Periaqueductal dysfunction (the Sylvian aqueduct syndrome): a sign of hydrocephalus?

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SUMMARY   A patient with hydrocephalus due to aqueductal occlusion is described in whom the Sylvian aqueduct syndrome appeared during a sudden increase in intracranial pressure. The ocular signs resolved completely when the hydrocephalus was relieved. Marked dilatation of the posterior part of the third ventricle and of the rostral aqueduct with axial displacement of these structures was demonstrated radiologically. It is suggested that the ocular signs in this case were the result of periaqueductal dysfunction due to assimilation and dilatation of the aqueduct, with secondary tentorial block. This abnormality may be the cause of the similar abnormalities commonly found in noncommunicating hydrocephalus in both infants and adults.

The Sylvian aqueduct syndrome (Elschnig, 1913; Salus, 1913; Koerber, cited by Cogan, 1956) was first clearly delineated by Kestenbaum in 1946. The clinical features of this syndrome were reviewed by Smith *et al.* (1959); they consist of

FIG. 1. *Pneumoencephalogram   The fourth ventricle is dilated. Only the caudal 2 mm of the aqueduct can be seen. Air did not fill the third and lateral ventricles, but the retrothalamic and quadrigeminal plate cisterns are dilated, and air has outlined the upper brain-stem. Later, some air passed up and outlined cerebral sulci.*

pupillary anomalies—for example, anisocoria and absence of the light reaction; impairment of conjugate upward gaze; convergence nystagmus occurring as a substituted movement on attempted conjugate upward gaze; retractory nystagmus, which is usually inconstant; vertical nystagmus on gaze upward or downward, and palsies of extraocular muscles. In all previously reported cases this syndrome has been associated with fixed, structural lesions in the rostral periaqueductal region.

It is the purpose of this paper to describe a patient with hydrocephalus due to aqueductal stenosis, who presented with ocular abnormalities and ataxia of gait, and in whom the ocular signs of the Sylvian aqueduct syndrome were observed during a brief episode of acute hydrocephalus. The significance of this observation will be discussed in relation to the radiological findings and to the pathogenesis of the characteristic ocular abnormalities found in some patients with hydrocephalus.

CASE REPORT

For six months a 19 year old student had noticed clumsiness of gait, and inconstant diplopia on upward gaze. During this time he had also noted some occipital headache and had found increasing diffi-

culty with his studies. For about a year his mother had noticed that his pupils were unequal.

On examination he was a tall youth who was alert and orientated, but a little vague. There was some truncal obesity. He walked clumsily and could barely walk heel to toe, but there was no limb ataxia. Fine rapid finger movements were slightly impaired on the left and there was some downward drift and pronation of the outstretched left arm. In addition there was a minimal left supranuclear facial weakness. The tendon reflexes were normal in the arms, but the knee and ankle jerks were increased, with unsustained clonus at the ankles, and the right plantar response was extensor. Tone was normal in all limbs and there were no sensory abnormalities. The fundi, and the visual fields and acuity were normal. The head was 58 cm in circumference.

NEURO-OPHTHALMIC FINDINGS   The eyes were slightly divergent at rest: gaze was fixed with the right eye,
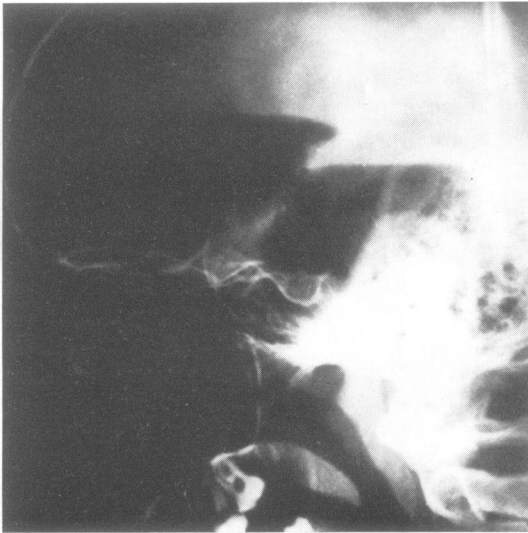
FIG. 2.   *Air ventriculogram   There is marked dilatation of the frontal horns of the lateral ventricles, of the anterior part of the third ventricle, and of the foramen of Monro.*

the left remaining 3–5° divergent. The pupils were large, unequal (right 5 mm, left 4 mm) and slightly irregular. Both showed a slight and only poorly sustained response to light and there was no response to accommodation, or to convergence. During this manoeuvre the right globe adducted a few degrees but the left did not move. Nonetheless, accommoda-

tion on near objects seemed normal. Conjugate upward gaze was restricted and the right globe lagged a little behind the left during this movement.

INVESTIGATIONS   Routine blood and urine studies, radiograph of the chest, brain scan, and electroencephalograph were normal. The WR was negative. Radiographs of the skull, the sella turcica, the craniovertebral region, and the cervical spine were normal.
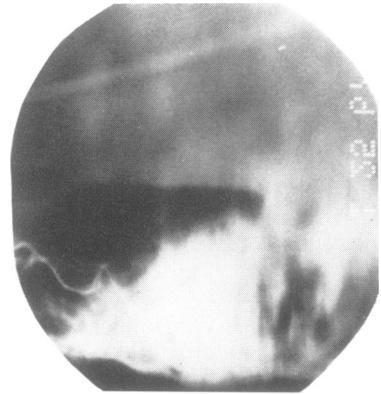
FIG. 3.   *Air ventriculogram   The posterior part of the third ventricle is greatly dilated. The rostral part of the aqueduct is assimilated into this dilated third ventricle. When this lateral radiograph, and the lateral film of the pneumoencephalogram, shown in Fig. 1, were superimposed discontinuity of the aqueduct was seen to be due to an interposed 'membrane' occluding its lumen.*

A pneumoencephalogram (Dr. B. Kaufman) failed to demonstrate the aqueduct, third ventricle, and lateral ventricles, but the cisterna magna, the basal and quadrigeminal plate cisterns, and the fourth ventricle were clearly outlined (Fig. 1). The fourth ventricle was dilated and was displaced posteriorly and caudally, in the midline, to a position 4 cm from the clivus. The retrothalamic cisterns were dilated, and air passed up through them and outlined cerebral sulci. Anteroposterior and lateral tomograms showed air in the prepontine cistern, which was slightly smaller than normal, and in both cerebellopontine angles. Only the caudal 1 mm of the aqueduct could be seen, at its origin from the rostral part of the fourth ventricle. The cerebrospinal fluid (CSF) contained 2 lymphocytes/cu. mm and 26 mg protein/100 ml.

PROGRESS After this investigation the patient's gait became more clumsy, both plantar responses were found to be extensor and early papilloedema was noticed. The ocular signs did not change. A right carotid arteriogram showed displacement of vessels consistent with hydrocephalus, and ventriculography was therefore performed (Figs 2, 3, and 4).

The ventricular pressure, measured in the supine position under local anaesthesia, was 100 mm CSF. There was marked symmetrical dilatation of both lateral ventricles and the thickness of the cerebral mantle was 3·5 cm anteriorly and 1·5 cm in the occipital region. The third ventricle was also greatly enlarged: in its posterior part its transverse diameter was 2·5 cm. Inferiorly it abutted on the diaphragma
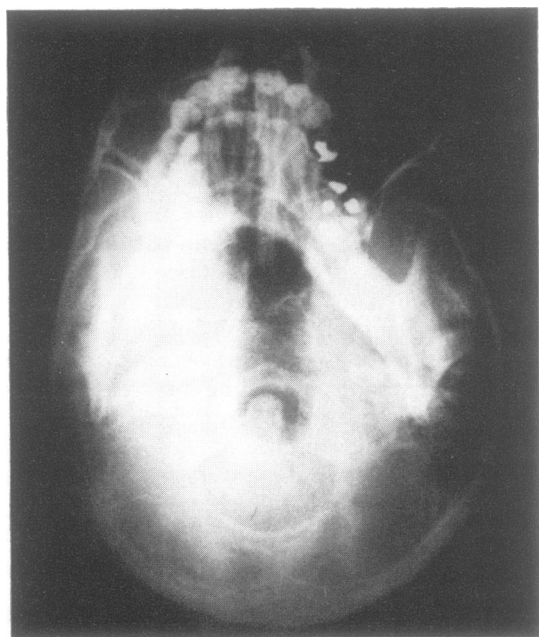

FIG. 4. *Air ventriculogram This submento-vertical projection illustrates the extent of the dilatation of the third ventricle, and of the assimilation and dilatation of the rostral two-thirds of the aqueduct.*

sellae and its posterior part was continuous with the dilated rostral aqueduct so that it seemed to extend under the tentorium cerebelli and into the posterior fossa. The infra- and suprapineal recesses could not be defined. It was impossible to determine the point of transition from third ventricle to aqueduct, but when the ventriculogram and pneumoencephalogram films were superimposed the rostral part of the

fourth ventricle and the caudal end of the dilated aqueduct apposed almost exactly, being apparently separated only by a thin membrane. A ventriculo-atrial CSF shunt was inserted (Dr. F. Nulsen) and the headache and papilloedema quickly subsided.

The patient then remained well until the sixth postoperative day when he again complained of headache and vomited several times. The CSF shunt was found to be blocked, and did not function again until it was cleared by a forced saline injection eight hours later. During this period the ocular signs changed and, for a four hour period before the shunt was cleared, the full Sylvian aqueduct syndrome was present.

NEURO-OPHTHALMIC FINDINGS The patient remained alert and cooperative, although nauseated he complained of headache, and that he could not focus on near objects. The pupils were large and unequal and were fixed to light, to accommodation and to convergence. The ciliospinal reflex was absent bilaterally. At rest and in attempted near vision the eyes remained in 10° divergence; fixation was usually accomplished with the right eye. There was neither ptosis nor lid retraction. Voluntary conjugate upward gaze was absent and could not be reflexly induced by oculocephalic, caloric, or optokinetic stimuli (Smith *et al.*, 1959). However, reflex conjugate upward gaze was observed during the palpebro-oculogyric manoeuvre (Bell's phenomenon). Conjugate lateral and downward gaze were normal, but there was a partial left lateral rectus palsy.

When he was re-examined two hours later (immediately before exploration of the shunt), the pupillary abnormalities and the resting divergence were unchanged, although bilateral sixth nerve palsies had appeared, that on the left being nearly complete. Conjugate downward and lateral gaze movements were otherwise normal, but volitional conjugate upward gaze was absent. Both the latter movement and attempted convergence released the substituted movement of convergence nystagmus, which was associated in the quick convergent phase with eye closure. Other than the associated eye closure there were no other facial movements. With encouragement by the examiner during attempted volitional upward gaze the convergence nystagmus became of much greater amplitude, although it did not change in frequency or rhythm. The most potent stimulus, however, was optokinetic. With the stimulus rotating downwards a response of consistently large amplitude was induced. Nonetheless, the movement could always be voluntarily inhibited by willed conjugate downward gaze.

PROGRESS That evening the ventriculoatrial shunt

was cleared by a forced saline injection through its distal connection. The next morning resting divergence was only about 2–3°. There was a minimal left sixth nerve palsy and the pupils remained unequal and unreactive to light. Conjugate upward and downward gaze were normal and optokinetic testing in all directions of gaze induced normal nystagmus. The stretch reflexes in the legs were still increased but both plantar responses were flexor.

Since then he has remained well and, when examined nine months later, no abnormality of intellect, gait, pupillary reaction or ocular movement could be found.

DISCUSSION

In a comprehensive review Segarra and Ojeman (1961) were able to find only 46 cases of the Sylvian aqueduct syndrome, none of them with hydrocephalus. Salus (1913) described a case associated with a cysticercus cyst in the peri-aqueductal region, and the syndrome has been reported since then, in patients with pinealomas (Elschnig, 1913; de Monchy, 1923), with arterio-venous aneurysm of the vein of Galen (Askenasy et al., 1953), with multiple sclerosis (Cogan, 1956), in cases of presumed encephalitis (Cogan, 1956), with third ventricular tumours (Christoff et al., 1960), with intrinsic astrocytoma of the rostral mesencephalon (Segarra and Ojeman, 1961), after stereotactic lesions placed in the rostral mesencephalon in man (Smith et al., 1961; Nathanson and Epstein, 1962), and with rostral mesencephalic infarction (Hatcher and Klintworth, 1966). A case of congenital rostral aqueductal cystic dilatation with similar ocular findings was studied by Fredericks and Van Nuis (1967). Walsh and Hoyt (1969) have recently pointed out that partial forms of the syndrome can be found with surprising frequency if opto-kinetic tests of upward gaze are included in the routine neuro-ophthalmic examination.

In all these instances the syndrome was irreversible and associated with fixed, structural lesions. In the present report, the ocular signs found when the patient was first examined were consistent with a lesion in the periaqueductal region. The full Sylvian aqueduct syndrome appeared when the ventriculoatrial shunt was occluded but when the shunt became functional again these signs rapidly disappeared and nine months later there were no ocular abnormalities.

The relationship of the ocular signs to flow and pressure changes within the CSF pathways is clear, as is their complete reversibility in these circumstances. The preoperative radiographic studies showed marked dilatation of the upper part of the aqueduct and axial, caudal displacement of the posterior part of the third ventricle. The upper brain-stem was displaced into the prepontine cistern. Jakubowski and Jefferson (1972) have pointed out that these radiological signs occur in benign aqueductal stenosis when the hydrocephalus is 'uncompensated'. They have suggested that decompensation is secondary to uncal herniation with axial displacement of the third ventricle and brain-stem, leading to a secondary block of the flow of cerebrospinal fluid at the tentorial hiatus and to compression of the upper brain-stem and have illustrated these abnormalities in their paper.

Although there have been previous reports of non-communicating hydrocephalus presenting in adult life with ocular abnormalities, the pathogenesis of these signs has remained obscure (Walsh and Hoyt, 1969) and, in particular, their similarity to those of the Sylvian aqueduct syndrome seems to have escaped notice. For example, Pennybacker (1940) reported five patients with adult-onset hydrocephalus, thought on radiological grounds to be due to aqueductal stenosis, in whom there was defective conjugate upward gaze and absence of the pupillary light reflex. These five patients were treated by third ventriculostomy and three years later their ocular signs had resolved. The close clinical resemblance to the present case is clearly evident. Similar ocular signs have been recorded in other series of cases of benign adult-onset aqueductal stenosis (Petit-Dutaillis et al., 1950; Nag and Falconer, 1966) and it therefore seems reasonable to suggest that these abnormalities must be the result of periaqueductal dysfunction.

Postmortem studies of such cases have rarely been reported. One of Globus and Bergman's (1946) cases had fixed pupils, paralysis of convergence and of upward gaze, and bilateral sixth nerve palsies. At necropsy there was hydrocephalus due to incomplete occlusion of the aqueduct at the junction of its rostral fifth and caudal four-fifths by a dense gliosis. Beckett et al.'s (1950) series of 11 cases that came to necropsy included three patients with prominent

ocular abnormalities. Their case 8 (aged 31 years) presented with paralysis of convergence and of conjugate upward gaze. In addition, the eyes were divergent at rest and the pupils were fixed to light and accommodation. At necropsy the aqueduct was occluded by gliosis in its lower third, but the degree of dilatation of the rostral part of the aqueduct was not described.

Since periaqueductal glial and ependymal changes similar to those found in these previously reported cases are present in many cases of aqueductal stenosis without such striking ocular signs (Russell, 1949), the ocular findings cannot be attributed directly to these changes alone. Furthermore, in most such cases, as in the present case, the ocular signs are most prominent when hydrocephalus is decompensated.

These observations provide evidence indicating that the ocular abnormalities found in these patients are due to dilatation and assimilation of the rostral part of the aqueduct, particularly when there is associated uncal herniation and axial displacement of the third ventricle, causing secondary compression of this region of the brain-stem. It follows that these ocular signs should occur more frequently in hydrocephalus due to aqueduct stenosis than in communicating hydrocephalus, since, in the latter, aqueductal dilatation and assimilation is usually slight, and uncal herniation with compression of the upper brain-stem is less likely to occur. Indeed, ocular signs consistent with rostral periaqueductal dysfunction did not occur in the series of cases of adult-onset, communicating hydrocephalus described by Foltz and Ward (1956), McHugh (1964), Hakim and Adams (1965), Messert and Baker (1966), and Hill *et al.* (1967).

Finally, it should be noted that ocular signs similar to those under discussion are a common presenting feature of infantile hydrocephalus. In many of these infants hydrocephalus is due to congenital or acquired aqueductal stenosis (Russell, 1949; Ford, 1966).

The occurrence of ocular signs in these infants is thus consistent with the hypothesis, although this is not their usually accepted explanation (Ford, 1966; Walsh and Hoyt, 1969). Further attempts to correlate the ocular signs with radiographic abnormalities of the rostral aqueduct should be made in such cases.

REFERENCES

Askenasy, H., Wijsenbeek, H., and Herzberger, E. (1953). Retraction nystagmus and retraction of eyelids due to arteriovenous aneurysm of midbrain. *Archives of Neurology and Psychiatry*, **69**, 236–241.

Beckett, R. S., Netsky, M. G., and Zimmerman, H. M. (1950). Developmental stenosis of the aqueduct of Sylvius. *American Journal of Pathology*, **26**, 755–787.

Christoff, N., Anderson, P. J., and Bender, M. B. (1960). Convergence and retractory nystagmus. *Transactions of the American Neurological Association*, **85**, 29–32.

Cogan, D. G. (1956). *Neurology of the Ocular Muscles*. 2nd edn. Thomas: Springfield.

Elschnig, A. (1913). Nystagmus retractorius, ein cerebrales Herdsymptom. *Medizinische Klinik*, **1**, 8–11.

Foltz, E. L., and Ward, A. A., Jr. (1956). Communicating hydrocephalus from subarachnoid bleeding. *Journal of Neurosurgery*, **13**, 546–566.

Ford, F. R. (1966). *Diseases of the Nervous System in Infancy, Childhood, and Adolescence*. 5th edn. Thomas: Springfield, Ill.

Fredericks, E. J., and Van Nuis, C. (1967). Diverticulum of the rostral cerebral aqueduct with ocular dysfunctions. *Archives of Neurology*, **16**, 32–36.

Globus, J. H., and Bergman, P. (1946). Atresia and stenosis of the aqueduct of Sylvius. *Journal of Neuropathology and Experimental Neurology*, **5**, 342–363.

Hakim, S., and Adams, R. D. (1965). The special clinical problem of symptomatic hydrocephalus with normal cerebrospinal fluid pressure. *Journal of the Neurological Sciences*, **2**, 307–327.

Hatcher, M. A., Jr., and Klintworth, G. K. (1966). The Sylvian aqueduct syndrome. *Archives of Neurology*, **15**, 215–222.

Hill, M. E., Lougheed, W. M., and Barnett, H. J. M. (1967). A treatable form of dementia due to normal-pressure, communicating hydrocephalus. *Canadian Medical Association Journal*, **97**, 1309–1320.

Jakubowski, J., and Jefferson, A. (1972). Axial enlargement of the 3rd ventricle, and displacement of the brain-stem in benign aqueduct stenosis. *Journal of Neurology, Neurosurgery, and Psychiatry*, **35**, 114–123.

Kestenbaum, A. (1961). *Clinical Methods of Neuro-Ophthalmologic Examination*. 2nd edn. Grune and Stratton: New York.

Koerber, H. (1956). Cited by D. G. Cogan in *Neurology of the Ocular Muscles*, 2nd edn. Springfield, Ill.

McHugh, P. R. (1964). Occult hydrocephalus. *Quarterly Journal of Medicine*, **33**, 297–308.

Messert, B., and Baker, N. H. (1966). Syndrome of progressive spastic ataxia and apraxia associated with occult hydrocephalus. *Neurology (Minneapolis)*, **16**, 440–452.

Monchy, S. J. R. de (1923). Rhythmical convergence spasm of the eyes in a case of tumour of the pineal gland. *Brain*, **46**, 179–188.

Nag, T. K., and Falconer, M. A. (1966). Non-tumoral stenosis of the aqueduct in adults. *British Medical Journal*, **2**, 1168–1170.

Nathanson, M., and Epstein, J. A. (1962). Convergence

nystagmus and paralysis of vertical gaze following balloon-made lesion for Parkinsonism. Sequence of events during recovery. *Transactions of the American Neurological Association*, **87**, 227–228.

Pennybacker, J. (1940). Stenosis of the aqueduct of Sylvius. *Proceedings of the Royal Society of Medicine*, **33**, 507–512.

Petit-Dutaillis, D., Thiébaut, F., Berdet, H., and Barbizet, J. (1950). A propos des sténoses de l'aqueduc de Sylvius d'origine non tumorale de l'adolescent et de l'adulte. *Revue Neurologique*, **82**, 417–421.

Russell, D. S. (1949). *Observations on the Pathology of Hydrocephalus*. Medical Research Council Special Report Series No. 265. H.M.S.O.: London.

Salus, R. (1913). On acquired retraction movements of the eyes. *Archives of Ophthalmology*, **42**, 34–44.

Segarra, J. M., and Ojeman, R. J. (1961). Convergence nystagmus. *Neurology (Minneap.)*, **11**, 883–893.

Smith, J. L., Nashold, B. S., Jr., and Kreshon, M. J. (1961). Ocular signs after sterotactic lesions in the pallidum and thalamus. *Archives of Ophthalmology* **65**, 532–535.

Smith, J. L., Zieper, I., Gay, A. J., and Cogan, D. G. (1959). Nystagmus retractorius. *Archives of Ophthalmology*, **62**, 864–867.

Walsh, F. B., and Hoyt, W. F. (1969). *Clinical Neuro-Ophthalmology*, 3rd edn. Williams and Williams: Baltimore.