SURGICAL TREATMENT OF DEAFNESS FOLLOWING MENINGITIS*

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Generally it is assumed that, when a child has become deaf or hard of hearing after meningitis, little if anything can be done to help the hearing. A review of the literature has not provided any optimistic information on the subject. Davis\(^1\) wrote that, “The knowledge of the nature of the injury in meningitis and in other forms of nerve deafness allow us to state categorically that no type of treatment, medication, or stimulation will improve the hearing of anyone whose deafness is due to meningitis or for whom a diagnosis of true nerve deafness can be made.”

Experience with 6 cases of this type of deafness treated surgically has shown that some patients can be helped by radical measures directed to the 8th cranial nerve.

The first patient in this small series was actually not admitted for treatment of his deafness and it was a surprise to find that something might perhaps be done to help his hearing.

Case 1. J.W., aged 5 years. The presenting complaint was convulsions following meningitis and in the investigation an air encephalogram was done. The films showed poor filling of subarachnoid channels over the cerebral hemispheres. In the next few days hearing was much improved and it was noticed that the boy’s balance was disturbed during the time that hearing was better. This effect on hearing and balance lasted for about 10 days. Apparently the 8th nerves were able to function better for a time and this temporary change was attributed to the mechanical effect of the air in the subarachnoid space around the 8th nerves. Accordingly an operation was planned in which the basal cisterns and cerebellopontine angles could be explored.

Operation. On Jan. 31, 1947 suboccipital craniotomy was done. Anesthetic was ether by nasal catheter.

With patient face-down on the cerebellar head-rest, a curved incision was used from one mastoid tip to the other. After reflecting muscles and periosteum from occipital bone down to the arch of the atlas, bone was removed from each occipital squama laterally as far as the lateral sinus. The bone removal was carried down into the digastric groove and each oval-shaped opening measured about 3.5 by 5.0 cm. (Fig. 1).

The foramen magnum was unusually large. When the dura mater was opened

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the cerebellum bulged until the cisterna magna had been opened. The arachnoid over the latter was quite tough and the cisterna magna was serrated at its edge, suggesting atrophy of the cerebellar folia. The left cerebellopontine angle was explored first and as the cerebellum was retracted medially the left auditory nerve was found to be covered with thickened, milky arachnoid. The anterior inferior cerebellar artery was folded over the nerve and then formed a second fold down in front of it before turning back again toward the cerebellum. This artery was quite beaded, apparently from traction by the bands of adhesions between cerebellum and dura mater (Fig. 2).

The adhesions were freed by opening the arachnoid widely and a small artery passing from the anterior inferior cerebellar artery toward the internal meatus was coagulated and divided. The folds of arachnoid could not be torn with the small
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Fig. 2. Case 1. The left 8th nerve as it was first exposed, obscured by the thickened and white arachnoid. The beaded effect can be seen on the anterior inferior cerebellar artery. (This drawing and that in Fig. 3 were elaborated from careful sketches by Dr. Robert S. Knighton* who was resident in neurosurgery and assisted at the operation.)

dissector and had to be cut with a scalpel or the cutting cautery. By then the beading on the anterior inferior cerebellar artery was appreciably less (Fig. 3). The work was facilitated by the use of a magnifying loupe. The 8th nerve appeared normal.

The right 8th nerve was exposed in the same way. Arachnoid was less thickened than on the left although it could not be torn with a small dissector (Fig. 4). A small artery passing from the anterior inferior cerebellar artery to the petrous bone was coagulated and divided as it seemed to be holding the larger artery against the 8th nerve. The 5th nerve was not seen on either side but a good view was obtained of the 9th, 10th and 11th nerves. The cerebellum appeared normal with the exception of the suspected atrophy around the cisterna magna.

The wound was closed in layers with black silk and without drainage.

Postoperative Course. Two days after operation the patient could hear fairly well. On the 4th day talking was improved and he seemed more cooperative and restful. He was noticing new sounds; for example, he asked his father about the sound of a siren which he had heard for the first time. Temperature varied from 99.8 to 101° by rectum and was normal on the day of discharge from hospital, 7 days after operation. There had been no convulsions since the day he was first admitted.

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Fig. 3. Case 1. The left 8th nerve after it was cleared of the thickened arachnoid. The beading
on the artery was appreciably less than when first seen.

Subsequent Course. A letter from the patient’s mother in March, 1947 indicated
that her son was improving steadily and that his hearing was very much better. He
was able to repeat the alphabet and to count up to ten. However, the minor
spells were returning and more recently they were becoming worse. They were
 ushered in by epigastric discomfort.

One year after operation the hearing was apparently normal. The parents re-
ported that, if they called from a distant part of the house, the boy would seem to
 hear them readily.

On July 26, 1948, 18 months after operation, hearing still seemed good. Audio-
gram showed loss of between 30 and 60 decibels on the right and from 30 to 50 on
the left (Fig. 5).

In the next 5 years, 5 other patients were treated along the same lines.
This makes a series of 6 cases, in 5 of which a craniotomy was performed.
The clinical material will be tabulated in brief case reports arranged chrono-
logically in a later section of this paper.

In all 6 cases the impaired hearing or deafness began during the acute ill-
ness. The organism was meningococcus in 2 cases, pneumococcus in 3 and
staphylococcus in 1. Patients were from 4½ months to 19 years of age at the
time of the acute infection. It was then from 3 to 7½ years before they had
the operations reported here. In the 9 cases in which the patients were
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Fig. 4. Case 1. View of the right side. The arachnoid is less thickened than on the left side. As mentioned in the text, the internal auditory artery passing from the anterior inferior cerebellar artery to the internal meatus seemed to be distorting the vessel and pulling it against the nerve. It was divided after being electrocoagulated.

helped, the time interval from the acute illness to the operative treatment was 3 years, 4½ years, and 7½ years respectively.

Hearing ranged from greatly impaired to completely absent. No patient was helped by operation who was completely deaf from meningitis.

In all cases an air encephalogram was done as a preliminary step with the

Fig. 5. Case 1. Audiogram showing the comparative values in each ear, before and after operation.
hope of gaining information about the subarachnoid cisterns around the base of the brain and the 8th nerves. Also it was used as a test to see if function of the 8th nerve would be altered by the mechanical effect of the air. This might be evident in a temporary or permanent effect on hearing or on control of balance. In cases of postmeningitic deafness, when the air encephalogram did not have some, even temporary, effect on 8th nerve function, there was no improvement following operation to explore the 8th nerves directly.*

**OPERATIVE TECHNIC**

For infants the anesthetic was ether with the usual pre-medication. Pentothal sodium was used in patients over 7 years of age. One per cent novocain was injected in skin and muscle. For the bilateral operation the patient was in face-down position but was not intubated. There was no mortality.

Incision in all but Case 1 was of small hockey-stick shape behind the mastoid. Bone was removed to uncover the outer limit of the cerebellum and usually it was not necessary to reach the cisterna magna for drainage of subarachnoid fluid.

After retracting the cerebellum medially a magnifying loupe was found to be helpful. Arachnoidal bands or septa could then be divided with the pointed scalpel or cautery-tip without injury to adjacent blood vessels. Small arteries and any bridging veins between cerebellum and petrous bone were electrocoagulated and divided, when necessary. Care was taken never to push the retractor against the 8th nerve.

In Cases 3 and 4 the nerve sheath was split lengthwise without any surface bleeding. From the present study one cannot say that it was helpful to do this.

Facial weakness, even slight and transient, did not occur in any case.

When the anterior inferior cerebellar artery was pressing on the 8th nerve it was from below, so that it was pushing against the cochlear portion. In this event the artery was dissected free enough to move it away from the 8th nerve. If necessary, a small piece of gelfoam can be interposed.†

**OPERATIVE FINDINGS**

Lesions affecting the 8th nerve, as found at operation in the present series, will be considered under three categories: (1) Changes in arachnoid. (2) Abnormalities in 8th nerve. (3) Compression by adjacent artery.

1. **Changes in Arachnoid.** Milky appearance of arachnoid was found in most cases following meningitis, indicating cellular infiltration or proliferation. With this there was thickening of the membrane so that it usually

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* It is obvious that this series is too small for a conclusion on this point.  
† N.B. In an adult with Ménière’s disease the vestibular portion of the left 8th nerve was divided. The patient also had poor hearing on the left and tinnitus. Gelfoam was used to hold the artery away from the nerve and, 3 months later, the patient was not only free from vertiginous attacks, but her hearing was normal and tinnitus occurred only if she would lie on her left side for a long time and not always then.
could not be torn but had to be cut with scissors, pointed knife or cautery. Such bands of thickened arachnoid were presumably sufficient in Case 1 to give the adjacent artery a beaded appearance. Traction by constricting bands could produce mechanical compression of the 8th nerve and also could embarrass the blood flow, both arterial and venous, in the nerve.

In Case 6 there was obvious loculation so that a series of sacs of fluid seemed to stretch the 8th nerves. After the sacs had been opened widely no investment of arachnoid could then be found on the nerves, indicating that the lesion was not a multilocular subdural hydroma.

2. Abnormalities in the 8th Nerve. In Case 4, the 8th nerve was bluish at first and more pink after the arachnoidal tension on it had apparently been relieved. Surface vessels, not visible at first on the nerve, were seen to open up when the arachnoidal bands were freed. In Case 3, the left nerve was discolored an ivory yellow and it was swollen.

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**Fig. 6. Case 2.** This represents the operative appearance on the left side. In (a) one can see the anterior inferior cerebellar artery bound tightly to the cerebellum by thickened arachnoid and adhesions. The artery pushes the 8th nerve up and forward, pressing chiefly against the cochlear portion. In (b) the artery has been dissected away from the cerebellum. Then it was pushed down where a small protrusion on the petrous bone held it away from the 8th nerve which was then straight.
3. Compression by Adjacent Artery. In Case 2, only the left nerve was exposed. The anterior inferior cerebellar artery was bound to the cerebellum by heavy adhesions and was lifting the 8th nerve from behind (Fig. 6). This would exert the greatest pressure on the cochlear portion of the nerve, with consequent effect on hearing.

RESULTS OF AIR ENCEPHALOGRAPHY

Of 6 patients who had air encephalography, 3 had improved hearing following it. In Case 1, the improvement was temporary. In Cases 2 and 5, it was definite but not enough to be considered satisfactory improvement. In 2 of these 3 cases operative exposure of the 8th nerves gave additional and more lasting benefit. The third patient has had air encephalography only. All 3 patients had had meningitis but 2 had at least a little hearing when first seen.

Sense of balance was affected in 2 patients, Cases 1 and 5, as a result of the air injection. It was transient, lasting for a few days and 3 weeks respectively.

RESULTS OF OPERATION

In the 5 patients operated upon improvement in hearing varied from none to very good. The best results were in patients who had slight or temporary benefit from the air encephalography. Two patients had useful return of hearing after operation.

Some improvement in balance control was found in 1 case, pointing to partial recovery of the vestibular portion of the nerve. This patient was Case 4, who had no change in hearing as a result of operation.

The measures that seemed to help the nerve were: (1) Release of subdural fluid. (2) Opening of cystic subarachnoid formations. (3) Dissection of thickened bands of arachnoid from around the 8th nerve. (4) Mobilization of anterior inferior cerebellar artery when it was pressing on the nerve.

TABULATION OF CASES

Case 1. J.W. Age 5 years Admitted Nov. 19 1946
Etiology of deafness—meningitis—at 4½ months following right otitis media staphylococcus aureus hemolyticus
Hearing—obviously decreased after the meningitis
at 9 months, would jump at a loud noise
later, could not hear other children when playing
at 5 years, it seemed possible that a loud tuning-fork was heard on the right
audiogram showed loss of from 60 to 90 decibels on right and from 56 to 80 decibels on left
Balance—not disturbed
Mentality—subnormal
had frequent temper tantrums
co-operated poorly, would spit at examiner
Speech—began at 28 months
always poor, as though tongue were thick
at 5 years, was still using single words only
Air encephalogram—films showed—poor filling of subarachnoid channels over the hemispheres
enlarged cisterns around cerebellum
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general effect—patient not unduly sick
effect on hearing—hearing was better within 5 days and improved for another week.
Then, within a few days, it regressed to the original level
effect on balance—between the 5th and 8th days patient staggered much and in-
dicated that he felt dizzy

Operation—bilateral
findings—arachnoid thickened and white, more on left than right
left anterior inferior cerebellar artery was beaded by bands of arachnoid, less so
after the bands were divided (Figs. 1, 2, 3)
procedure—bands of arachnoid cleared away, including small vessels
result—hearing improved in 2 days. In 4 days patient heard a siren for the first time. One
year after operation his parents felt that, for practical purposes, his hearing was
normal

Case 2. J.R.  Age 9 years  Admitted Sept. 27, 1948
Etiology of deafness—meningitis—at 20 months
meningococcus

Hearing—almost absent on left although loud tuning-fork heard at 1½ inches
school report showed decrease to 27 per cent of normal on right and absent on left
Weber referred to right side
Balance—not disturbed
Mentality—not too alert
attended school but progress said to be fair
Speech—enunciation poor
would make short sentences
Air encephalogram—x-rays—poor filling of subarachnoid channels
general effect—not very sick, went home in 2 days
effect on hearing—patient said that after 1 day he could hear better so that a tun-
ing-fork could be heard on the left better than on the right
in the Weber test sound was referred to the left
effect on balance—none

Operation—left side only
findings—arachnoid somewhat tougher than usual
anterior inferior cerebellar artery was pressing against cochlear division in two
places and was bound to the cerebellum (Fig. 6)
procedure—artery was mobilized and was moved away from the 8th nerve
result—slow but steady improvement in hearing
1 year after operation a hearing aid was provided on the right
3 years after operation, patient could hear the examiner's spoken voice without a
hearing aid. Patient's mother reported that he was not turning up the radio as
loud as a few months before

Case 3. C.Y.  Age 4½ years  Admitted Oct. 18, 1948
Etiology of deafness—meningitis—at 7½ months following otitis media
pneumococcus

Hearing—not very good
Mentality—much retarded
had not been trained for the toilet
generally irritable, unco-operative
would pound head and hold it as though it hurt
Speech—no words at all
Air study—ventriculogram showed ventricles greatly enlarged.
no air entered the basal cisterns
Operation—bilateral
findings—arachnoid very tough and thickened on both sides
left 8th nerve was an ivory-yellow color, also somewhat swollen
there appeared to be two layers of arachnoid that required opening before the left
nerve was seen
procedure—thickened arachnoid was cleared away from both 8th nerves
the sheath was split over the left cochlear portion, without bleeding
result—1 year after operation there was only suggestive evidence that patient could hear.
He sometimes would turn around when he was called. Also he liked to play with a
rattle
4 years after operation the parents felt that the child could not hear. He was less
restless and appeared to have less headache
mentally he was only a little better than before and he had been admitted to an
institution

Case 4. E.N.  
Age 23 years  Admitted Aug. 15, 1948
Etiology of deafness—meningitis—at 19 years
meningococcus
Hearing—completely absent after the acute illness
  tinnitus on shaking head or when excited
Balance—quite unsteady with eyes closed, only since the acute illness
Mentality—very bright
Speech—excellent but talked in a monotone and low pitch

Fig. 7. Romberg tracings in Case 4. These are made by placing a small pen on the patient’s head and
a horizontal board above this so that, in the Romberg test, the patient makes a tracing on the paper. The
method has been described previously.2 The tracings made before operation show the great amount of
swaying with eyes closed and the later tracings show the improvement mentioned in the text. The trac-
ings with eyes open are about twice as wide as the average normal.

Air encephalogram—x-rays—normal filling of subarachnoid spaces over convexity and in basal cisterns
general effect—not much upset
effect on hearing—no change of any kind
effect on balance—less unsteadiness with eyes open and much less unsteadiness
  with eyes shut (Fig. 7)

Operation—left side only
  findings—arachnoid tough and adherent to the anterior inferior cerebellar artery and to the
  8th nerve
  8th nerve was quite blanched at first but after the arachnoidal adhesions had been
cleared away it was pink and small vessels on the sheath were more numerous
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procedure—arachnoid was cleared away from the artery and nerve sheath was split without bleeding
result—no change whatever

Case 5. E. I. Age 8 years Admitted Oct. 21, 1948
Etiology of deafness—meningitis—at 5 years pneumococci
Hearing—was lost during the acute illness
no demonstrable hearing when tested by audiometer
Balance—very dizzy for 3 or 4 months after the meningitis
Mentality—apparently normal
Speech—good
Air encephalogram—x-rays—no filling of subarachnoid channels over the surface
right lateral ventricle was filled and of normal size
left lateral ventricle did not show
basal cisterns well filled
general effect—not particularly upset
effect on hearing—no immediate change
8 months later patient’s mother felt that there had been no change although patient was able to hear a tuning-fork by air conduction on the right and in the Weber test the sound was referred to the right. At school the teachers thought that hearing was present
in the next 3 years there was no additional improvement in hearing
effect on balance—for about 8 weeks after the air encephalogram patient was quite unsteady

Fig. 8. Case 6. The cystic formation of the arachnoid is depicted on the right side where septa were found so that when the arachnoid was first opened down toward the 9th nerve, it was still necessary to open it in two or three other places and release additional fluid before the 8th nerve was fully exposed. The 8th nerve appeared normal here although an unusual extent of it was visible, suggesting that the loculations in the arachnoid had stretched the nerve.
Case 6. G. R.  Age 8 years  Admitted Dec. 9, 1950

Etiology of deafness—meningitis—at 2½ years pneumococcus

Hearing—not completely lost on left but not good enough to use a hearing aid
Balance—not very steady on his feet
Mentality—good
Speech—not very good, attributed to inadequate teaching

Air encephalogram—x-rays—no air in subarachnoid space over the hemispheres
large subdural crescents
general effect—very sick for several days
effect on hearing—none
effect on balance—none

Operation—bilateral
findings—subarachnoid space appeared to have several compartments so that it was locu-
lated and the space between the petrous bone and cerebellum was increased so
that the 8th nerves appeared stretched (Fig. 8)
procedure—arachnoid was opened widely
result—disposition improved in that patient was less irritable
hearing not apparently altered although patient was trying more to talk and the
parents thought he might be hearing some sounds better

SUMMARY

Six cases are reported of children who were hard of hearing or totally deaf
following meningitis between 3 and 7 years previously.

Operative exposure of the 8th nerves allowed release of arachnoidal adhesions, loculated fluid collections or of compression by the adjacent an-
terior inferior cerebellar artery.

In 2 of the 5 patients operated upon there was improvement in hearing.

In 3 cases air encephalography was followed by temporary or slight
improvement in hearing. This diagnostic measure was used to try to decide on
the advisability of operation. The 2 patients who were helped by the opera-
tion had had some improvement after the air injection.

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REFERENCES