TUMORS IN THE REGION OF THE FORAMEN MAGNUM

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Clinical neurology has established certain rules for a spinal-cord tumor to follow: (a) Long-tract signs indicate which areas of the cord are involved; focal signs, such as wasting, depressed reflexes, and segmental sensory changes, give the cross reference and pin point the anatomic site. (b) An anatomic diagnosis established, the history of the disorder should be one of steady progression. (c) There should be a partial or complete block to Queckenstedt's maneuver; and a myelogram should reveal the site.

Unfortunately, extramedullary tumors in the region of the foramen magnum are notable exceptions to the rules and thus are misdiagnosed frequently. They have been reported on by Elsberg,14 and further documented by Cadwalader,9 Frazier and Spiller,17 Stookey,27 and Globus and Strauss,28 and later summarized by Bogorodinsky,5 Symonds and Meadows,40 and Cushing and Eisenhardt.11

In the present communication 4 cases are reported and help to illustrate: (a) how the anatomic diagnosis may be erroneous, with wasting of muscles of a lower motor-neuron type occurring several segments below the level of the lesion; (b) how bizarre deficits and a relapsing, remitting course frequently lead to a diagnosis of multiple sclerosis; and (c) how myelography may be apparently normal on one or more occasions.

The appearance of atrophy in groups of muscles several segments below the caudal end of the tumor is of interest not merely because it may lead to a false anatomic diagnosis, but its causation still remains in dispute and merits review.

CASE REPORTS

Case 1. A 23-year-old male gave a 5-year history of almost constant posterior cervical pain. Fifteen months prior to admission, he had noted transient tingling along the medial aspect of his left arm when stooping or flexing his neck. One month later, a persistent numbness of the left thumb and index finger appeared, which gradually spread to involve the entire hand and all the fingers. Within 1 year he was aware of a slowness in walking, and his left knee buckled occasionally. The left hand grip became mildly weak and clumsy, and he had urinary urgency. A pneumencephalogram was reported as normal; but it did not show air in the cervical canal. He was referred to the neurological service with a diagnosis of multiple sclerosis.

Neurological examination revealed no deficits of psychological function or of cranial nerves. There was mild but definite atrophy of all groups of muscles of the left hand, of the forearm, especially the flexor group, and of the biceps. There was mild generalized weakness of all movements of this extremity. The left calf measured 4 cm. less in girth than the right. All deep tendon reflexes were hyperactive on the left, and the left plantar response was extensor. The superficial abdominal reflexes were absent. There were dysalgesia and hypalgesia confined to the left C6 dermatome. Sensations of vibration and position were diminished markedly in the left upper and lower limbs, and decreased moderately in the right lower extremity. Sense of temperature was normal.

Cerebrospinal fluid manometrics were normal; the fluid contained 71 mg. per cent protein.

An electromyogram showed fibrillary action potentials in the left 1st dorsal interosseous muscle, confirming the clinical impression of denervation of muscles at the C8–T1 level.

A myelogram revealed the presence of an extramedullary mass at the level of the 3rd and 3rd cervical vertebrae.

Operation. A neurilemmoma was found arising from the left C3 root, which did not extend below the lower border of the C3 vertebra.

The patient made an excellent postoperative recovery.

Comment. The wasting of the left forelimb in Case 1 suggested involvement of anterior horn cells from C5 to T1, supported by an objective C6 sensory lesion, and a history
of paresthesiae of the left hand. The hyper-reflexia, including the biceps reflex, indicated pyramidal involvement above C3; and this was the only correct part of the anatomic diagnosis. The location of the tumor leaves unexplained the segmental changes below C5.

**Case 2.** A male, aged 48 years, gave a history of numbness of the right hand of 2½ years' duration, followed within a few months by a similar numbness in the left hand. The numbness spread slowly to the shoulders. A cervical myelogram performed at the time was reported as normal. The cerebrospinal fluid contained 64 mg. per cent protein. At about this time the patient noted dyesthesiae and numbness over the inner part of the left thigh and later over the entire left lower extremity. Two months before admission, he had a similar sensory involvement of the right leg, and a second myelogram was reported as normal. A diagnosis of multiple sclerosis was entertained.

*Neurological examination* on admission revealed slight atrophy of the intrinsic muscles of both hands, with moderate weakness of all extremities. All deep tendon reflexes were increased, right more than left, the superficial abdominal reflexes were absent, and both plantar responses were extensor. There were hypesthesiae over both hands, the right forearm, and the left thigh and leg, with vague borders, accompanied by dyesthesiae. There was hypesthesia over a small area of the left C4 dermatome. Sense of position was decreased in the fingers and toes, and sense of vibration was absent at the left ankle.

Roentgenograms of the cervical spine showed minimal widening of the canal at C1 to C2. Lumbar puncture demonstrated normal manometry and the cerebrospinal fluid contained 64 mg. per cent protein. An air myelogram showed the presence of a tumor at the level of C2 without a block (Fig. 1).

*Operation.* An encapsulated neurofibrosarcoma, 3×5 cm. in size, was found in the interlaminar space on the right, arising from the C2 nerve root. The tumor was removed entirely.

The patient showed steady postoperative improvement in both his sensory and motor symptoms.

*Comment.* The sensory history and examination suggested an anatomic diagnosis at C3, or multiple lesions. The wasting of the muscles of the hand was significant and suggested a T1 lesion. The two "normal" myelograms appeared to exclude a tumor but, presumably to prevent spilling the contrast medium into the posterior fossa, were not carried higher than the C3 level. On the present occasion, air was selected for the contrast material as a tumor of the foramen magnum was suspected. The location of the tumor was consistent with the sensory and motor changes, except for the wasting of the intrinsic muscles of the hand. While the cervical roentgenogram suggested a widening of the canal, this was recognized only after air myelography had confirmed the situation of the tumor.

**Case 3.** A 31-year-old female began to suffer stiffness of the neck 5½ years prior to admission, followed shortly by frequent headaches in the vertex, at times lasting 7 days. Two years later she noted numbness in the ball of the left index finger and thumb, as well as paresthesiae of both feet. Some months later, she experienced ascending numbness of the left upper extremity, which spread to involve the shoulder and the left anterior area of the chest and neck to the angle of the jaw. The numbness gradually disappeared (except for brief episodes involving her shoulders) during the next 1½ years. Two years before admission, she first consulted a neurologist.

An electroencephalogram and cervical myelogram were reported as normal, but her cerebrospinal fluid contained 78 mg. per cent protein. Six months later, she first noted bilateral weakness of the leg and numbness in the right upper extremity, followed by slowly progressive weakness of both upper extremities, as well as urinary urgency and hesitancy. One year before admission she had "measles" and virtually complete quadriplegia developed rapidly, with only the left hand relatively spared. After 6 weeks a remission began and she improved to the point of being able to do all her housework, other than ironing. Two
months before admission, however, there was onset of rapidly progressive generalized weakness, and within 2 weeks she was bedridden.

Examination. On admission, her pulse rate was 140 per min. and her respirations were shallow. There was no evidence of intellectual change or involvement of cranial nerves, except for moderate wasting of both sternocleidomastoid muscles. There was moderate diffuse wasting of the muscles of the shoulder girdle and upper extremities. With the exception of small movements of the left hand and foot, she was entirely quadriplegic with spasticity, hyperreflexia and extensor plantar responses. There was a sensory level to all modalities up to, but not involving, the trigeminal area. She complained bitterly of feeling “cold all over.”

Roentgenograms of the skull showed ballooning and slight depression of the floor of the sella turcica and slightly demineralized posterior clinoids, suggesting increased intracranial pressure.

An air myelogram revealed a complete block between C1 and C2 vertebrae (Fig. 2). The cerebrospinal fluid contained 200 mg. per cent protein.

Operation. An extradural meningioma was disclosed, which extended from the clivus to the upper border of C2, with compression or incorporation of the left vertebral and the basilar arteries. Total excision of the tumor could not be accomplished, because of its extent and situation.

Following operation, respiratory paralysis developed and she died. A postmortem examination could not be obtained.

Comment. The clinical examination suggested an anatomic diagnosis at the C1 level with intracranial spread. The relapsing and remitting course and the normal myelogram (which did not reach the C1 level adequately) prompted a prior diagnosis of multiple sclerosis. The severe local pain and the repetition of lesions in the same site, however, might have suggested a different pathology. The pathological diagnosis fails to explain adequately either the fluctuating clinical course or the diffuse wasting of the forelimb and shoulder girdle.

Case 4. A 31-year-old female first noticed numbness of both legs and occasional matutinal headaches 5 years before admission. Her condition was stable for 1 year, after which burning paresthesiae developed in both legs. After treatment with B vitamins improvement occurred. During a pregnancy that followed, she became completely asymptomatic until the last month of pregnancy when her dysesthesiae returned. During the following 6 months there developed stiffness of the left leg, and weakness and burning dysesthesiae in the left arm, and shortly thereafter in the right arm. Several months before admission she complained of stiffness of the neck, spasms of the legs, and a feeling of intense cold in the left arm and leg.

Findings on examination were reported as follows: nystagmus on gaze to either side, moderate atrophy of intrinsic muscles of the hand bilaterally, strength greatly reduced in all extremities, and tone increased pathologically. All deep tendon reflexes were hyperactive, the plantar responses extensor, and superficial abdominal reflexes absent. Hypalgesia was noted in the distal portions of the left upper and lower extremities. Lumbar puncture revealed a pressure of 80 mm., and the fluid, grossly bloody, contained 220 mg. per cent protein.

She was discharged with the tentative diagnosis of multiple sclerosis.

Examination. The weakness had gradually increased and on the present admission she showed: paraplegia in flexion and greatly diminished strength in all other muscles, except for the sternocleidomastoids and the upper trapezi; a diffuse wasting of the shoulder girdle and forelimbs; hyperactive tendon reflexes; depressed superficial abdominal reflexes; vestibular nystagmus on lateral gaze to either side; a sensory level to pin prick at C4 on the left and T1 on the right; and impaired graphesthesia below the C3 segments.

Fig. 2. Case 3. Air myelogram, showing tumor at C1-2 with complete block.
Roentgenograms of the cervical spine were normal. A cervical myelogram showed a complete block at the level of the interspace between C2 and C3, and the cerebrospinal fluid contained 92 mg. per cent protein.

Operation. A high cervical laminectomy was performed, revealing an extradural perineurial fibroblastoma, lying between the atlas and axis on the left side, with the 2nd cervical root incorporated in the tumor. Complete removal of the tumor was not possible.

Since operation a moderate return of motor function has occurred.

Comment. The presence of vestibular nystagmus, remitting sensory symptoms in the legs, and later involvement of the upper limbs probably was the reason for the first neurological diagnosis. A protein of 200 mg. per cent is, however, high for multiple sclerosis, even in the presence of a traumatic tap.

The examination on admission indicated the anatomic lesion above the C3 segment. The pathological diagnosis leaves unexplained the clinical remission or the diffuse wasting below.

DISCUSSION
In each of the 4 cases there were focal signs suggesting a lesion or lesions over a much greater length of the neuraxis than the actual size of the tumor. A diagnosis of multiple sclerosis had been made in each case, partly by apparent exclusion of a neoplasm by myelograms, and partly by a relapsing remitting course. Only in Case 3, with evident involvement of the vertebral and basilar arteries, could a fluctuating course be explained readily.

The literature contains many similar cases of such "paradoxical" atrophy, and temporary remission of symptoms, and of various sensory modalities, feelings of coldness, and dissociation of modalities, mediated by posterior-column and lateral spinthalamic tracts, also was recognized by Elsberg, and has been noted by subsequent writers. All of our patients reported burning dysesthesiae at one time or another during the course of their illnesses, and this was a major complaint in Case 4. Cases 3 and 4 also complained bitterly of a severe "cold sensation" over the affected extremities. Wide disparities in degree of involvement of the various sensory modalities were also encountered in all our patients at some time during their course.

The observation of atrophy in cases of high cervical tumors is credited to Oppenheim. Characteristically, the intrinsic muscles of the hands are most atrophied, but in advanced cases the entire shoulder girdle and upper extremities may be wasted. Cushing, in his monograph on meningiomas, illustrated a patient who, in addition, had marked wasting of the intercostal muscles; and Bogorodinsky commented that "The degen-
ervative atrophies are not limited to the level of compression but involve the cervical, the thoracic and sometimes even the lumbar segments of the cord."

Similar atrophy also has been reported in other conditions in which the cervical cord is distorted mechanically, such as platybasia, discal protrusion, or spondylosis, leading to erroneous diagnosis, especially that of motor-neuron disease.

The mechanism by which such distant atrophy is produced is still uncertain. Bailey and Bucy in 1930 and later Symonds and Meadows expressed the view that the mechanism was compression of the descending arterial supply to the anterior-horn cells.

Tureen surmised that compression could produce either partial or complete block of the anterior spinal artery or its branches to produce the dissociated sensory losses, which had been reported in cases of protruded cervical discs. Stookey, Love et al., and Dodge et al. also have stressed this possibility, and have cited cases in which the vertebral and basilar arteries obviously were compressed by, or incorporated within, tumors of the foramen magnum. Presumably, the anterior spinal artery supplies the low cervical and upper thoracic segments of the cord from above. In some patients, at least, the radicular spinal arteries, which enter the intervertebral foramina at some level between C5 and C8 to join the descending anterior spinal artery, are not sufficient to nourish the area in question.

Unfortunately, neither the normal direction of flow, nor changes in patterns of flow in cases of compression, have been measured, and there is thus no unequivocal evidence that this mechanism actually is operative. Certainly, neither the clinical picture nor the rapid recovery following decompressive surgery is consistent with more than incomplete occlusion of the anterior spinal artery.

Inferences based on pathological studies are similarly equivocal: Mair and Druckman described the lesions found in 3 autopsied cases of cervical spondylosis as resulting from reduction in blood supply in the distal distribution of the anterior spinal artery. Brain et al., Payne and Spillane (who cited Girard et al.), and Wilkinson found no evidence for involvement of the anterior spinal artery in similar cases.

Störtebecker, however, has suggested that conditions that may affect the radicular arteries in the low cervical region, may produce damage of anterior-horn cells and result in a clinical picture that is indistinguishable from amytrophic lateral sclerosis.

Whatever role ultimately is assigned to these radicular arteries, it seems well established by the anatomical studies of Suh and Alexander and Gillilan that, in the presence of impaired function of the anterior spinal artery, the extraspinal arterial channels probably assume great significance for the integrity of the ventral horns. No writer has suggested yet, however, the manner in which these radicular arteries might be compromised in instances of upper cervical or foramen-magnum compression. On the contrary, pathological examination by McAlhany and Netsky of spinal cords compressed by extramedullary neoplasms (of which 2 were in the cervical region) showed that "The radicular and sulcal arteries were always patent and were not altered except for occasional endothelial proliferation. The veins were normal, but were occasionally distended."

An alternate mechanism, first considered by Tureen and later by Brain, was the compressive effect of cervical-disc protrusion on the low-pressure veins of the cervical cord. Since their flow is upwards, such pressure should result in edema of the cord for some segments below the site of compression. They believed further that arterial blood supply is likely to suffer late, if at all.

It is of interest that, some years earlier, Fay had suggested that bulging epidural veins in the cervical region, even if not thrombosed or infected, occasionally were found in patients with the clinical picture of amyotrophic lateral sclerosis—although the existence of an entity "epidural varicosities" and the possibility of compression of the cord by bulging veins today is open to question. Suh and Alexander referred to a case of
myelomalacia extending over 6 thoracic segments following compression of a radicular vein by a neoplastic metastasis, but stated that “the only veins, occlusion of which causes destruction of the anterior part of the gray matter, as well as of the white matter, are the paracentral veins.”

The difficulties in accepting the explanation of venous congestion and edema of the cord, as operating to produce distant atrophy, are several. First, Mair and Druckman in their cases of cervical spondyllosis, found no evidence to suggest that venous stasis resulted in a lesion of the compressed segment, and considered the distribution of the lesions virtually identical with the field of supply of the anterior spinal artery. Second, there is a rich communication of all venousplexuses on the surface of the cord and within the canal itself, and, unlike the radicular arteries, radicular veins are present at virtually every cervical segment. It is unclear then how even total venous blockage in the high cervical segments can have produced stasis to cause sufficient edema to result in dysfunction of the anterior-horn cells; and because of the many venous channels that connect both halves of the cord, it is difficult to see how such stasis might produce only unilateral atrophy, as in our Case 1.

Moreover, Taylor, in a recent article, reported 7 cases of neurinoma or meningioma between C1 and C4 in which there appeared to be a complete block at myelography or operation, but a normal Queckenstedt’s test. This finding was used as evidence for the continued patency of the extradural spinal veins, if correct. Significant venous obstruction, in instances of incomplete or absent block of cerebrospinal fluid, such as in 2 of our 4 patients with atrophy, would be even more unlikely.

A remaining possibility is that mechanical factors, akin to those proposed by Kahn to account for involvement of lateral columns in cases of cervical-disc protrusion, may somehow be operative in cases of extramedullary tumor. Whether the stresses, produced by anchoring of the cord by the dentate ligaments under these circumstances, can of themselves produce damage of anterior-horn cells or can act in some way to compromise further the blood supply to this area, is not known. To date, no pathological support for Kahn’s hypothesis has appeared.

Equally puzzling is the occurrence (seen in 2 of our 4 cases) of partial remission of symptoms. As early as 1921, Cadwalader cited older French and German reports of virtually complete remissions, some of them lasting months to years, in patients later proven to have compressive cervical lesions. This can hardly be ascribed to change in size of the mass of tumor or canal, but could be explained on a vascular basis, if early compression compromises flow, at times transiently, later augmented by collateral flow. The left vertebral artery and the basilar artery were incorporated in the tumor in Case 3—the patient who gave the history of the most startling remissions and relapses—highly consistent with vascular insufficiency. In Case 1, the tumor was located where this supply could be compromised, and the remission, postpointing, and vestibular nystagnus would fit well with vascular compression.

It appears probable that distant changes and a remitting course are both on the basis of arterial insufficiency; but the final answer awaits experimental investigation.

SUMMARY AND CONCLUSIONS

Four cases of tumors in the region of the foramen magnum are reported and the literature is reviewed. The occurrence of a relapsing remitting course, the presence of diffuse anatomical changes, and the high incidence of normal myelograms frequently lead to the erroneous diagnosis of multiple sclerosis. Air myelography may help exclude such tumors when suspected. The pathogenesis of atrophy in muscles innervated by segments well below the site of the tumor is discussed, and arterial insufficiency appears to be the most probable explanation.

REFERENCES

1. Abbott, K. H. Foramen magnum and high cervical cord lesions simulating degenerative disease of