony structure about the intervertebral foramen, as well as by the removal of the underlying ridges. Operation usually covered multiple segments.

In 3 patients of this group, a very definite malformation accompanied the above-described spondylosis. There was tremendous thickening of the laminae with the pedicles appearing closer together than normally encountered, the combination resulting in a narrow canal of the type described earlier as developmental. The facets and articular processes were unusually prominent and approached the midline, almost touching the spinous process. This made laminectomy extremely difficult. The similarity to the spine in the achondroplastic dwarf was striking. Ridges of bone or of dense fibrous tissue, when accessible anterior to the nerve root or to the theca, were removed, using pituitary rongeurs and sharp curettes. All degenerated
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Fig. 3. Myelogram of a 53-year-old woman with an 8-year history of bilateral sciatic pain, more severe on the left side. Collapse and fusion had occurred at the 4th interspace with no specific deformity in the myelogram in the anteroposterior projection. The lateral exposure, however, showed a prominent spur arising primarily from the inferior margin of the 4th lumbar vertebra.

Surgical result after laminotomy, foramenotomy and removal of spur was excellent.

disc tissue within the interspace was extracted. In the unusually narrow canals, where it was impossible to retract the nerve root or the dural envelope safely, a dorsal decompression by means of laminectomy and foramenotomy was all that could be achieved, and this alone proved to be adequate.

Frank extrusion of disc tissue, lying entirely free within the vertebral canal, was found in only 2 patients, both with significant degrees of spondy-
losis. In 1, the patient's illness was acute in onset, only 3 weeks in duration. The patient presented with a profound neurological deficit and with evidence of a complete block on myelography. The second patient, similarly, had an acute onset of symptoms with severe disability and a partial block on myelography. The amount of extruded material was small in both cases, in the aggregate measuring less than 1 cc. This was sufficient to further narrow an already stenotic canal beyond the tolerance required by the enclosed cauda equina.

Postoperative Course. There was early and at times striking relief of the severe radicular pain, often noted within the first 24 hours. When pain recurred, it was rarely of the disabling character present before surgery, except in 1 patient who approximately 1 year postoperatively experienced a gradual return of his former distress. This patient presented the longest history of pain in the back and extremity in the entire group. While his initial response was gratifying, his subsequent course was disappointing. Interlaminar laminotomy at multiple levels performed on this patient was felt to have been inadequate. Such a patient would now be subjected to total laminectomy and foramenotomy.

Sphincteric disturbances of an appreciable degree pre-operatively were poor prognostic signs. They usually remained as a serious problem throughout the postoperative course, both rectal and urinary incontinence persisting in 2 of the 3 patients so afflicted prior to surgery. After 9 months in the 1 woman with this problem, adequate function was restored. In 1 patient with only slight difficulty pre-operatively, severe disability in this regard developed after surgery. Improper use of rongeurs, with nerve-root compression at the time of laminectomy, resulted in a permanent loss of sphincteric function, emphasizing the need for a complete understanding of the bony architecture and the soft-tissue pathology. The insertion of a metallic instrument into the narrow canal, such as a retractor or tip of a rongeur, can further compress an already severely traumatized nerve root to the point of complete interruption of function.9

Postoperatively, improvement in sensation, reflex and motor power was noted in varying degree and no specific pattern could be defined. Those with a short duration of symptoms and a less severe deficit showed most improvement. With relief of the disabling pain, the majority of these patients returned to former or restricted activity of variable degree. The reflex status was slow to improve and was in no way related to functional capacity. There were 4 excellent results in this group with restoration of former activity, and 4 good responses with return to useful functional capacity, with minimal restrictions. Three modest responses were noted with persistence of varying pain and restriction of activity yet with appreciable improvement. The 3 remaining patients must be regarded as failures, difficult if not impossible to rehabilitate adequately, 2 because of sphincteric dysfunction, and 1 because of recurrent, intractable pain. Rehabilitation has been facilitated by reorganization of the lives of many of these patients, reducing occupa-
narrowed to far ligamentous

There were no deaths in this series. The patients have been followed for periods of from 6 months to 7 years, the average interval being from 2 to 3 years.

DISCUSSION

An accurate understanding of the anatomical relationships of the nerve root and the foraminal boundaries is essential for understanding the mechanism of compression in this disease. The upper and lower boundaries of the intervertebral foramen are formed by the pedicles of the two opposing vertebrae. Posteriorly, the superior and inferior articular processes with the ligamentum flavum form the dorsal roof. Anteriorly lie the intervertebral disc and the adjacent vertebral bodies. Postural changes result in variation of the size of this opening which in the lumbar area is normally five to six times as large as the diameter of the nerve passing through it, allowing for a generous reserve cushion. Dorsal extension and lateral bending decrease the diameter of the foramen by as much as one-third.

In spondylosis, encroachment upon the critical reserve space of the canal and foramen occurs. Thinning of the intervertebral disc results in approximation of the pedicles, reducing the cephalocaudal diameter of the foramen. Osteophytes projecting backwards from the vertebral margins further contribute to foraminal constriction. As the disc narrows, the lower vertebra is wedged forward because of the incline to the plane of the posterior articulation, resulting in a reverse spondylolisthesis, decreasing the antero-posterior diameter of the foramen and the spinal canal by a step-like deformity. With this subluxation, the upper tip of the lower articular process projects into the foramen (Fig. 4). Associated hyperplasia or ossification of the ligamentum flavum further compromises this important reserve space. Bulging of the degenerated annulus backwards and laterally displaces the nerve root against the unyielding uppermost pedicle. As a result of compression and chronic irritation, fibrotic changes and adhesions develop in and about the nerve. These alterations have been well documented by Hadley. Persistent and irreversible disability despite surgical decompression may well be referred to such changes.

The present surgical measures advocated are not as yet fully established and much remains to be refined and elaborated in order to improve results. A more comprehensive understanding of the alterations in the bony and ligamentous investments of the spinal canal and foramina with advancing age, in response to stress, movement and postural changes is mandatory in planning treatment. An appreciation of congenital alterations, which are far more common than anticipated previously, should alter our approach to this problem effectively. As has already been indicated, developmentally narrowed canals require more aggressive decompressive measures than simple interlaminar laminotomy in order to provide better results. No effort
has been made to include the large number of patients with herniated discs in whom spurs of secondary importance form part of the mass protruding into the spinal canal.

The present problem is approached best by the combined efforts of the orthopedist and neurosurgeon. The unfortunately prolonged period of “conservative” treatment is deserving of re-evaluation in the light of present innovations. A hopeless attitude regarding the surgical approach to this issue is no longer tenable.

Cordotomy need not be considered necessary for the relief of pain in these patients. Laminectomy and foramenotomy are less hazardous than unilateral or bilateral cordotomy in the upper thoracic or cervical regions. Not only can pain be relieved, but motor and sensory changes may regress and function of the bladder improve.

SUMMARY

In spondylosis, injury to the spinal cord and nerve roots is caused by narrowing of the vertebral canal and intervertebral foramina by protruding osteophytes. Symptoms are progressive in nature and may be confused with those caused by spinal cord tumors and herniated discs.

In patients with lumbar involvement, pain is a conspicuous feature, involving the lower part of the back and spreading down one or both extremities in a radicular pattern. In advanced cases, sphincteric function can be seriously compromised, a grave prognostic sign. Mobility of the back is restricted; reflexes, especially at the level of the ankle, are depressed to absent. Sensory changes may involve multiple dermatomes. Weakness and atrophy may be profound, and fasciculations frequent.

Conservative treatment may provide temporary relief by means of im-
mobilization and traction. With an advancing neurological deficit despite such measures, decompression by means of laminectomy and foramenotomy with removal of osteophytes and ridges can provide improvement in from 50 to 70 per cent of patients. Congenital narrowing of the canal in the lumbar region, alone or with disc and spondylotic changes, appears to be a definite but inadequately appreciated clinical entity. In this group of patients, minimal protrusion of disc tissue or spur formation in the ventral quadrants of the spinal canal results in painful and disabling nerve-root compression. Decompressive laminectomy over multiple segments is the treatment of choice. A hopeless attitude regarding the surgical approach to this problem is no longer justified.

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These patients have been assembled from the Neurosurgical Services of the Long Island Jewish Hospital, New Hyde Park, New York; The North Shore Hospital, Manhasset, New York; The Mount Sinai Hospital, New York City, and St. John's Episcopal Hospital, Brooklyn, New York.

REFERENCES