

The Clinical Manifestations of Spondylochondrosis (Spondylosis) of the Cervical Spine*

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SPONDYLOCHONDROSIS CAN NOW be considered a well established pathological and clinical entity. The condition, described in various terms, has been recognized for many years, but the evolution of our present knowledge and recognition of the clinical significance have been very gradual. In 1911 Bailey and Casamajor² pointed out that osteoarthritis of the spine might cause compression of the spinal cord and nerve roots secondary to changes in the intervertebral disk. They stated that these changes were due to thinning of the intervertebral disk, followed by trauma to the bodies of the vertebrae with gradual bony overgrowth. In the same year, Goldthwait¹¹ described protrusion and herniation as a cause of lumbago, sciatica and paraplegia. In 1911 Middleton and Teacher¹³ also described injury to the spinal cord following rupture of an intervertebral disk. These contributions lay dormant for many years, but gradually there has been general recognition of the morbid states due to pathologic changes in the intervertebral disk. Many of the earlier observers considered these disk protrusions to be neoplastic, an example of which is Adson's¹ report of a chondroma in 1925. In the twenties Schmorl began to examine spinal columns routinely, and reported in 1929¹⁸ on a series of 2000 cases; in 737 (37 per cent) the intervertebral cartilage had herniated into the vertebra or beneath the posterior longitudinal

ligament. In 1926 Elliott⁷ described cervical arthritis as a cause of nerve root compression due to narrowing of the intervertebral foramen.

Stookey²⁰ (1928) clearly established the clinical significance of intervertebral disk protrusion as a cause of spinal cord and nerve root injury due to chronic compression on these structures; he considered the protrusions neoplastic in origin, and used the term "chondroma." In 1929 Dandy⁶ described two cases of loose cartilage from the intervertebral disk, which simulated tumor of the spinal cord, and in 1930, Bucy⁵ reported a chondroma of the intervertebral disk. Elsberg⁹ (1931) modified the neoplastic theory and attributed the protrusions to a local hyperplasia of cartilage to which he applied the name "echondrosis." In 1934 Peet and Echols¹⁷ reported on herniation of the nucleus pulposus as a cause of compression of the spinal cord, and the classic paper of Mixter and Barr (1934)¹⁴ firmly established rupture of the intervertebral disk as a clinical entity. From this time on, many contributions have been published on the diagnosis and treatment of intervertebral disk protrusion and herniation. Since it is not the purpose of this paper to consider the acute type of disk lesions, they will not be discussed further.

Saunders and Inman (1940),¹⁸ in discussing the pathology of the intervertebral disk, described narrowing of the intervertebral disk and protrusion of the annulus with osteophytic overgrowth. Browder and Watson (1945)⁴ reported on the clinico-patho-

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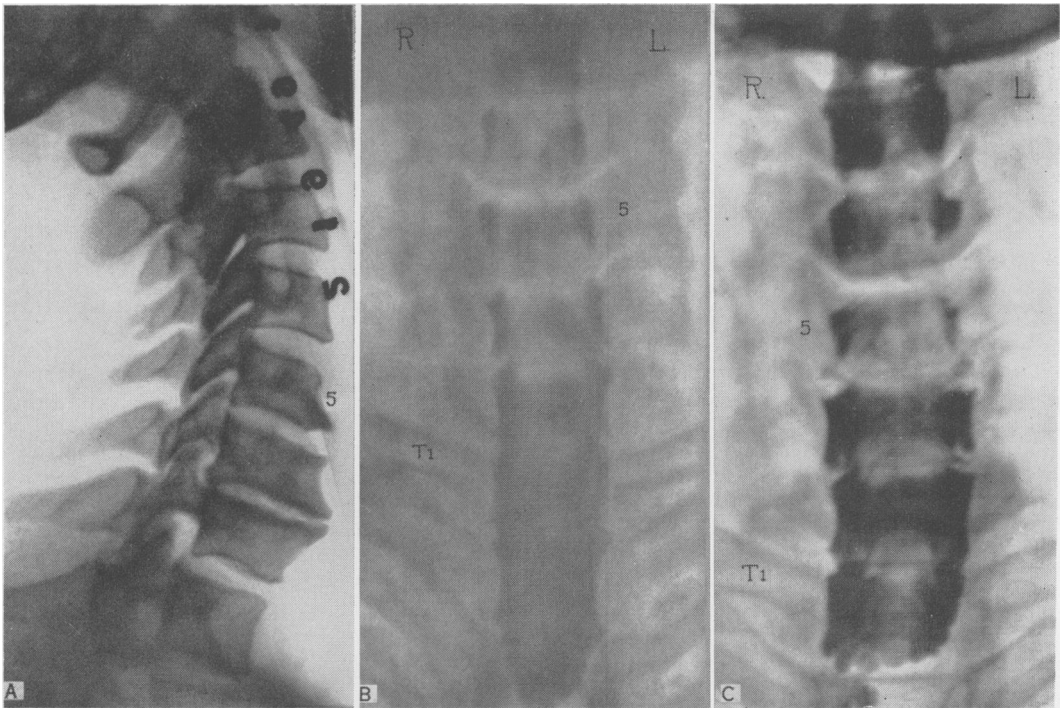


FIG. 1 (Case 1). (B) Lateral roentgenogram taken 4 years before onset of major symptoms (1949), showing narrowing interspaces C₅ and C₆; slight subluxation C₇-T₁; anterior lipping. Note especially the posterior osteophytic overgrowth of Vertebrae C₅ through C₇. (A) Myelogram (1949) showing radiolucency at C₃ through C₆ interspaces. (C) Repeat myelogram 4 years later (1953); essentially same findings.

logic study of 22 cases due to lesions of the cervical intervertebral disks; they described four cases in which the lesion was due to ridges of *annulus fibrosus* surmounting hypertrophic bone at the margins of adjacent vertebrae. Kahn (1947)¹² published a very significant paper concerning the role of the dentate ligaments in spinal cord compression due to midline herniation of the nucleus pulposus. Frykholm, in reference to noteworthy studies summarized in monograph form (1951),¹⁰ pointed out that both nuclear herniation and annular protrusion may be transformed into a firm mass due to calcification. He also called attention to the fact that the clinical manifestations are due to the variable location of the protrusions: (1) dorsal protrusions which are entirely intraspinal may produce unilateral or bilateral cord compression, and, in the lateral position, may compress the nerve

root intraspinaly; (2) intraforaminal protrusions which emerge from what he defined the uncinat part of the disk and compress the radicular nerve, and in some instances are capable of compressing the vertebral artery and vein; (3) ventral protrusions. Brain, Northfield and Wilkinson (1952)³ presented a very comprehensive description of the neurologic manifestations of cervical spondylosis, with the presentation of both clinical and pathological data. They called attention to the necessity of differentiating between herniation of the intervertebral disk and spondylosis, stating: "Our investigation has yielded support for the view put forward by one of us (Brain, 1948), and adopted by Frykholm (1951), that herniation of the nucleus pulposus of an intervertebral disk in the cervical region, whether occurring spontaneously or as a result of trauma, is nosologically different

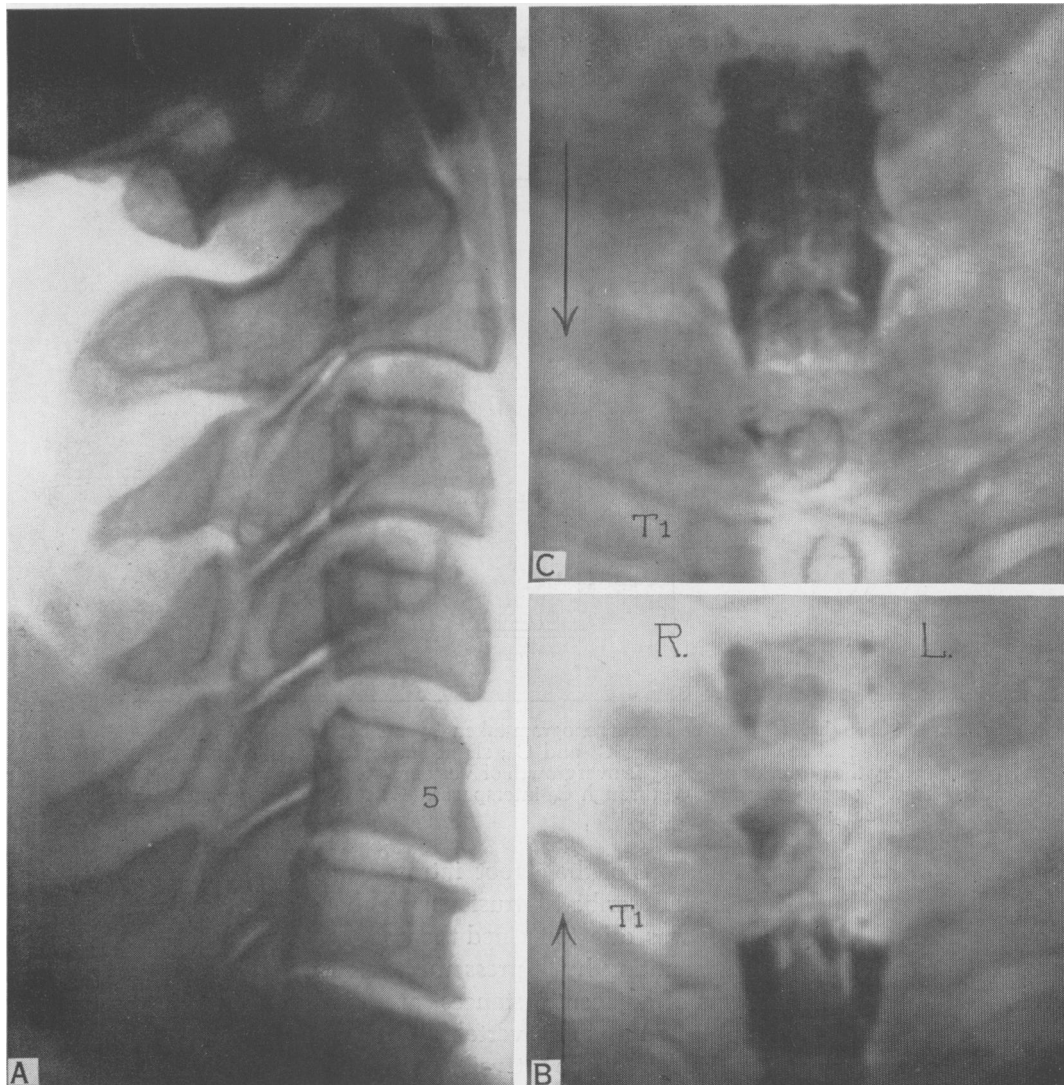


FIG. 2 (Case 2). (A) Minimal anterior lipping of bodies C₅ and C₆ with narrowing of corresponding interspaces; loss of normal lordotic curve. (B) Myelogram showing partial block at C₇ interspace as oil ascends. (C) Partial block at C₆ as oil descends.

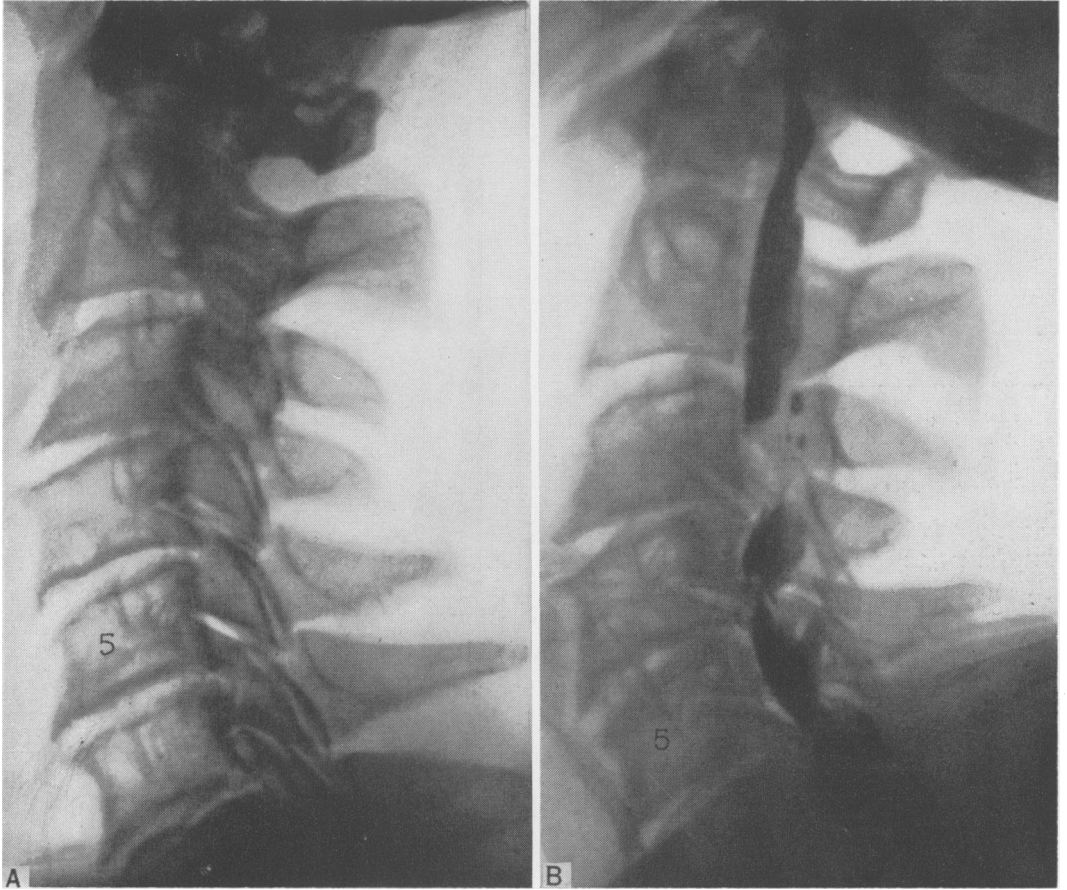
from cervical disk protrusion in cervical spondylosis. In the latter, the intervertebral disk is the site of a degeneration which evokes an osteophytic reaction in the bodies of adjacent vertebrae." It is the author's conviction that the term "spondylosis" is not sufficiently descriptive (*spondyl*, spine; *osis*, condition), and that the term "spondylochondrosis" (*spondyl*, spine; *chondro*,

cartilage; *osis*, condition) is preferable in that it takes into account both the cartilaginous protrusion as well as the osteophytic overgrowth of the vertebrae.

This paper is based upon ten cases of cervical spondylochondrosis. In seven the long tracts were primarily involved, with resulting paraplegia; in two cases the anterior roots only were involved, producing

FIG. 3 (Case 5). (A) Lateral roentgenogram to show marked anterior and posterior lipping vertebrae C₃ through C₆. (B) Lateral myelogram showing partial block C₃, C₄ and C₅ interspaces.

SPONDYLOCHONDROSIS OF THE CERVICAL SPINE



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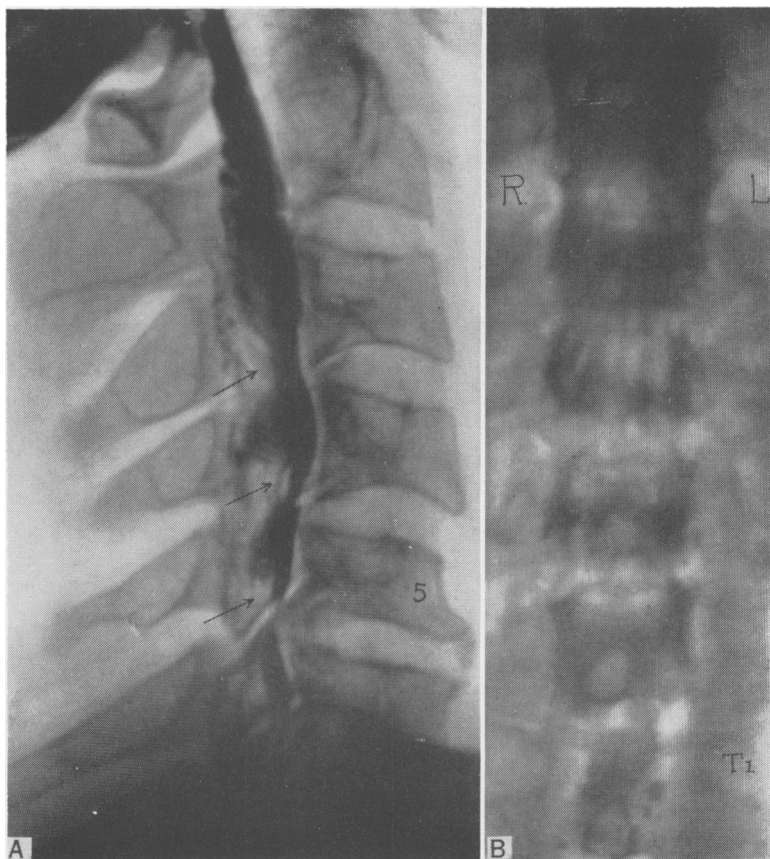


FIG. 4. (Case 8). (A) Lateral myelogram showing anterior indentations of oil column, which is interrupted at interspace C₅; note especially the indentations in posterior part of oil column (arrows). (B) AP myelogram shows transverse defects corresponding to interspaces C₅ and C₆, partial block at C₄.

the "anterior root syndrome"; and in one case there was marked involvement of both the long tracts and anterior roots.

CASE REPORTS

Case 1. (D.C.J.) W.F. age 43. In 1949 she complained of intractable headache, and had a pneumoencephalogram done to exclude intracranial tumor. *Roentgenograms:* Anterior hypertrophic changes bodies C₅ through C₇ with narrowing of 5th and 6th disk interspaces. *Myelograms:* Lack of filling at 4th, 5th and 6th interspaces (Fig. 1). In 1950 there was numbness of the left thumb, and the index and middle fingers. During a short period, she complained of weakness of the left leg. The suggested diagnosis was disseminated sclerosis. The condition remained essentially stationary until the summer of 1953, when walking became difficult, and she soon had to grasp objects for

support. Flexing the neck caused shock-like sensations extending into the back and legs.

Examination (October 1953, Union Memorial Hosp.). Slight weakness of flexor muscles of the left hand, with hypesthesia of thumb and the index and middle fingers. There was marked weakness of both legs, with marked increase of deep tendon reflexes and bilateral clonus. There was adductor spasm, with increase in extensor tone, and flexor plantar responses; hypesthesia below T₈; analgesia T₈ to L₄, and hypalgesia from L₄ through the sacral segments. *Myelograms* were repeated and the same defects as seen in 1949 (Fig. 1) were found.

Laminectomy (C₄ through C₇) was performed on November 2, 1954. In region of C₅ and C₆, dura in close apposition to laminae, with firm resistance at C₅. After opening dura, cord was displaced posteriorly at level of C₄ and C₅. Dentate ligaments cut bilaterally from C₃ and below C₅, when cord could be retracted to reveal small trans-

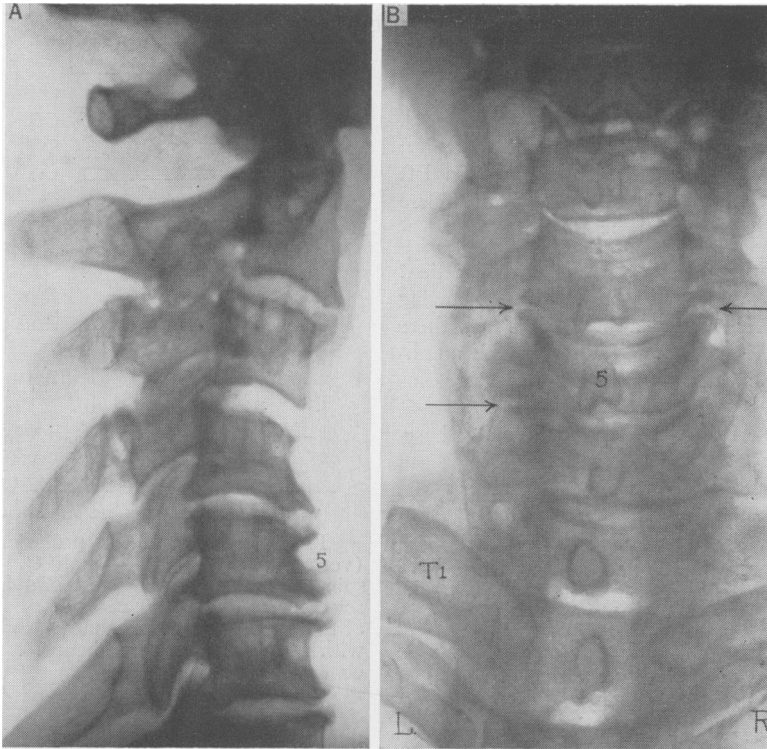


FIG. 5 (Case 9). (A) Lateral roentgenogram showing anterior and posterior lipping with subluxation of vertebrae C₂ over C₃, C₃ over C₄. (B) AP roentgenogram showing osteophytic overgrowth of uncinates (arrows).

verse ridge at C₄ interspace; a larger ridge (about 3 mm.) was seen at C₅. The dura was left open to prevent constriction of the cord.

Course. The day following operation there was definite improvement in sensation and in the left grip. There was rapid improvement in both sensation and motor power in legs; she could walk without assistance on the 16th postoperative day. In June 1954 (9 months later) she considered her gait essentially normal. Deep tendon reflexes were hyperactive, but muscle tone was normal. Sensation was normal except for slight hypalgesia between T₁₁ and L₂. The left grip was almost normal.

Case 2. (A.T.) W.M., age 58. In 1941 he had sustained multiple injuries, including fracture of left tibia, followed by weakness in left leg. In 1951 there was increased stiffness in the left leg. In June 1953 he experienced weakness in right leg. Pressure applied to left foot caused its shaking (clonus since 1941). From June to October, 1953, weakness progressed in both legs; he could walk the length of a room only with difficulty.

Examination (October 1953, St. Agnes Hospital). This disclosed spastic paraplegia, with increased extensor tone and adductor spasm, and a

scissor-type gait. Knee and ankle jerks were greatly hyperactive, with ankle and patella clonus. Plantar responses extensor bilaterally. There was about 40 per cent loss of motor power in the legs. There was no deficit sensory examination except for paresthesia along ulnar side of both forearms. There was very minimal weakness in the right grip.

Roentgenograms. Anterior hyperostosis (lipping) bodies were found C₅ through C₇, with narrowing of the 5th and 6th disk interspaces. *Myelograms.* Lack of filling between 5th and 7th interspaces (Fig. 2). Spinal fluid showed normal cell count with total protein of 54 mg. per cent, and manometric studies, with a rapid rise with slow fall.

Laminectomy (November 17, 1954) C₅ through C₇. There was no pulsation of the dura until the 5th lamina was removed; the dura closely applied to laminae of C₆ and C₇, and arachnoid adherent to it. At C₆ the dura felt firm, with decreased resiliency. Four dentate ligament attachments were cut bilaterally, following which the cord showed rotary type of pulsation. Its retraction revealed a ridge (3 mm.) at C₅; and a smaller ridge seen at C₆, both being stony hard on palpation. The dura was closed.

Course. There was marked subjective improvement 24 hours following operation, with decreased stiffness of the legs. Plantar responses changed to flexor on right; clonus was less marked. Six weeks following operation the muscle tone was normal. He could walk several blocks without difficulty; the motor power was somewhat stronger in left leg, although it had been weak for 12 years. There was normal grip in the left hand.

Case 3. (E.B.) W.M., age 57. In 1937 patient experienced weakness of the left leg, showing little or no progression until 1944, when there was onset of difficulty in equilibrium, with numbness in hands and feet. Mild bladder symptoms were indicated since 1937.

Examination (1944). Slightly positive Romberg, weakness of flexors left thigh, hyperactive knee and ankle jerks, and normal plantar responses. The spinal fluid examination was normal. In 1945 complaint of increasing frequency of urination, with slight numbness in hands and feet. Myelogram in 1949 showed questionable defect at T₅ but exploratory laminectomy revealed no abnormality. Several months later there was progressive weakness in left leg, with onset of slight weakness of right leg. Occasional "electric shock" sensation in 4th and 5th fingers of both hands. Early in 1954 there was marked progression of weakness in the left leg, and weaker grip in the left hand, with difficulty in holding a fork.

Examination (1954, Mercy Hospital). The patient had great difficulty in walking, with inability to dorsiflex the left foot. Knee and ankle jerks were very hyperactive. There was bilateral ankle clonus and extensor plantar responses, and patchy hypalgesia left leg. *Roentgenograms:* Slight anterior and posterior hyperostosis of bodies C₅ and C₆. *Myelograms:* Minimal indentation contrast media at interspaces C₃ through C₅. Spinal fluid showed normal dynamics and cell count, total protein of 41 mg. per cent.

Laminectomy (April 16, 1954) C₃ through C₆. After dura was opened, a bony ridge (2 mm.) was found at C₄, and another (3 mm.) at C₅. The left anterior nerve root C₆ compressed by restraining action of dentate ligament. Cutting dentate attachment revealed a transverse indentation on left anterior root C₆ at point where it was crossed by the dentate. Four dentate attachments sectioned bilaterally, followed by marked increase in cord pulsation; the dura was closed.

Course. The course was stormy, with complete urinary retention necessitating retention catheter. There was loss of motor function complete in the left leg, 75 per cent in the right leg, and about 50 per cent in both arms. The motor power

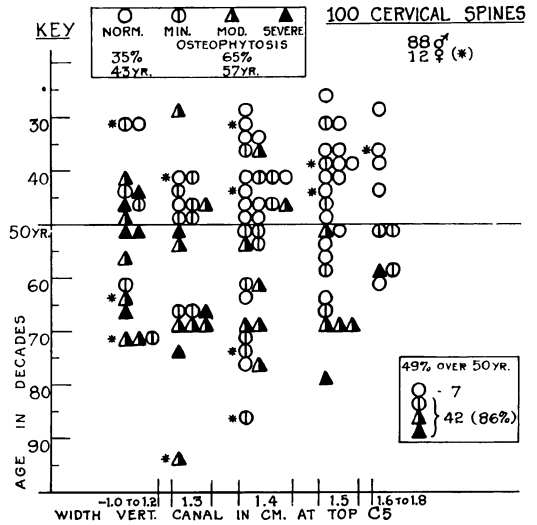


FIG. 6. Incidence of posterior osteophytosis (vertebral bodies C₃ through C₇) impinging on spinal canal and/or intervertebral foramina in unselected series of 100 cervical spines. Correlation of this abnormality and canal width (ave.—1.4 cm.) with age of cadaver (by chance, essentially 50 per cent over 50 years).

gradually improved in all extremities, and at discharge (May 22) he could walk without support. There was about 20 per cent residual weakness in the left arm; 60 per cent in the left leg, and 20 per cent in the right leg. The patient was known to have benign prostatic hypertrophy, and a transurethral resection done. Since the neurogenic element was predominant, a suprapubic cystostomy was necessary.

Re-examination (September 24, 1954) showed marked improvement. The left grip was much stronger than before operation, and the gait was 50 per cent improved. Patient could elevate the left heel from the floor, cross the left leg over the right, squat and return to the standing position. This was not possible before operation. Suprapubic drainage was still required but patient was otherwise well pleased with the progress.

Case 4. (M.N.H.) W.M., age 43. About 1946 patient experienced onset of dragging of the right foot. In 1951 his gait became more awkward; he walked with a wide base. In 1953 there was weakness of the right hand. He had difficulty in raising his right arm above his head. Five weeks before admission he experienced a burning pain in the right thigh and in the left leg, brought on by extreme flexion of neck. He described this as an electric-shock-sensation localized to the posterior aspect of leg and toes. Since 1950 there has been trembling in the legs (clonus) brought on by pres-

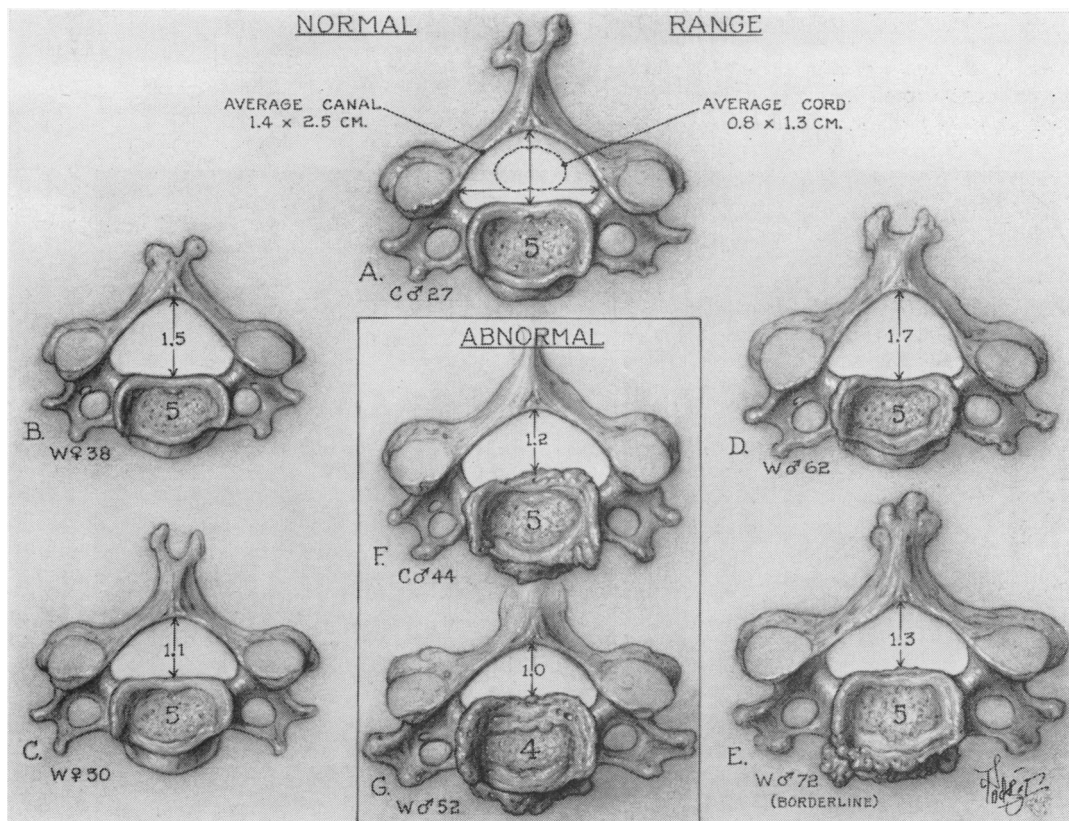


FIG. 7. Drawings indicating sample range of normal variation in conformation of spinal (vertebral) canal occurring in 100 cervical spines; its AP width at top of C₅ is 1.4 cm. (Padgett¹⁵), where the cord at maximum cervical enlargement averages 0.8 cm. (100 cases, Elliott⁸). Insert shows posterior osteophytosis of body, unilateral (F) and bilateral (G); note that such ridging within the canal would resemble that often described as intraforaminal in reference to oblique roentgenograms (F). Marked anterior osteophytosis may occur in the absence of posterior ridging (E).

sure applied to feet. There is slight difficulty in urination since 1950; polycystic kidneys diagnosed in 1952.

Examination (April 7, 1954, on admittance to University Hospital). The weakness in the right grip was minimal; moderate in right deltoid; hyperactive deep tendon reflexes in arms, more marked on right; increased extensor tone, and adductor spasm in legs, with generalized weakness in both legs; walking was difficult, with scissor-type gait, hyperactive knee and ankle jerks. There was sustained ankle clonus, and extensor plantar responses bilateral. Abdominal reflexes were absent. Moderate atrophy of right deltoid, with winging of right scapula. The sensory examination was entirely normal.

Roentgenograms: Moderate anterior hypertrophic changes bodies C₄ and C₅, with slight narrowing at 4th and 5th interspaces. **Myelograms:**

AP view showed lateral defects at C₄ through C₆, the lateral view an anterior indentation in oil column at C₄ and C₅. The spinal fluid showed normal dynamics, globulin 1 plus, and total protein of 121 mg. per cent.

Laminectomy (April 4, 1954) of C₄ through C₆, partial at C₇: Following incision of dura, a small bony ridge was seen at C₄; at 5th and 6th interspaces there were larger ridges (3 to 4 mm.). The nerve roots appeared normal, and 4 dentate attachments were cut bilaterally. The dura was closed.

Course. All extremities moved following operation, but the right arm was somewhat weaker than before operation. On the second day, there was inability to move the right arm, with moderate weakness in the left arm, and complete paralysis of both legs. Hypalgesia below 6th cervical segment. The wound was reopened, but insuffi-

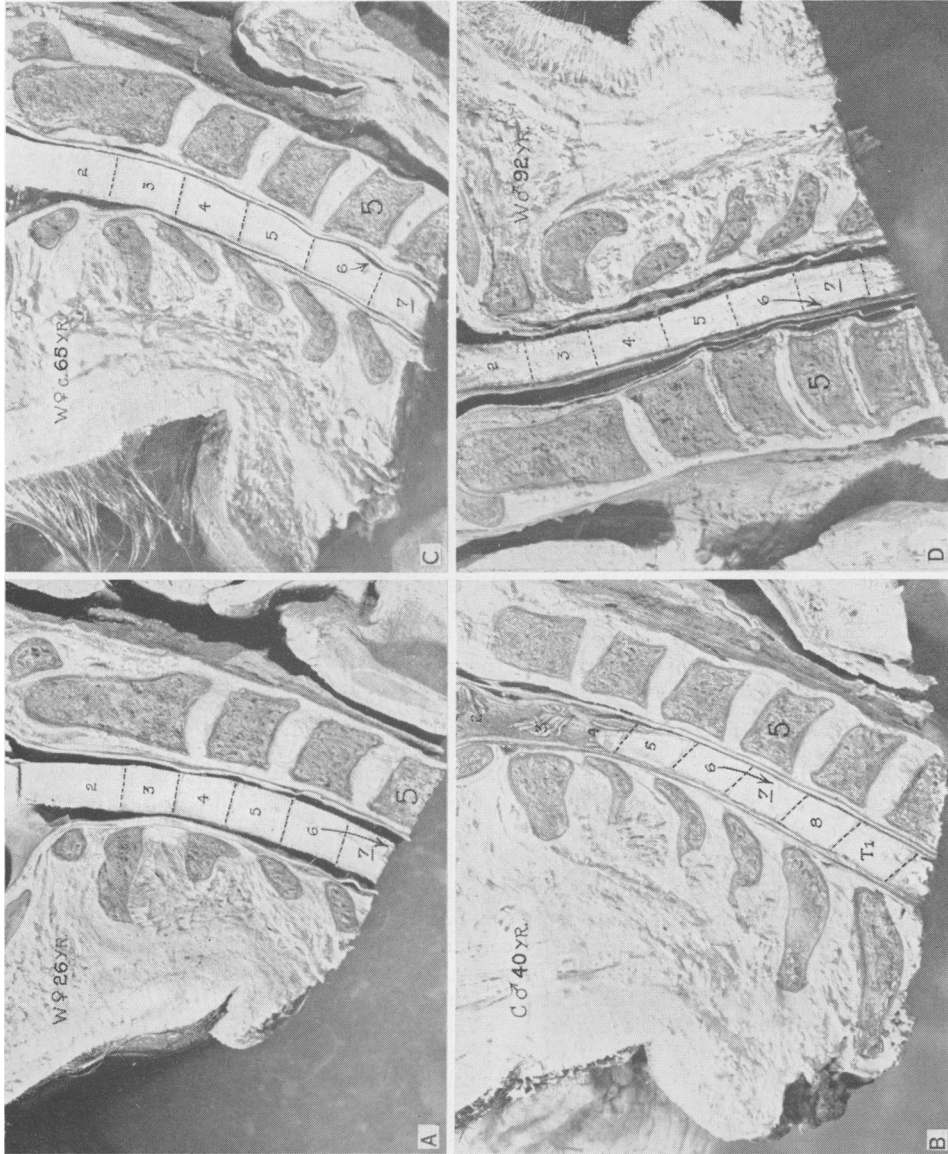


FIG. 8. Mid-sagittal cervical sections from 4 unselected cadavers (photographed actual size, reduction by one-third); Note variation in width of canal and in level of cord segments (see text); the latter indicates (arrows) the differing length and direction of the respective intrathecal nerve roots. In (B) the anterior roots enter the dural pouch at a definitely lower level than do the posterior roots. The vertebrae and disks in (A) and (B) are within normal range, but (C) and (D) show minimal and advanced spondyloarthrosis, respectively, with compression of the cord and anterior roots in the former (see Fig. 9).

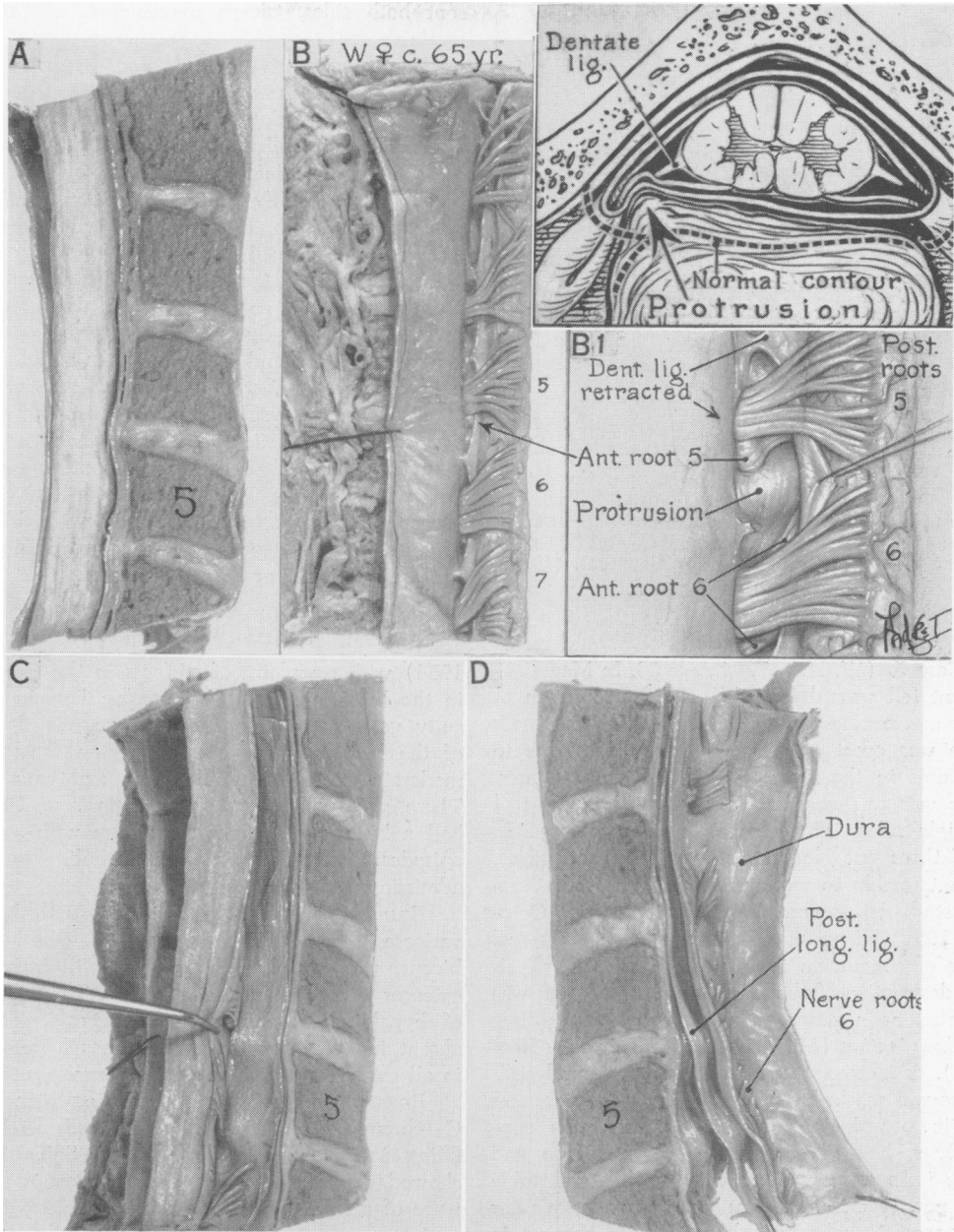


FIG. 9. (A), (B) and (C) are photographs of the same cadaver specimen shown in Figure 8 (C) following laminectomy; (D) is the opposing (right) side with dura and posterior longitudinal ligament retracted from protrusions at disks C₄₋₅ and C₅₋₆. (B1) is an enlarged drawing of detail in (B) after retraction of dentate ligament, which grooved the anterior root. The upper right insert is a semidiagrammatic reconstruction of a transverse section through disk C₄₋₅ (right side of figure shown as normal for comparison).

cient clot was found to account for progressive symptoms; the dura was left open because the cord was swollen; urinary retention developed. There was gradual improvement; the sensory level dropping to L1. At discharge patient could move

all toes, and had slight motion in right thigh. The left arm returned to preoperative state, and the right showed about 40 per cent return of function. We were unable to get progress notes since his discharge.

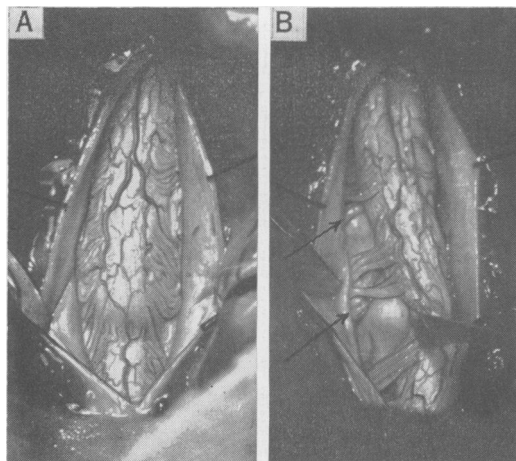


FIG. 10. Photographs made at operation: (A) shows localized bulge in cord caused by a large ridge (C₆₋₇) exposed in (B); smaller ridge at C₅₋₆. Note appearance of anterior roots (C₆ and C₇) after cutting and retraction of dentate ligament. (Courtesy Dr. R. K. Thompson.)

Case 5. (W. M.) W. M., age 63. In May 1945 patient fell several feet, followed by sensation of "pins and needles" in all extremities. In June 1945, there was onset of difficulty in walking, due to weakness in the right leg. Several months later, there was weakness in the left leg. Diagnosis of multiple sclerosis, treated with liver therapy. In 1947 there was moderate weakness in both arms; patient unable to work since then. His condition was studied in several hospitals, including (October 1951) diagnosis of "injury to the cervical spine of concussion type, with subsequent gliosis and destruction of the long tract"; myelogram was reported as negative.

Examination (March 29, 1954, University Hospital). Patient complained of "creeping paralysis": There was marked weakness of both deltoids; and spastic paraplegia (few steps taken with support), with marked adductor spasm. Knee and ankle jerks were hyperactive, with bilateral ankle and patella clonus. There were extensor plantar responses. Hypalgesia below T₃ with sparing in sacral region, and mild hypalgesia in distribution of 6th and 7th dermatomes of both arms. Flexor tone was slightly increased in the right forearm, with loss of function of about 50 per cent in biceps and triceps, and 25 per cent in deltoid. The fingers were held in flexor position, with marked weakness both hand grips. There was fibrillation in right biceps and deltoids; slight atrophy biceps, triceps, and deltoids; vibratory sense diminished in both legs; biceps reflex ab-

sent both sides, triceps hyperactive, and radial diminished.

Roentgenograms disclosed hypertrophic changes, with narrowing interspaces from C₃ through C₆. **Myelograms:** Anterior indentations oil column, particularly at C₃ and C₅ interspaces (Fig. 3). Spinal fluid examination showed partial block; fluid slightly xanthochromic, globulin 1 plus, total protein 164 mg. per cent, negative STS, and normal cell count.

Laminectomy (April 3, 1954) C₃ through C₆: Dura quite firm in region of C₄, and when opened revealed a large ridge at this interspace; smaller ridges at C₃, C₅, and C₆. All dentate attachments cut bilaterally at C₃ through C₆, and dura closed.

Course. One week following operation, there was marked reduction of muscle tone in both legs. There was definite improvement in muscle power in the arms. At discharge (June 3, 1954) patient could walk to the bathroom with the aid of crutches. Deep tendon reflexes were unchanged, but the right plantar response flexor.

Case 6. (W. S.) C. M., age 42. Patient was admitted to University Hospital (February 25, 1954) with complaint of stiffness in the legs and in the back muscles for 3 months; he had difficulty getting out of a chair. There was shaking of the legs on attempt to straighten them, and moderate numbness of all fingers and both legs. There was some urgency on urination. Patient had a history of chronic alcoholism with several episodes of delirium tremens, including one on admission.

Examination. Swelling both feet with healed varicose ulcers. Slight weakness right deltoid and biceps, generalized in both legs, with increased extensor tone and adductor spasm. Patchy areas of hypalgesia in thoracic region. Position sense absent in toes. Deep tendon reflexes hyperactive in all extremities, and plantar responses equivocal.

Roentgenograms showed narrowing interspaces C₂ through C₅. **Myelograms** disclosed defect of filling interspaces C₃ through C₆. Spinal fluid showed normal dynamics and cell count, faint trace of globulin, and total protein of 65 mg. per cent.

Laminectomy (March 19, 1954) of C₄ through C₆, partial at C₃ and C₇: Resistance at C₄ interspace on palpating dura; bony ridge found beneath after opening dura. Anterior roots on both sides were constricted by the dentate ligaments; the dentates when cut revealed an indentation of these nerves. Smaller ridge at C₅. Four dentate attachments cut bilaterally and dura closed.

Course. There was a definite improvement in motor power, and a decrease in muscle tone on

SPONDYLOCHONDROSIS OF THE CERVICAL SPINE

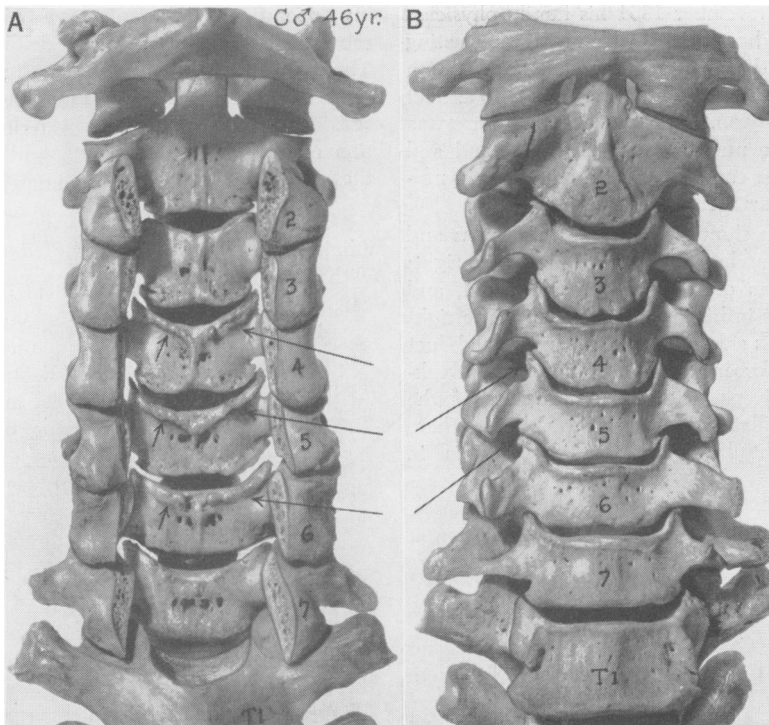


FIG. 11. Photographs of a cervical spine: (A) is dorsal view after removal of laminae showing both normal vertebrae and those with posterior osteophytic ridges, which extend into the intervertebral foramina at C₄₋₅ and C₅₋₆, as seen also in the anterior view (B). The difficulty of removing these ridges surgically is apparent.

the 3rd postoperative day, as well as a definite reduction in adductor spasm. At discharge (April 15, 1954) he was walking very much better, with definite improvement of motor power in both arms.

Case 7. (I. K.) W. M., age 48. Patient was admitted to the University Hospital (September 23, 1953). In March of 1953 he sustained a 22-foot fall, landing on his feet; he sustained chip fracture of the right calcaneus. Shortly thereafter he experienced weakness of the right leg. In June 1953 there was onset of weakness of the right arm and progressing in right leg. Finally, there was onset of weakness of the left leg.

Examination. Weakness of about 20 per cent of the right biceps and triceps, with some diminution of power in the deltoid. There were deep tendon reflexes hyperactive in the right arm. There was an increase in the extensor tone of the legs with generalized weakness, more marked on the right; patient could walk only one block with difficulty. The knee jerks were hyperactive. There was bilateral ankle clonus, with plantar response flexor on the left, equivocal on right. Abdominal

reflexes were absent, and the sensory system was normal.

Roentgenograms showed slight narrowing of the C₆ interspace, with small anterior and posterior hyperostosis of bodies, particularly at C₆. **Myelograms** showed small indentations at C₄ through C₆. Spinal fluid showed normal dynamics and cell count; there was no increase in globulin, with total protein of 46 mg. per cent. Patient was discharged on October 31, 1953.

Laminectomy (University Hospital, April 13, 1954) of C₃ through C₇: the dura opened to reveal bony ridges at C₄ through C₆. Five dentate ligament attachments were cut on each side, and the dura was closed.

Course. Patient experienced inability to void for 3 days, and complained of a considerable pain in the neck. There was no definite improvement at discharge on May 11, 1954. Re-examination (Nov. 29, 1954) showed no essential change.

Case 8. (O. A.) W. M., age 57. Patient was admitted to the University Hospital (December 21, 1953) with complaint of inability to use his

right arm. In November 1951 his family physician was consulted because of weakness and wasting of muscles of the right shoulder and arm, which progressed; by April 1953, he was unable to abduct and flex the forearm. In November 1953 there was mild, subjective numbness of the right hand and forearm. Patient complained of a stiff neck; symptoms were present for several months.

Examination showed atrophy of the supra and infra spinati muscles, deltoid and biceps on right; 90 per cent loss of function in the deltoid, and 80 per cent loss in biceps and brachialis. The right arm hung by his side due to his inability to abduct it or flex the forearm. There was minimal weakness of the triceps and extensor muscles of the wrist, and fibrillation of the right deltoid. There was very slight hypalgesia and hypesthesia in 5th and 6th cervical dermatomes. The biceps reflex was absent. Past history was of interest because of operation for lumbar disk protrusion at L5 (August 1948). He had moderately severe arteriosclerosis and blood pressure of 210/100.

Roentgenograms showed slight subluxation (3 to 4 mm.) of C₄ over C₅; there was posterior narrowing due to bony overgrowth at C₂ through C₅ interspaces. *Myelograms* showed increased radiolucency interspaces C₃ through C₆ in AP view, and corresponding anterior indentations in the oil column in the lateral view (Fig. 4). Spinal fluid showed normal dynamics and cell count, with total protein of 76 mg. per cent.

Laminectomy (December 29, 1953) C₄ through C₆: The dural pulsation was diminished. On right at C₄, the anterior root of C₅ was tightly constricted by a dentate ligament. After the dentate attachment was cut, its groove in the nerve root was seen, lateral to which the nerve appeared to be kinked into a small ball; a bony ridge at the joint space had displaced it posteriorly. At the 5th space the 6th root was also constricted by the dentate, but with no kinking of the nerve. Dentate attachments cut bilaterally at C₃ through C₆, after which pulsation of cord was strikingly different. Transverse ridges also present at interspaces C₆ and C₆.

Course. There was improved power of the right deltoid and biceps, dramatic on 3rd postoperative day, and by the 2nd week, patient was able to elevate his arm above the horizontal position, and to flex his forearm against gravity. The postoperative course was stormy, however. Patient complained of severe neck pain for 10 days. On the 13th day he experienced drowsiness and nystagmus, with weakness of the left arm and leg. Patient's mental confusion disappeared one week later; the nystagmus and weakness cleared. Patient returned to work 10 weeks follow-

ing operation. *Re-examination* 7 months later showed diminished atrophy of deltoid and biceps. There was marked improvement in his grip. Patient could flex the right forearm against slight resistance, and abduct it above horizontal position against moderate resistance. Minimal hypesthesia remained, however.

Case 9. (J. W.) W. M., age 54 Patient was admitted to Mercy Hospital (January 18, 1954) with complaint of weight loss and hemoptysis; cause unexplained. There was a history of progressive loss of power in the left arm for 9 months, resulting in loss of abduction and flexion. The extremity hung flail-like at his side, and hypesthesia had also been noted.

Examination disclosed complete loss of function of the left deltoid and biceps, with moderate weakness of the left grip. Biceps and triceps reflexes were absent. The knee and ankle jerks were hyperactive; plantar responses were flexor; and no objective sensory deficit was elicited.

Roentgenograms showed loss of normal curve, subluxation C₃ and C₄, marked hypertrophic spurring, with narrowing of disk interspaces at C₄ through C₆ (Fig. 5). *Myelograms* showed lack of filling at C₄ through C₆ interspaces, with a corresponding indentation of the oil column. Spinal fluid showed normal dynamics and cell count, normal globulin, with total protein of 46 mg. per cent.

Laminectomy (February 19, 1954) of C₄ through C₆: There was resistance of dura on palpation; when opened, transverse ridges were felt at C₄, C₅ and C₆. At C₄ the 5th anterior root was constricted by the dentate ligament, lateral to which it had a kinked or balled-up appearance; the nerve root had, therefore, been constricted between the dentate and the bony protrusion. At 5th space the 6th root was also moderately constricted. Dentate attachments cut both sides at C₄ through C₆, and the dura was closed.

Course. As early as 48 hours following operation function began to return in the deltoid and biceps. On the 7th postoperative day, patient was able to elevate the arm above the horizontal position, and to flex the forearm against gravity. Improvement was progressive, and at discharge (March 10, 1954) function of the biceps and deltoids had returned to 75 per cent of normal.

Case 10. (J. W.) C. M. age 57. In March 1952 patient experienced intermittent numbness of the hands, with cramps in the forearms. There was gradual weakness in both arms, progressing to the point where each hung flail-like, with no useful motion in biceps and deltoids. By late 1952 there

was onset of difficulty in walking, both legs becoming quite stiff.

Examination disclosed almost complete bilateral loss of function of the biceps and deltoids. Both grips were weak. There was marked increase in extensor tone and adductor spasm in the legs. Knee and ankle jerks were markedly hyperactive, with ankle clonus and extensor plantar responses bilaterally. There were no objective sensory changes.

Roentgenograms showed anterior hypertrophic changes in bodies C₅ through C₇, with narrowing at C₄ through C₆ interspaces. *Myelograms* showed lack of filling at C₄, C₅ and C₆. Spinal fluid showed normal dynamics and cell count, no increase in globulin, with total protein of 56 mg. per cent.

Laminectomy (April 7, 1954; Franklin Square Hospital) of C₄ through C₆: There were transverse calcified ridges at C₄ and C₅. Three dentate ligament attachments were cut on each side, and the dura was closed.

Course. There was progressive gain following operation, and at discharge (April 20, 1954) there was marked improvement in the power of deltoid and biceps; marked diminution of spasticity in the legs, with improved walking. *Re-examination* (November 12, 1954) 7 months postoperatively disclosed that patient could raise both arms above the horizontal position against moderate resistance, and flex both forearms against resistance, with motor power improved in the legs about 75 per cent. Deep tendon reflexes were hyperactive. Muscle tone was only slightly increased, and plantar responses flexor.

COMMENT

The age of the patients at the time of operation ranged from 42 to 63 years. There were nine males and one female. The duration of symptoms ranged from three months to 16 years. In general, the onset and progression of symptoms are insidious, but the symptoms occasionally may come on fairly acutely after external trauma, such as a fall. Symptoms relative to the neck are complained of infrequently, but mild discomfort associated with movements of the head may sometimes be present. Movements of the neck are, for the most part, relatively unrestricted. The symptoms and physical signs are dependent upon the level of the lesion and the location of the osteochon-

droitic ridges in relation to the spinal cord and nerve roots. Pain is practically non-existent if the protrusion is intraspinal, whereas pain is the predominant symptom when the protrusion and osteophytic overgrowth are intraforaminal. The protrusions occur from the 3rd through the 7th intervertebral spaces, and may be single or multiple. The physical signs in the upper extremity, therefore, are naturally extremely variable. Motor weakness ranges from minimal weakness to complete paralysis of one or more muscle groups. In two cases, almost complete paralysis occurred in the deltoid and flexor muscles of the forearm, so that the extremity hung flail-like to the side. Browder and Watson⁴ reported a case that showed marked paresis of the muscles of the shoulder girdle without other demonstrable abnormalities, which they attributed to disturbance of the ventral gray column. Brain *et al.*³ state: "When symptoms and signs are limited to the upper limb, it is sometimes difficult to know whether to attribute them to a lesion of the nerve roots or to one of the corresponding segments of the spinal cord." Because the writer has seen constriction of the anterior root by the dentate ligament several times at operation and in a cadaver (Fig. 9), he believes the lesion to be in the root rather than the ventral gray column. Muscular atrophy is also variable. Sensory changes are far less prominent than the motor deficit; these range from mild paresthesias to a moderate degree of hypesthesia and hypalgesia. The sensory changes do not, as a rule, follow a definite dermatome pattern except, of course, those related to intraforaminal lesions. The deep tendon reflexes range from normal to absent responses, or they may be modified due to the simultaneous involvement of both the upper and lower motor neurons. Muscular fibrillation is not uncommon.

The physical signs in the lower extremities are essentially those of a spastic para-

plegia, with motor involvement being predominant. Increase in muscle tone with extensor rigidity and adductor spasm is frequently more severe than is motor weakness. The deep tendon reflexes are increased, there is a variable degree of clonus, and the plantar responses are also variable. The sensory changes are extremely variable. There may be minimal to complete loss of response to superficial pain; position and vibratory sense may be diminished or absent. It should be stressed, however, that sensory changes may be entirely lacking. Disturbance of sphincter control, for the most part, is unaltered, or at best, is minimal, as indicated by hesitancy and urgency.

Spondylochondrosis may be misdiagnosed as amyotrophic lateral sclerosis, primary lateral sclerosis, multiple sclerosis and subacute combined degeneration. It should be kept in mind that these degenerative diseases may also be confused with spondylochondrosis.

Routine roentgenographic examination may reveal several significant findings. Narrowing of the intervertebral space is frequently associated with osteochondrosis, but posterior protrusion may be present without narrowing. The anterior osteophytic changes, often interpreted as osteoarthritis ("lipping"), are frequently associated with posterior osteophytic reaction, although the latter changes are often overlooked, and, as Brain *et al.*³ have pointed out, may occur in the absence of change along the anterior border. It is evident that more attention should be directed to the posterior bony irregularities than heretofore. Proliferation of the uncinat part of the disk with narrowing of the intervertebral foramen can frequently be demonstrated. Occasionally minimal to moderate degrees of subluxation are seen if views are taken with the neck in flexion. While the routine findings of roentgenograms are important, the degree of posterior protrusion can be determined only by myelography.

In the AP view, the bony ridges produce areas of radiolucency at the intervertebral spaces. The lateral view will show the exact degree of posterior protrusion. Not infrequently posterior indentations of the oil column are seen opposite the intervertebral spaces, the significance of which is not yet clear (Fig. 4).

The spinal fluid findings are variable and are dependent upon the degree of protrusion. In the majority of cases the dynamics and protein content of the spinal fluid are normal. Infrequently a partial block may be seen, with a moderate increase in total protein; slight xanthochromia was present in one case in this series.

The incidence of cervical spondylochondrosis is much more frequent than has heretofore been recognized. Pallis *et al.* (1954)¹⁶ have recently reported a survey of 50 hospital patients over the age of 50, to determine the frequency of osteochondrosis in patients who were admitted with no presenting neurological complaints. Seventy-five per cent showed narrowing of the spinal canal due to various combinations of osteophytosis, subluxation of cervical vertebrae, and loss of cervical lordosis. Fifty per cent of the patients with narrowing of the spinal canal showed physical signs suggestive of cord involvement. After the age of 65, the incidence rose to 75 per cent. Seventy-five per cent of the patients showed narrowing of the intervertebral foramina due to osteoarthritis at the neurocentral and apophyseal joints. These authors rightly conclude that cervical spondylochondrosis is a common disease in elderly people. In the course of this study, Padget¹⁵ studied 100 cervical spines to determine the frequency of osteophytosis, and the typical conformation of the spinal (vertebral) canal and intervertebral foramina: The age at the time of death ranged from 25 to 94 years; in the group as a whole, only 35 per cent were normal, and 65 per cent showed varying degrees of osteophytosis; in the age group of 50 or over,

osteophytosis was found in 86 per cent, and was most frequent in vertebrae with narrow canals (Fig. 6). The AP (ventrodorsal) width of the spinal canal of the 5th cervical vertebra was measured, and the average, both in the group as a whole and in those with normal vertebrae, found to be 1.4 cm.; the narrowest canal was 1 cm., and the widest 1.8 cm. (Figs. 6 and 7). The size of the cervical spinal canal seems unquestionably a significant accessory factor as the cause of symptoms in spondylochondrosis, as shown in Figure 8. Specimens (A) and (D) show the relationship of the spinal cord to the spinal canal in cases of a wide canal; posterior protrusions have occurred in (D) without indentation of the spinal cord; (B) is an example of a narrow canal in a normal subject, and (C) shows cord indentation by posterior protrusions in a narrow canal. These specimens (Fig. 8) also indicate the variation in the relation between the vertebral bodies and the segments of the spinal cord: (C) shows the more or less accepted relationship with a differential of one segment of cervical spinal cord in relation to the vertebral bodies; segment 6, for example, being opposite the body of the 5th vertebra; (A) and (B) show a differential of two segments with segment 7 being opposite vertebra 5, in which case a mass at a single disk interspace in the lower cervical region could affect two or even three nerve roots (Padget).¹⁵

TREATMENT

Conservative treatment has little or no place in spondylochondrosis unless the findings are minimal and non-progressive. As might be expected, the results are poorer in cases with long standing symptoms. Minimal symptoms may be present for many years, followed by a fairly sudden exacerbation and marked progression of symptoms. When this occurs surgical treatment is indicated without further delay. The

laminae should be removed above and below the affected interspace, and extensive laminectomy is required when multiple lesions are present. In cases of a narrow canal, the removal of the lamina can be expected to decompress the spinal cord. I am in agreement, however, with Kahn (1947)¹² that the dentate ligaments play a significant role as a cause of cord compression, and am convinced, furthermore, that they also frequently compress the roots. As the localized protruding ridge displaces the spinal cord posteriorly, the dentate ligaments, anchored laterally, exert a definite restraining influence on the spinal cord and roots; cutting the dentate attachments will allow the cord much more freedom from the protruding mass. The relation of the dentate ligament to the nerve roots is shown in a cadaver specimen (Fig. 9B). Similar constriction of the anterior root by the dentate ligament has been seen at operation several times; after cutting and retracting the ligament, an indentation can often be seen in the anterior root at the point where the ligament crosses the root. Lateral to the constricting point, the root sometimes appears coiled as shown in Figure 10 (B), a photograph of an operative case showing a large protruding mass (C6-7) exerting pressure upon the anterior root. In this series of cases the dentate attachments have been cut routinely. The intervertebral foramen should be investigated with a probe, and if the root is tight, a foramenotomy is indicated. The necessity for doing a foramenotomy can be fairly well predicted if pain is a significant factor, but in this group of patients such procedure was unnecessary. Cases 8 and 9 are examples of anterior root compression. Improvement was rapid and progressive after cutting the dentate ligaments, and without decompression of the foramen. Removal of the ridges has been advocated by a number of investigators, but this can be a hazardous procedure; in fact, study of cadaver specimens suggests

that adequate removal of these ridges is practically impossible (Fig. 11). If the protrusion is soft and laterally placed, removal can, of course, be done without difficulty. Laminectomy, including section of the dentate ligaments, and without removal of the bony ridges, is probably the most satisfactory method of treatment. In cases of long standing compression of the spinal cord by spondylochondrosis, the margin of safety is very small, and even minimal operative trauma may cause further damage to the cord. If the protruding ridge is large, it may be advisable to leave the dura open; this was done in Case 1. When a calcified protrusion extends into the foramen, decompression of the foramen without removal of the bony mass has been found satisfactory.

SUMMARY

1. Spondylochondrosis is suggested as a more descriptive name than "spondylosis."

2. Ten cases are reported: Seven showed predominant long tract signs, two anterior root involvement, and one a combination of both.

3. The clinical manifestations and roentgenographic findings are discussed.

4. Anatomical data are presented to show that the size of the spinal canal plays a role in the causation of symptoms.

5. The condition occurs more frequently than has been heretofore recognized.

6. Spondylochondrosis may simulate other neurological disease, and vice-versa.

7. Conservative treatment is not indicated except in minimal and non-progressive cases.

8. Laminectomy with section of the dentate ligament seems to be the treatment of choice. Attempted removal of the ridge is hazardous.

9. Operative results were excellent in four cases; moderate in three; slight in one; no improvement in one, and one was worse.

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DISCUSSION.—DR. GILBERT HORRAX, Boston, Mass.: I think this an important and very timely paper. Dr. Arnold was good enough to let me see the paper beforehand, and I was greatly interested in reading it. I say it is a timely report for this reason; this is one more condition which has been taken out of the scrap basket into which we used to put multiple sclerosis or spinal degenerative disease, and the more of those that can be taken out of the scrap basket, and the more patients that can be operated on and cured the better.

Dr. Arnold has covered the subject so well and so beautifully, and has all these splendid illustrations of everything we could think of, that there is very little I can say except that, as he said, we have to differentiate this condition from other spinal conditions such as I mentioned, and also occasionally spinal cord tumors, syringomyelia, and such conditions as arachnoiditis. It is of the highest importance, of course, to do a complete study; not just a neurologic examination and perhaps a lumbar puncture, but also myelography. Even though we have these various features of roentgenography in general, nevertheless we gain further information by myelography in differentiation from other possible conditions.

I should like to ask Dr. Arnold whether he has ever found a complete block with elevated total

protein in any of these patients, and I am glad he emphasized the role of the dentate ligament in this condition, because it has been perfectly obvious in some of these cases that the dentate makes an actual nick in the spinal root at times, and it is easy to see how it can give this paralysis of which he spoke.

I must congratulate him also on his results. I do not have our figures here, so I cannot compare them in any way, but I am sure they are no better than, or perhaps not as good as, Dr. Arnold's. Anyone who can get the majority of his patients well from a condition such as this is certainly to be congratulated, and I think it is a very important paper.

DR. JAMES G. ARNOLD, JR., Baltimore, Md. (closing): I wish to thank Dr. Horrax for his discussion. In this group of ten cases we have not seen a complete block, but one case showed partial block at two levels. The spinal fluid findings have been very variable. In about half the cases the spinal fluid was normal. We have seen xanthochromia in one case of the ten; the spinal fluid protein has ranged from normal to as high as 160 or 170 mg. per cent. The cell count has been normal in all instances. The manometric studies showed a partial block in two cases.