COMPRESSION OF THE CERVICAL SPINAL CORD BY
HERNIATED INTERVERTEBRAL DISCS

PAUL C. BUCY, M.D., ROBERT F. HEIMBURGER, M.D., AND HAROLD R.
OBERHILL, M.D.
The Chicago Memorial Hospital and College of Medicine, Department of Neurology and
Neurological Surgery, University of Illinois, Chicago

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The difficulties in differentiating some instances of degenerative disease of the spinal cord from compression of the spinal cord could be thoroughly illustrated from almost any experienced neurologist's practice. Nevertheless, errors in making such a differentiation continue to be relatively common. Because of the frequency with which obstruction of the spinal subarachnoid space, as demonstrated by Queckenstedt's maneuver, and an elevation in the protein content and a xanthochromia of the spinal fluid are observed with intraspinal neoplasm, it has become commonplace to expect these important diagnostic findings with all lesions that compress the spinal cord. Unfortunately, they are by no means always present. Although numerous examples of spinal cord tumor could be cited in which one, two or even all of these alterations were lacking, it is even more common to find these criteria lacking with non-neoplastic compression of the spinal cord. In fact, it has been our experience that with median herniations of cervical intervertebral discs which impinge upon the spinal cord these findings, upon which such great dependence is often placed in making a differential diagnosis, are often lacking. This fact plus the facts that there are often few or no symptoms pointing to the neck or even the upper extremities, that simple X-ray examinations of the cervical spine are often negative, and that the neurological signs and symptoms are either confined to, or predominate in, the motor system makes differentiation of such herniations from multiple sclerosis, primary lateral sclerosis, and amyotrophic lateral sclerosis often most difficult.

This is not a new observation. Median herniations of the cervical intervertebral discs with compression of the spinal cord have been described by many observers since Stookey,\textsuperscript{22} in 1928, so clearly delineated this problem (Elsberg;\textsuperscript{6,7} Adson;\textsuperscript{1} Peet and Echols;\textsuperscript{16} Mixter and Barr;\textsuperscript{15} Mixter and Ayer;\textsuperscript{14} Hawk;\textsuperscript{9} Love and Camp;\textsuperscript{12} Craig and Shelden;\textsuperscript{5} Stone, Arief, Kaplan and Brown;\textsuperscript{21} Péron, Lereboulet, Guillaume and Dumas;\textsuperscript{17} McKenzie and Botterell;\textsuperscript{13} Haynes;\textsuperscript{10} Portugal;\textsuperscript{18} Epstein and Davidoff;\textsuperscript{8} Broager;\textsuperscript{2} Kahn;\textsuperscript{11} Bradford and Spurling;\textsuperscript{2} and others). Many of these observers have pointed out the similarity between the symptoms that arise as the result of a median herniation of a cervical intervertebral disc and those commonly associated with degenerative disease of the spinal cord. Nevertheless, it is still not commonly appreciated that spasticity and weakness in the lower extremities, often with considerable disturbance of equilibrium, developing without
obvious cause in a young adult, with no or trivial sensory abnormalities, with or without discomfort in the neck, and with little or no sensory or motor alterations in the hands, and frequently with no, or minimal, changes in the spinal fluid, may be the result of compression of the spinal cord in the cervical region. Furthermore, it is of the greatest importance that such cases be recognized early and promptly treated if serious, irreparable damage to the spinal cord is to be avoided.

It is for the purpose of emphasizing these points, and of illustrating the diagnostic criteria of median herniations of the cervical intervertebral discs that we are reporting 4 recent cases of this type.

Case 1. H. G., truck-driver, 39 years old. Weakness in knees and unsteady gait, 5 weeks; numbness of 3rd, 4th, and 5th fingers, 4 weeks; unable to work, 3 weeks. Constipation. Examination—Mild hypalgesia 3rd, 4th and 5th fingers and ulnar borders of hands; spasticity in legs; unsteady gait; hyperactive tendon reflexes; Hoffmann's sign; 80 mg. per cent protein in spinal fluid; obstruction of spinal canal to pantopaque. Operation—Removal of herniated intervertebral disc from between C5 and C6. Recovery.

H. G., a 39-year-old truck-driver, referred by Dr. Richard Bubolz of Chicago, was admitted to The Chicago Memorial Hospital on Mar. 25, 1947. For several years he had noted a slight aching pain at the base of his neck posteriorly after driving his truck a hundred miles or so. This is not an uncommon complaint among truck-drivers. Apart from this minor complaint he had been well until 5 weeks before admission, when he noticed a weakness in his knees on awakening in the morning. He was forced to walk with his feet spread widely apart and to take short steps in order to maintain his balance and even then he staggered. He did not fall. These symptoms grew steadily worse. About a week after the onset there developed a numbness of the 3rd, 4th, and 5th fingers of each hand and across the lower part of his back and abdomen. Three weeks before admission he was forced to cease driving his truck. For 2 weeks prior to admission he had been constipated but there was never any disturbance of urination.

His past medical and family histories seemed unrelated to his present complaints.

Examination. He was a very well developed, well nourished man. The general physical examination was entirely negative. There was no stiffness or tenderness of his neck. There was no evidence of any disturbance of the cranial nerves. The only sensory disturbance was a mild hypalgesia of the ulnar aspect of both hands and of the 4th and 5th and the ulnar half of the 3rd fingers. There was no muscular weakness anywhere. There was a slight spasticity in both lower extremities. Coordination on the heel-to-knee test was slightly impaired on both sides. On Romberg's test he swayed toward the right. He walked with his feet spread widely apart. He could not hop on either foot alone or walk tandem with one foot in front of the other. The knee jerks and ankle jerks were equally hyperactive in both lower extremities. Plantar stimulation elicited a plantar flexion of the great toe on the right side and no response on the left. Hoffmann's sign was present bilaterally, more marked on the left. The left abdominal reflexes were more vigorous than those on the right side.

Urinalysis, the blood count and the Wassermann and Kahn tests on the blood were all negative.

A lumbar puncture was made. The initial pressure was 90 mm. of fluid. The pressure rose rapidly and freely on jugular compression and fell freely when the compression was released.

At the conclusion of this examination we were confronted with a relatively young man who was suffering from a rather rapidly developing disability of his legs consisting of slight spasticity, hyper-reflexia and ataxia and dysequilibrium so severe that he was forced to cease work. There was no evidence of any obstruction of the spinal canal. It seemed most likely that he was suffering from multiple sclerosis with involvement of the descending motor pathways and the spinocerebellar tracts in the lateral columns of the spinal cord. A few days later the
following report was received. The spinal fluid contained no white blood cells. The Wassermann test was negative and the colloidal gold curve was 0000111000. There was a trace of globulin on Pandy’s test and the total protein was 80 mg. per cent. This finding suggested the possibility of an expanding intraspinal lesion rather than a degenerative one.

Fig. 1. Case 1. (a) Lateral roentgenogram of cervical spine. It is essentially negative but careful examination reveals a very slight narrowing of the intervertebral space between the 5th and 6th cervical vertebrae. (b) Myelogram shows the pantopaque arrested at the level of the interspace between the 5th and 6th cervical vertebrae.

X-ray examination of the cervical spine was negative except for a very slight narrowing of the intervertebral foramen between the 6th and 7th cervical vertebrae bilaterally, and an equally slight narrowing of the intervertebral disc between the 5th and 6th cervical vertebrae (Fig. 1a). These findings were too trivial to be of diagnostic value. In spite of the normal findings on Queckenstedt’s test and because of the increase in the amount of protein in the
spinal fluid, 3 cc. of pantopaque were injected into the lumbar spinal canal. The patient was then tipped head downward and the passage of the oil was observed under the fluoroscope. The pantopaque was completely arrested at the interspace between the 5th and 6th cervical vertebrae (Fig. 1b).

Operation. On April 1, 1947 a laminectomy of the 5th and 6th cervical vertebrae was made. The spinal cord was found to be pushed sharply backward at this level and with each respiratory movement it rocked back and forth over a mass lying anterior to it. The dentate ligaments were severed from the dural walls on both sides. The spinal cord was retracted ex-

posing a large mass lying anterior to the dura mater in the central portion of the spinal canal at the level of the interspace between the 5th and 6th cervical vertebrae, somewhat more to the left of the midline than to the right (Fig. 2). This mass consisted of several firm cartilaginous chips which were molded together into a hard well-circumscribed mass. A large portion of this herniated disc material was removed extradurally but the more central portion had to be removed by retracting the spinal cord and making an incision in the dural sac anteriorly.

Microscopic Examination. The tissue removed at operation was typical fibrocartilage (Fig. 3a).

Postoperative Course. Following the operation he had some unpleasant paresthesias of his hands for a few days but these soon subsided and he recovered promptly. He was allowed up and about on the 8th postoperative day and was discharged to his home on the 12th day after the operation. At home his improvement continued steadily. On June 30th, 3 months
after the operation, his walking was normal. He could walk with one foot in front of the other without difficulty. He swayed slightly on Romberg’s test. His reflexes were normal. He had no pain or numbness. Thereafter he returned to work.

Comment. In retrospect the explanation of the symptomatology is easy here. Yet at the time the diagnosis was not readily apparent. If we had
relied upon the oft repeated erroneous dictum that it is useless to make a myelogram in cases where Queckenstedt’s test reveals no evidence of a complete or partial block, the proper diagnosis might well have been long delayed here. Such a delay may well prove harmful. Both Stookey\textsuperscript{22,23} and Elsberg\textsuperscript{7} have noted that the results of removal of these median herniations of the cervical intervertebral discs are often not good. This they attributed in part to prolonged traumatization of the spinal cord by the hard mass. However, this case (symptoms for 5 weeks) and Elsberg’s Case 5 (symptoms for only 2 months) clearly indicate that where such masses can be removed early excellent results may be obtained.

It is obvious that the subjective paresthesias and the mild hypalgesia of the 3rd, 4th, and 5th fingers of both hands are not symptoms of involvement of the 6th cervical roots at the level of the herniation. Instead they must be attributed to other factors. Compression of the 6th cervical root, a not uncommon result of a laterally lying herniation, typically produces sensory disturbances in the thumb.

Three months after the first patient was seen another with very similar symptomatology was admitted. Benefiting by our earlier experience the proper diagnosis was immediately recognized.

Case 2. E. R., meat dealer, 33 years old. Numbness of hands, 4 months; fingers clumsy and handwriting deteriorated; staggered; clonus at ankles on bracing his car. Examination—No definite sensory alterations; hands and fingers awkward; writing poor; all tendon reflexes hyperactive; Hoffmann’s sign; sustained ankle clonus; no Babinski; gait unsteady; spinal fluid normal; X-ray picture cervical spine normal; pantopaque obstructed. Operation—Excessive extradural vascularity; herniated disc removed from between C4 and C5. Recovery.

E. R., a 38-year-old wholesale meat dealer, referred by Dr. C. H. McKenna of Chicago, was admitted to The Chicago Memorial Hospital on June 24, 1947. Four months prior to admission he began to have numbness in both hands. This he described as similar to the sensation present after exposure to extreme cold. The sensation was present even when the skin of the hands was warm. His fingers became clumsy, especially in buttoning his clothes, dealing cards, and other activities requiring dexterity. He found that it took him one hour, instead of the usual half hour, to dress himself. His handwriting also changed during this period, so that he had some trouble in cashing his checks. These symptoms became increasingly severe.

During the same period he began to stagger while walking. The staggering was not affected by exercise or fatigue. He was unable to walk slowly because of difficulty in maintaining his balance, and he had to hold on to something when standing still. His feet frequently “danced” (clonus), particularly when he attempted to use the foot brake on his car.

In his work as a meat dealer he had become accustomed to throwing up baskets of meat weighing 100 to 150 pounds and catching them across his shoulders and the base of his neck to get them into a position for carrying.

The past and family histories seemed unrelated to these complaints.

Examination. He was very well developed and well nourished. The general physical examination was negative. The blood pressure was 106/80. On neurological examination there was no evidence of any disorder of the cranial nerves. There were only slight and indefinite alterations in sensibility. Pin prick was readily perceived but elicited a tingling sensation over the left foot and ankle. The outlines of this paresthetic area were not well defined. The perception of light touch with cotton was diminished in this same area. Position sense of the digits, vibratory sense, and the localization of areas stimulated, were intact everywhere. Stereognosis was less acute in the left hand than in the right and the perception of numbers written on the skin seemed less acute on all four extremities than is usual in most people. There
was no definite muscular weakness but he was very awkward in manipulating small objects with his hands, and his writing was poor. The tendon reflexes in the arms and in the legs were all hyperactive and equal on the two sides. Hoffmann's sign was present bilaterally and a sustained clonus could be elicited at both ankles. Babinski's sign was not present on either side. He walked on a wide base with his feet spread apart and he was unsteady, especially if

![Fig. 4. Case 2. (a) Lateral roentgenogram of cervical spine revealing no abnormality. (b) Myelogram reveals an obstruction of the column of pantopaque at the level of the interspace between the 5th and 6th cervical vertebrae.](image)

he walked slowly. Walking with one foot in front of the other and hopping on either foot alone were poorly done. There was no stiffness or tenderness of the neck.

Urinalysis, the blood count and the Wassermann and Kahn tests were all negative.

A lumbar spinal puncture was performed. The initial pressure was 110 mm. of fluid. On compression of the jugular veins the pressure rose slowly to 250 mm. and when the compres-
sion was removed the spinal fluid pressure fell slowly back to normal. The spinal fluid contained no white blood cells. There was a trace of globulin on Pandy's test. The total protein was 50 mg. per cent. The colloidal gold curve was 000000000 and the Wassermann test was negative.

X-ray examination of the cervical spine revealed a perfectly normal picture (Fig. 4a). There was no narrowing of any intervertebral disc and no arthritic change. After the intrathecal injection of 3 cc. of pantopaque the spinal canal was examined under the fluoroscope. The column of iodized oil was partially arrested at the interspace between the 5th and 6th cervical vertebrae, when the neck was extended (Fig. 4b).

Operation. On June 27, 1947 a laminectomy of the lower cervical region was made. An unusually large and extensive plexus of epidural veins was found. It was divided between a series of silver clips. The dura mater appeared normal. It was incised. The dentate ligaments were severed from the dural wall and the spinal cord was rotated. No abnormality was exposed at the interspace between the 6th and 7th, or the 5th and 6th vertebrae, but at the interspace between the 4th and 5th vertebrae a large rubbery mass lay anterior to the dura mater just to the right of the midline and pushed the dura mater backward against the spinal cord. The spinal cord was gently retracted toward the left. The dura mater was incised anteriorly and a large herniation of the intervertebral disc was removed.

Microscopic Examination. The material removed at operation was typical fibrocartilage (Fig. 3b).

Postoperative Course. Following the operation the patient had considerable pain, numbness, and feeling of swelling in the hands. This gradually subsided. On the 7th postoperative day he was allowed up out of bed. His station and gait were unsteady at first but they soon improved. The tendon reflexes were still hyperactive at the time he was discharged from the hospital, 14 days after operation, on July 11th.

On August 15th he returned to work. Although the awkwardness of his hands, the unsteadiness in his walking, and the ankle clonus have steadily improved they had not, as yet, completely disappeared.

Comment. Here again we find paresthesias in the hands with little objective sensory change in the upper extremities or anywhere else. In addition there was a striking awkwardness of the hands here, and again there was little in the way of muscular weakness but there was definite spasticity with markedly hyperactive reflexes. His equilibrium was grossly disturbed. As in Case 1, there were no symptoms or findings directly referable to the cervical spine and the ordinary X-ray examination of the spine was not helpful.

In this case there was a partial block of the spinal subarachnoid space but the protein content of the fluid was raised little. The obstruction of the spinal canal which was shown with pantopaque myelography at the interspace between C5 and C6 was a partial one and demonstrable only when the neck was hyperextended. Obviously it was below the level of the lesion and the cause for it is obscure. Mixter and Ayer had a somewhat similar experience in one of their cases. They injected lipiodol into the cisterna magna and it seemed to be blocked at the 1st cervical vertebra, whereas the lesion lay between the 3rd and 4th cervical vertebrae. There is, of course, the possibility that in injecting the oil at the cisterna magna it was introduced into the subdural rather than the subarachnoid space and therefore remained near the site of injection. In Case 2 above, the oil was injected in the lumbar region and rolled freely through the subarachnoid space until it reached the lower cervical region.

The symptoms in this case had been present much longer (4 months)
than in Case 1 (5 weeks) and, although his postoperative recovery is satisfactory and he is able to return to work, his improvement has not been as rapid and, as yet, not as complete as in the first case.

During this same brief period of time a third patient suffering from the same type of lesion but with a different neurological picture was admitted to the hospital.

**Case 3. J. B., mechanic, 55 years old.** Head injury 1916, no known sequelae. Temporary numbness right leg, 3 months before admission; numbness left leg 3 months; progressive weakness right leg, later left leg. *Examination*—marked hypalgesia and hypothermesthesia, left side below 4th rib; slight weakness right elbow; weakness right knee; gait unsteady; hyperactive tendon reflexes; Hoffmann and Babinski signs on right; normal spinal fluid; obstruction to pantopaque. *Operation*—Removal of herniated disc between C5 & C6. *Recovery.*

J. B., a 55-year-old mechanic, who was referred by Dr. Edward J. Lewis of Chicago, was admitted to The Chicago Memorial Hospital on May 6, 1947. He had always been well except for a head injury in 1916. This had resulted in several hours of unconsciousness but he had then made a complete recovery without any apparent sequelae. About 3 months before admission his right leg had become numb. This, however, persisted for only a short time and then improved. Shortly after the onset of this condition numbness developed on the lateral aspect of his left leg and this persisted up to the time of his admission. This numbness of his left leg had been associated with his right leg which grew steadily worse. Some time after the right leg became weak the left leg became similarly involved but never to the same degree. At no time did he have any pain, any symptoms referable to the upper extremities, or any disturbance of the function of the bowel or bladder.

*Examination.* He was a well developed, well nourished man. The general physical examination was negative except that the prostate gland was somewhat enlarged and of a rubbery consistency. There was no stiffness or tenderness of the neck. On neurological examination the cranial nerves appeared to be intact except for an impairment of hearing in the left ear which had been present since the head injury in 1916. The only abnormal sensory finding was a marked hypalgesia and hypothermesthesia over the trunk and lower extremity on the left side from the level of the 4th rib downward. There was a slight weakness of extension of the right elbow and a weakness of flexion of the right knee. There was no muscular atrophy anywhere. Coordination was normal in all four extremities. He walked on a wide base with his feet spread widely apart. His gait was slightly unsteady. He tended to drag his right foot. Hopping on the right foot was poorly done. He could walk with one foot in front of the other without difficulty. The tendon reflexes were increased in the right upper extremity and Hoffmann's sign was present on that side. The right knee jerk and ankle jerk were hyperactive and Babinski's sign was present on the right side. The abdominal reflexes were active and equal bilaterally.

Urinalysis, blood count and Wassermann and Kahn tests on the blood were all negative.

A lumbar spinal puncture was made. The initial pressure was 180 mm. of fluid. The pressure rose rapidly on jugular compression to 300 mm. and fell freely when the pressure was released. The fluid contained no white blood cells. Pandy's test was negative. The total protein was 30 mg. per cent. The Wassermann test was negative and the colloidal gold curve was 0000000000.

X-ray examination of the cervical spine showed no narrowing of any of the intervertebral spaces (Fig. 5a). There was no erosion of any of the pedicles and no increase in the interpedicular distances. The spinal canal was examined under the fluoroscope after the intraspinal injection of 3 cc. of pantopaque. The oil passed freely up the spinal canal in the cervical region on the left side but met with a partial obstruction on the right side at the level of the interspace between the 5th and 6th vertebrae when the neck was extended (Fig. 5b). After the oil had run by the lesion into the upper cervical region the patient was turned around so that his head was uppermost. The pantopaque then ran down the spinal canal into the caudal sac except for a small globule which caught above the lesion on the right side (Fig. 5c).
Operation. A laminectomy was made on May 8, 1947. The spinal cord was pushed backward sharply at the level of the interspace between the 5th and 6th cervical vertebrae. With each respiratory movement the cord rocked back and forth over a mass lying anterior to it. Three dentate ligaments were divided on both sides. The spinal cord was retracted toward the left, exposing a large mass lying anterior to the dura mater, largely to the right of the midline. The dura mater was incised anteriorly and 12 fairly large pieces of intervertebral disc substance were removed.

Microscopic Examination. The tissue removed was typical fibrocartilage (Fig. 3c).

Postoperative Course. Following the operation he had some pain and paresthesias in the arms for 3 or 4 days. Thereafter he had no discomfort. The sensory level dropped to the 7th thoracic dermatome immediately after the operation and the sensory loss continued to disappear. He was up in a chair on the 7th day and left the hospital on May 19th, 11 days after operation. His gait was steadily improving. He returned to work 2 months after operation. On July 19th, the right hand was still a little more awkward than the left. His walking was almost normal. Sensation in all forms was intact everywhere. When last seen in July 1948 he had no symptoms and was working every day.

Comment. Here we see a primarily unilateral involvement of the spinal cord with a typical Brown-Sequard syndrome. The patient had noted some
weakness in the left leg but it was purely subjective. The almost complete absence of symptoms or findings relative to the neck or the upper extremities is striking. It is also notable that although the compression of the spinal cord was at the level of the interspace between the 5th and 6th cervical vertebrae, the upper limit of sensory loss was at the 4th rib. This phenomenon of the sensory level's being much lower than the location of the compression would lead one to expect, was noted by Stookey in his original paper.22

As in the first two cases, this man walked on a wide base and his gait was slightly unsteady, although his equilibrium was less disturbed than in the others. Spasticity was present but only on the side of the lesion.

Here the findings on spinal puncture and in the spinal fluid were entirely negative. Furthermore, the ordinary X-ray examination of the cervical spine was also negative. Fluoroscopic examination of the spinal canal with pantopaque was the only thing that gave an accurate localization of the lesion and demonstrated its obstructive and compressive character. Even this examination almost failed us—with the patient’s neck straight there was no demonstrable obstruction. Fortunately, however, we commonly do our fluoroscopic examination of the cervical spine with the head hyperextended to prevent the pantopaque from entering the intracranial cavity. This alteration from the usual position was enough to demonstrate the lesion, but when the neck was straightened the oil ran freely by.

Some time after the preceding patients had been seen a fourth one appeared, in whom the symptoms were so slight that their significance would probably not have been appreciated if we had not had these other examples to guide us. In spite of their relatively slight nature they were disabling and of considerable importance to the patient. They were somewhat different from those presented above.

Case 4. C. N., a taxi driver, 37 years old. Dec. 29, 1946, fell on head, right arm and shoulder. Pain and weakness developed in right shoulder and upper extremity. Hand and fingers clumsy. Examination—Hypalgesia ulnar border of hands; slight weakness right upper extremity; atrophy right deltoid and infraspinatus; hyperactive tendon reflexes; bilateral Hoffmann’s sign; questionable Babinski on right; mild disturbance of use of legs; spinal fluid negative; partial obstruction to pantopaque between C4 and C5; temporary Horner’s syndrome on right. Operation—Removal of herniated disc. Partial recovery.

C. N., a 37-year-old taxi driver, was referred by Dr. David Templin of Gary, Indiana. He was admitted to The Chicago Memorial Hospital on Nov. 19, 1947. On Dec. 29, 1946 he slipped on an icy sidewalk and fell, striking his right shoulder, elbow and his head. He suffered immediate pain and numbness in his right arm which subsided in about 15 minutes shortly thereafter a persistent pain developed over the point of his right shoulder and from time to time he had a tingling in the fingers of his right hand. He was off work from January 15 to March 1 because he could not handle a shovel. He worked for 7 days in March but because of persistent weakness and pain in his right shoulder and numbness in his right fingers he could not continue. Sometime later he began his present work as a taxi driver. In the summer of 1947 he had similar symptoms in his left hand, although they were much milder. His fingers gradually became clumsy in buttoning clothes and handling coins. The pain in his right shoulder and hand was aggravated by extending his neck, and he therefore carried his head slumped forward.
The past, medical and family histories were of no apparent significance in relation to the present complaints.

*Examination.* He was a very well developed, muscular man of stocky build. The blood pressure was 130/80. The heart, lungs and abdomen were negative on physical examination. The cranial nerves appeared to be intact. On sensory examination there was a diminution in the perception of pin prick over the ulnar borders of both hands. Stereognosis was less acute in the right hand. There was a slight weakness of the right upper extremity. The right infraspinatus and deltoid muscles were definitely atrophic and weaker than those on the left. The tendon reflexes in the arms and legs were all hyperactive. Hoffmann’s sign was present bilaterally. The abdominal reflexes were present and equal bilaterally. The plantar response was questionable on the right side, but was definitely flexor on the left. He walked with his feet somewhat separated and handled his right leg less well than the left. He was unable to
stand on either foot alone and swing the other. He walked tandem poorly. There was no stiffness or limitation of movement of his neck.

Urinalysis, blood count and the Wassermann and Kahn tests on the blood and spinal fluid were all negative. The spinal fluid was clear and colorless. It contained 3 lymphocytes per c.mm. Pandy’s test was negative. The total protein was 38 mg. per cent. The colloidal gold curve was flat.

On spinal puncture the pressure was 180 mm. of fluid. The pressure rose rapidly on jugular compression but fell rather slower than usual. Three cc. of pantopaque were injected into the spinal canal and observed under the fluoroscope, with the patient suspended head downward. There was a partial obstruction to the free flow of the oil at the level of the interspace between C4 and C5, principally on the right side of the spinal canal (Fig. 6b). After the oil had passed into the upper cervical region the patient was reversed and the oil allowed to flow back into the lumbar region. Some of it caught momentarily above the obstruction. After the myelogram the patient exhibited a definite Horner’s syndrome on the right side, with narrowing of the right pupil and a slight ptosis. This disappeared after 24 hours.

Ordinary X-ray films of the cervical spine showed a slight osteoarthritis at the level of the interspace between the 4th and 5th cervical vertebrae (Fig. 6a).

Operation. On Nov. 20, 1947 a laminectomy of the 3rd, 4th and 5th cervical vertebrae was made. The dura mater was incised in the midline. The spinal cord did not appear abnormal. Two dentate ligaments were cut on each side and as the cord was retracted toward the left an extradural mass was exposed lying just to the right of the midline at the level of the interspace between the 4th and 5th vertebrae. An incision was made through the anterior dura mater and cartilaginous material herniated into the field. This was removed. A much smaller protrusion of disc material was exposed on the left side but because of troublesome extradural bleeding and the smallness of the mass of cartilaginous material, which was firmly attached to the intervertebral disc, it was not removed. The spinal cord seemed to be thoroughly decompressed.

Microscopic Examination. The material removed at operation was typical fibrocartilage (Fig. 8d).

Postoperative Course. His course was much smoother than that of the other 3 patients. He had none of the postoperative paresthesias in the upper extremities which had annoyed the others. He was up out of bed on the 8th day and was discharged on December 2, 12 days after operation. He had no complaints of either pain or numbness. The strength in his arms, hands and shoulders has steadily improved, but his recovery is not complete. He still has complaints relative to his neck and upper extremities but is working.

DISCUSSION

TYPES OF HERNIATION

Although Elsberg\(^4\) had described a single isolated case of compression of the spinal cord by herniation of a cervical intervertebral disc (called chondroma) and Adson\(^1\) had briefly alluded to another (which was described in detail by Love and Camp\(^12\)), it remained for Stookey\(^22\) to write the classical definitive paper on this subject. In that paper Stookey described the three clinical pictures that result from such herniations. There is little to add to his early description except for minor details. At present the best known of the three groups is the laterally lying herniation with compression of a single nerve root, usually the 6th or 7th cervical. This picture has been thoroughly clarified and documented by Stookey\(^22,23\) McKenzie and Botterell\(^18\); Semmes and Murphey\(^19\); Bucy and Chenault\(^4\); Spurling and Sco-ville\(^20\); Bradford and Spurling\(^2\); and others. This common type does not con-
cern us here. The other two types described by Stookey are both well illustrated here. One consists of the relatively median lying lesion with almost symmetrical neurological disturbances (Cases 1 and 2). The other results from a protrusion lying to one side of the midline beneath one side of the spinal cord. It produces the Brown-Sequard syndrome typical of involvement of one lateral half of the spinal cord (Case 3).

**SYMPTOMATOLOGY**

If these lesions are to be promptly recognized and appropriately treated it is essential that the picture they produce be thoroughly familiar to us.

**Age and Sex Incidence.** As Stookey, Elsberg, Mixter and Ayer pointed out this is a disease predominantly of males. All of Stookey’s patients and all of ours were men. Elsberg described the occurrence of such a herniation in a woman and so did Broager, Epstein and Davidoff, Kahn, and Mixter and Ayer. Stookey’s patients ranged in age from 44 to 68 years and Mixter and Ayer’s from 28 to 54. Our four patients were 39, 33, 55, and 37 years old. Craig and Sheldon described a most unusual case. Not only was the patient a girl but she was only 16 years old. We know of no other similar case.

**The Neck.** The absence or trivial nature of any symptoms referable to the neck is striking and unexpected in these patients with median herniations. It has been noted by several authors (Stookey; Elsberg; Bradford and Spurling; Kahn) and was notable in our cases. It is surprising that stiffness of the neck, local pain and tenderness are relatively rare. In a few instances flexion of the neck produces an electric shock-like sensation in the neck and back (Elsberg; Bradford and Spurling) and even the lower extremities. The failure of ordinary roentgenograms of the cervical spine to give diagnostic assistance is obvious in our cases and in those of most others. Occasionally narrowing of the related intervertebral space and osteoarthritic changes may be present but they are usually mild.

**Upper Extremities.** Whereas involvement of the upper extremity is the outstanding symptom when the herniation lies far laterally involving a single cervical root (Semmes and Murphey), such involvement is commonly trivial or even absent with median herniations. When symptoms are present subjective paresthesias, often without objective sensory changes, are the most common. In a smaller number of cases weakness and awkwardness of the hands (Case 2) and in a few cases atrophy of the intrinsic muscles of the hands have been reported (Stookey; Elsberg; Mixter and Ayer; Stone, Arieff, Kaplan and Brown; Portugal; and Kahn). Stookey also noted fibrillations in the muscles of the upper extremities and shoulder girdles. In our Case 4 there was atrophy and weakness of the deltoid and infraspinatus muscles of one shoulder. The important point is, however, not that both motor and sensory changes occasionally occur in the upper extremity as one might expect but that they are so commonly either entirely absent or very trivial.

**Spasticity and Equilibrium.** The most striking symptoms are the muscular spasticity with hyper-reflexia and the disturbance of equilibrium. The spasticity is most common and most marked in the lower extremities. The
patients are frequently annoyed by the clonus that develops when pressure is put on the foot (Case 2). Spasticity may or may not involve the upper extremities. Even in those cases where there is no demonstrable resistance to passive manipulation of the arms the tendon reflexes are commonly definitely exaggerated. In such cases Hoffmann’s sign is usually easily elicited. The explanation for the hyper-reflexia which is so common in the upper extremities in these cases is not readily apparent. These herniations most frequently occur at the interspace between the 5th and 6th or the 6th and 7th cervical vertebrae, i.e., at or below the 6th or 7th cervical segment of the spinal cord. There must be something other than simple compression of the spinal cord at these levels to explain a hyperactive biceps reflex. The tendon reflexes in the lower extremities are more commonly rendered hyperactive than are those in the arms. And it is not uncommon to be able to elicit clonus, particularly at the ankle joint. Babinski’s sign may or may not be present regardless of the severity of the spasticity. The abdominal reflexes, likewise, may persist. Muscular weakness is usually not striking and is by no means proportionate to the spasticity and the hyper-reflexia.

The disturbance of gait (Cases 1 and 2) is commonly disproportionately severe in consideration of the other neurological disturbances. Our patients walked unsteadily with their feet widely separated. They had to take special care to avoid falling. One walked with small steps (Case 1), another could not walk slowly (Case 2). In spite of these marked difficulties in walking and in maintenance of balance their sense of position was not disturbed and there was little or no ataxia on heel-to-knee tests. Furthermore, the amount of muscular weakness was not sufficient to account for this disability. It seems likely that the disturbance of equilibrium in these cases is the result of a combination of the mild muscular weakness, the more considerable muscular spasticity and involvement of the spino-cerebellar pathways.

Sensation. In comparison with the other neurological changes those in sensibility were relatively mild with these median protrusions of the cervical intervertebral discs. Mixter and Ayer, as well as others, made similar observations. When the projection of the herniated disc lies somewhat lateral to the midline, compressing one lateral half of the spinal cord predominantly, there may be a marked loss of pain and temperature sensibility on the opposite half of the body. Tactile sensibility is seldom involved. Vibratory and position sense (joint, muscle and tendon sense) are usually completely spared. All other authors have made the same observations.

As noted in connection with Case 3, when there is a loss of sensibility the upper border of the area of sensory disturbance is apt to be considerably lower than one would expect, considering the level of the compression of the spinal cord. Stookey, Elsberg, Mixter and Barr, and Péron, Lereboullet, Guillaume and Dumas have all made similar observations. It is thus obvious that in such cases the upper border of the area of sensory loss is valueless in determining the location of the lesion. The explanation of this apparent discrepancy is not obvious.

As has been noted above, even when there are subjective sensory dis-
turbances in the upper extremities in these cases of median herniations of the cervical intervertebral discs there are often no objective alterations and even in those cases where the examiner can demonstrate an area of sensory diminution it is commonly vague and its borders are neither constant nor clear cut. Furthermore, as noted in connection with Case 1, those paresthesias and areas of slight hypesthesia which are present in some cases do not correspond with the distribution of any cervical root which would be involved at the level of the herniation. This is not surprising as these herniations lie at or near the midline beneath the spinal cord and not laterally where they would compress the individual cervical roots.

Bowel and Bladder. The functions of the bowel and bladder are seldom disturbed and then only mildly (Bradford and Spurling). Of our cases only one (Case 1) had any such involvement. He had become constipated. One of Kahn's patients had difficulty urinating and Mixter and Barr reported a similar difficulty. Elsberg's6 patient had trouble with both bowel and bladder.

Sympathetics. Only one of our patients had any evidence of involvement of the sympathetic nervous system (Case 4), and that was of very short duration and occurred following myelography. Elsberg, Stone, Arieff, Kaplan and Brown, and Epstein and Davidoff all reported instances where a Horner's syndrome was present in association with lesions of this type.

Spinal Puncture and Spinal Fluid. The findings on spinal puncture are far from dramatic. With Queckenstedt's test Elsberg found a complete block of the spinal subarachnoid space in 35.7 per cent of the cases, a partial block in 28.5 per cent and none in 35.7 per cent. Many of his cases were far advanced. It is obvious from our own experience and from the literature that with earlier cases the findings on manometric examination will be even less significant than Elsberg found. In view of the great desirability of relieving the compression of the spinal cord as early as possible in these cases very little reliance can be placed upon this test which serves such a useful function in the diagnosis of most cases of spinal cord tumor. This is one of the most important points in arriving at an early diagnosis of a median herniation of a cervical intervertebral disc. Where such a diagnosis is a possibility one must not be misled by the normal findings so commonly present with Queckenstedt's test.

It is noteworthy, however, that even though there is no evidence of obstruction of the spinal subarachnoid space by Queckenstedt's test myelography with pantopaque or lipiodal may reveal a partially obstructive lesion in the spinal canal. The same is, of course, occasionally true with intraspinal neoplasms, but such is a common experience with herniations of cervical intervertebral discs (Cases 1, 3 and 4). Epstein and Davidoff and others have had similar experiences. On the other hand, myelography is not entirely reliable. Stookey found no obstruction in one case. Kahn observed only a suggestive defect in one of his cases and Mixter and Ayer saw no evidence of a lesion with lipiodal in one of their 6 cases. In our Case 3 the obstruction could be demonstrated only when the neck was hyperextended.
The spinal fluid may show a moderate increase in the protein content (Case 1) or it may be normal (Cases 3 and 4). Elsberg found the average total protein in cases of herniated intervertebral disc ("chondroma") to be 88 mg. per cent, considerably less than that found with intradural (213 mg. per cent) or even extradural (97 mg. per cent) neoplasms. However, Elsberg was considering lumbar as well as cervical herniations of the intervertebral discs and it is likely that the average figure for lesions in the cervical region is considerably lower than 88 mg. per cent. In Mixter and Ayer's cases of herniated cervical discs the protein content of the lumbar spinal fluid varied from 32 to 186 mg. per cent. In our 4 cases the figures were 80, 50, 30 and 38 mg. per cent respectively. Craig and Shelden reported a case which among other unusual features had 360 mg. per cent of protein in the spinal fluid. We have found no other cases where the figures even approach this high level.

**DIFFERENTIAL DIAGNOSIS**

It is obvious that the differentiation of these lesions from other disorders of the spinal cord may not be easy. A herniated cervical intervertebral disc should be suspected whenever a young adult or middle-aged male, who is otherwise healthy, develops either a Brown-Sequard syndrome or a spasticity of both legs with considerable difficulty in walking and in maintaining his balance. The absence of symptoms and findings referable to the neck and upper extremities is of little importance in making such a diagnosis.

Often it may be difficult or impossible to differentiate a herniated disc from a tumor in the cervical spinal cord. Fortunately, that is a matter of little importance as both would be treated surgically. However, the possibility of confusing a herniated cervical intervertebral disc with multiple sclerosis, primary lateral sclerosis or amyotrophic lateral sclerosis is a serious matter, as the herniated intervertebral disc can be removed and the neurological symptoms relieved if the operation is performed promptly enough, whereas as yet there is no known treatment of value for any one of the degenerative diseases listed above. Every patient suspected of suffering from a degenerative disease of the spinal cord should have a lumbar spinal puncture and if there is any suspicion that there might be a herniated cervical intervertebral disc a myelogram with pantopaque or lipiodal should be made. This rule should be followed even though there is no evidence of block on Queckenstedt's test and the spinal fluid is normal. Myelography carries with it little or no risk and if the contrast medium is removed at the conclusion of the examination, as it can and should be, there should be no sequelae.

It is obvious that a disease characterized by spastic weakness of the lower extremities which may be associated with little or no sensory change, and with which there may be atrophy and weakness, and even fibrillations (Stookey), in the upper extremities may be readily confused with amyotrophic lateral sclerosis. Naturally, if there is evidence of involvement of the bulbar mechanism a herniated cervical intervertebral disc usually may be excluded. However, in Portugal's case there was an unexplained hemi-
atrophy of the tongue. In addition we have recently seen a 53-year-old woman at the Illinois Neuropsychiatric Institute whom many regarded as suffering from amyotrophic lateral sclerosis. There was no significant sensory change. The jaw jerk, as well as all of the tendon reflexes in the extremities, was hyperactive. Lumbar spinal puncture revealed no block of the spinal subarachnoid space but a myelogram disclosed the presence of an obstructive lesion at the level of the 4th and 5th cervical vertebrae. At operation it proved to be a neurofibroma. The presence of the hyperactive jaw jerk is still unexplained. These two unusual cases make it obvious that one must be careful not to conclude that a compressive type of lesion in the cervical spinal canal is impossible because of some slight change suggestive of a higher involvement.

Likewise, there will be no doubt of the diagnosis of multiple sclerosis in typical cases beginning in young people with remissions and relapses, with multiple and widely dispersed symptoms, with involvement of speech, and with diplopia and central scotomas. Those are not the cases that concern us here. However, the mere existence of a nystagmus is not sufficient to exclude a herniated cervical disc. Hawk, Elsberg and Haynes all reported cases of herniated cervical discs in which a nystagmus was present—in Elsberg's case it was said to have been marked. In particular, we must learn to suspect all cases where the patient is a male, in his thirties or older, and where the symptoms could all be explained by a single lesion in the cervical region. We cannot agree with Broager that a history of trauma is important in making the differential diagnosis. Such a history may be obtained (Cases 2 and 4), but most often no such history can be elicited.

ETIOLOGY

It is the general feeling that herniations of the lumbar intervertebral discs are largely if not exclusively traumatic in origin (Bradford and Spurling). In the cervical region the obvious relationship between injury and symptomatology is commonly not present, particularly with the median herniations. Stookey originally took note of this fact. However, there is strong indirect evidence of the traumatic origin of the condition. First and foremost almost all of the patients who suffer from this condition are males. In all of them the symptoms develop during their active years when they are subjected to the greatest amount of trauma. Even Kahn's female patient had struck her head in diving some years before the onset of symptoms. In some cases, as our Case 4, there is a definite history of injury with the symptoms developing shortly thereafter. In other cases, such as that of E. R. (Case 2), who threw 100 to 150 pound baskets of meat up onto the back of his head and neck, there was ample opportunity for injury even though no specific instance could be recalled. It is our opinion that these single median herniations of cervical intervertebral discs with compression of the spinal cord are usually if not always the result of injury to the cervical spine.
PATHOGENESIS OF SYMPTOMS

The mechanism of development of the paresthesias, muscular weakness and atrophy in the upper extremities from pressure upon the cervical spinal cord and its roots is obvious. The explanation of the absence of such symptoms in some cases where the median herniation does not press upon one or more of the roots is equally obvious.

The explanation of the spasticity, hyper-reflexia, disturbance of gait and balance and the sensory changes, if present, is one that has recently attracted the attention of Kahn. He has presented an attractive and unique hypothesis. He states that the pressure of the herniated disc on the anterior columns of the spinal cord results in little in the way of symptoms because of the nature of the pathways located there. However, this pressure forces the cord backwards, producing traction on the dentate ligaments which in turn place the greatest stress upon the posterolateral columns—the pyramidal tract and the spinocerebellar pathways—resulting in spasticity, weakness, and in disturbance of gait and balance. On the other hand, the posterior columns particularly and to a lesser extent the anterolateral thalamic pathways are spared except with those lesions lying to one side of the midline so that half of the cord is compressed directly (Case 3).

The possibility that compression of the anterior spinal artery by the herniated intervertebral disc may play some role in the development of symptoms in these cases cannot be completely ignored. Obviously the symptoms are not those of a complete obstruction of that vessel. However, that symptoms of involvement of the spinal cord such as are present in these cases might develop as the result of partial obstruction of this artery or as the result of spasm of the walls of the artery secondary to irritation by such a mass cannot be readily denied. Neither is there any means of readily establishing such a possibility. The fact that the motor pathways are more severely involved in these cases than are the sensory tracts, although both are supplied by the anterior spinal artery, would make it seem likely that Kahn's mechanical explanation of the development of these symptoms is more applicable than is the vascular one.

SITE OF HERNIATION

As with the more laterally lying herniations those lying more centrally and compressing the spinal cord are found most commonly arising from the intervertebral discs between the 5th and 6th or the 6th and 7th cervical vertebrae. Less commonly they are found at the interspace between the 4th and 5th cervical vertebrae (Cases 2 and 4), or even between the 3rd and 4th vertebrae (Mixter and Ayer).

TREATMENT

We would agree with Elsberg that these lesions are best dealt with through a wide bilateral laminectomy of at least two vertebrae. It is important that the operator have ample room and an adequate exposure to avoid
all possible injury to the spinal cord, which must be dislocated in order to remove the cartilaginous material. It is likewise important that he not disturb the articular facets of the cervical vertebrae lest a postoperative dislocation result. A thorough familiarity with the anatomy of the cervical spine should enable one to avoid these complications.

In many instances the results from removing such masses have not been good. Stookey and Elsberg were obviously not enthusiastic about their results. Hawk noted no improvement in the case he reported. Mixter and Ayer had no case that they could report as well, although 5 of the 8 were said to be improved. Fortunately, others, like ourselves, have had more favorable experiences. If we are to achieve the best possible results from removing such masses it is obvious that we must not only operate upon the patients early before the spinal cord has been irreparably injured but we must also damage the cord as little as possible at operation. The first step in protecting the cord is an adequate exposure. The second is, obviously, the most delicate manipulation of the spinal cord that is possible.

It is seldom feasible to remove a centrally placed herniation of a cervical intervertebral disc entirely extradurally. In most instances the lesion can be dealt with most easily and most safely by making a long incision in the dura mater posteriorly and then in addition, making short transverse incisions at each end of the axial incision if necessary to provide ample room. Two or three dentate ligaments should then be divided on both sides of the spinal cord. The cord should then be gently rotated by grasping the dentate ligament, elevated, and placed on a small, smooth, curved retractor which can be used to dislocate the cord and expose the mass (Fig. 2). This maneuver must be done with the utmost gentleness to avoid injury to the cord and to the anterior spinal artery. It is our feeling that, except for occasional very brief periods, this task of retracting the spinal cord should be assumed by the operator and not delegated to any assistant.

An axial incision should then be made in the anterior dural mater overlying the mass. The mass will be found to be composed of a variable number of firm irregular cartilaginous chips which can be easily removed one at a time with any small grasping instrument. We find a very fine rongeur, originally designed for the removal of pituitary adenomas or for intranasal surgery, the most satisfactory instrument for this purpose. Care must be taken to remove all of the pieces. No effort should be made to remove additional cartilaginous material from between the vertebral bodies. Such an attempt would probably be futile and would certainly endanger the spinal cord.

The incision in the anterior dural wall need not be closed. The posterior incision and the soft tissues of the neck will be closed as usual after any laminectomy. No bone graft or other stabilizing procedure is indicated.

Immediately following the operation most of our patients have suffered from very annoying paresthesias of the hands and forearms. These have usually persisted in intense form for 2 to 3 days and then gradually sub-
sided. Our patients have usually been able to be up and out of bed in from 7 to 10 days after the operation. Their convalescence from there on has been one of steady improvement.

As Epstein and Davidoff have shown, simple decompression of the spinal cord without removal of the herniated disc material does not give satisfactory results. The herniated cartilaginous material should be removed in every instance, if possible. Occasionally, particularly in long-standing cases, the herniated material may become calcified or may be associated with osteophytes arising from the vertebral bodies. Often these calcareous or osseous projections cannot be removed without too greatly endangering the spinal cord.

PROGNOSIS

Although, as noted above, the experience of some surgeons with these median herniations of cervical intervertebral discs has been rather disappointing, our experience and that of a number of others has been most encouraging. It seems likely that with the earlier diagnosis of these conditions and the increasing skill that is bound to come with greater experience our results from surgical treatment will steadily improve. However, with advanced cases of long standing and with those with severe neurological disturbances the results of the removal of median herniations of cervical intervertebral discs are likely never to be as good as the outcome following the removal of benign neoplasms of the spinal cord. Early diagnosis and prompt treatment are of the greatest importance in obtaining satisfactory results.

SUMMARY

Four cases of compression of the spinal cord by herniations of cervical intervertebral discs are described.

The confusion of such cases with degenerative diseases of the spinal cord, such as multiple sclerosis, primary lateral sclerosis and amyotrophic lateral sclerosis, and the differential diagnosis are discussed.

Median herniations of cervical intervertebral discs are characterized predominantly by spasticity and hyper-reflexia in the lower extremities and by unsteadiness of gait. Sensory changes are commonly mild or absent. Pain, tenderness and stiffness of the neck are very uncommon. There may be paresthesias and muscular weakness and awkwardness in the upper extremities. Evidence of obstruction of the spinal canal on Queckenstedt’s test is not present in many cases. The spinal fluid is normal except for a moderate elevation of the protein content in some cases. Lipiodal or pantopaque will reveal an obstruction or deformity of the spinal canal in a majority but not in all cases. These herniations are best removed transdurally through a bilateral laminectomy of at least two vertebrae. The results of such operations in early cases should be excellent but in severe cases of long duration poor results have not uncommonly been reported.
REFERENCES


